WESTERN ENERGY COMPANY

A Westmoreland Mining LLC Company
138 ROSEBUD LANE • P.O. BOX 99 • COLSTRIP, MT 59323
(406) 748-5100

January 13, 2015

Paul Skubinna
Department of Environmental Quality
Water Quality Discharge Permits Section
PO Box 200901
Helena, MT 59620-0901

RECEIVED
JAN 16 2015
DEQ/WPB
PERMITTING & COMPLIANCE DIV.

Permit ID: MT0023965
Revision Type: Renewal Application
Permitting Action: Submittal
Subject: Permit Modification Application

Dear Paul:

Enclosed please find the MPDES #MT0023965 Permit Modification Application with accompanying fee.

If you have any questions regarding this submittal, please contact Wade Steere at (406) 748-5199.

Sincerely,

Wade Steere, P.E.
Environmental Engineer
Western Energy Company
Rosebud Mine
Phone: (406) 748-5199
Fax: (406) 748-5202
wsteere@westmoreland.com

Enclosures: MPDES #MT0023965 Permit Modification Application
Application Fee

cc: Daniel Munoz
Wade Steere
Dicki Peterson

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TABLE OF CONTENTS

Introduction

Western Energy Company (WECO) is a surface coal producer with an average annual production rate of approximately 10-12 million tons of sub-bituminous coal from the Rosebud Mine located adjacent to Colstrip, Montana. Coal is surface mined through dragline-implemented overburden removal, followed by a truck and loader coal extraction operation.

The coal mining process at the Rosebud Mine requires surface disturbance of approximately 350 acres annually. The two primary sources of wastewater runoff include precipitation event runoff occurring over these disturbed drainages and groundwater inflow into the open mine pits from bisected overburden.

Wastewater is treated by various sediment control facilities including ponds, traps, and alternate sediment control installations (BMP's). Sediment control structures are designed, constructed, and maintained in accordance with ARM Sections 17.24.315, 17.24.603, 17.24.639, 17.24.640, 17.24.640, & 17.24.642.

Existing sediment control facilities are located around the perimeter of the active mine areas. These facilities are installed at a point downstream of all mining related disturbance and upstream of undisturbed tributaries to native receiving water.

This modification application reflects a total of 156 outfalls (Addition of 6 internal Western Alkaline Outfalls and removal of 1 Outfall), including 81 Active and 75 Western Alkaline outfalls.

Sediment ponds and traps located upstream of Active outfalls are designed to contain at least the theoretical runoff from a 10-year 24-hour precipitation event and provide additional volume for a calculated 3-year sedimentation yield.

Sediment control for Western Alkaline outfalls are specified by a drainage specific, DEQ approved, Sediment Control Plan.

A main component of WECO's wastewater is precipitation based runoff, which is highly variable with respect to time (intensity, duration, frequency) and volume. However, due to the relative proximity of outfalls and general similarities between drainages the wastewater quality is relatively constant throughout the mine. Discharges contained in Appendix D are considered representative for the Rosebud Mine for the purposes of this permit application.

A copy of WECO's existing MPDES discharge permit #MT-0023965 has been included (Attachment A).

The following is a summary of the changes requested in this application:

- The receiving water East Fork Armells Creek has been studied and reported to have portions of intermittent and ephemeral portions (See Attachment B "Western Energy – Rosebud Aquatic Survey Assessment" by Arcadis U.S. Inc. and Attachment C "Report Assessment of East Fork Armells Creek Vicinity of Areas A and B" by Nicklin Earth and Water, Inc.). Per the MPDES

Permit effective November 1, 2012 this entire reach was termed ephemeral in nature with effluent limits to reflect that condition. With these findings, WECO requests that DEQ re-evaluate the effluent limits in the intermittent reach (See Attachment D "Memorandum: Issues Relating to Deriving Effluent Limits for Intermittent Reaches").

- Per conversation with DEQ staff, the following internal Western Alkaline Outfalls are requested in Mine Area C-North: 028-1A, 028-2A, 028A, 028B, 113D, and 120A (See Appendix A and Exhibit B for Outfall locations). The drainages that flow to these outfalls constitute the reclaimed portions of Mine Area C-North on the south side of the divide between Stocker Creek and West Fork Armells Creek. These drainages conform to 40 CFR 434 Subpart H and have DEQ approved sediment control plans (See "Western Energy Company Site Specific Sediment Control Plan" prepared by Hydrometrics, Inc. dated April 2011 previously submitted)
- The current flow path downstream of Outfall 10C flows through a culvert under State Highway 39 down to Western Alkaline Outfall 010. WECO requests that Outfall 010 be active and that Outfall 10C be removed from the permit. Sediment control is already established at Outfall 010 (Pond 10). As a suggestion Outfall 010 could be accessed during a precipitation event and would be a possible replacement as a representative outfall if Outfall 10C is removed.
- WECO requests that Outfall 021 be removed from the list of those outfalls that contain activity contained in 40 CFR 434.11. Outfall 021 has no area within its drainage boundary that would be considered a "coal preparation plant", "coal preparation plant associated areas", or "coal plant water circuit".
- WECO requests that DEQ re-evaluate the process by which they set effluent limits for precipitation based discharges. Due to the ephemeral and intermittent nature of the receiving waters the equation for the RPA does not include any flow from the receiving water. WECO, in order to comply with ARM 17.24.639, is required to maintain adequate storage for the theoretical runoff from a 10-year 24-hour precipitation event. In the event that a runoff would exceed that event WECO would potentially begin discharging. With that type of runoff event there would certainly be some flow in the stream therefore contradicting the zero flow assumption in the RPA analysis. WECO requests that DEQ review and consider the procedure included as "Memorandum: Issues Relating to Deriving Effluent Limits for Intermittent Reaches".

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Montana Department of **ENVIRONMENTAL QUALITY**

WATER PROTECTION BUREAU

Agency Use	
Permit No.:	MT0023965
Date Rec'd	1/16/15
Amt Rec'd	$2000
Check No.	✓ #
Rec'd By	bd

FORM 1

GENERAL INFORMATION

(See instructions before completing)

Section A – Montana Pollutant Discharge Elimination System

SPECIFIC QUESTIONS	YES	NO	FORM ATTACHED	SPECIFIC QUESTIONS	YES	NO	FORM ATTACHED
1. Is this facility a publicly owned treatment works which results in a discharge to state surface waters or waters of the U.S.? (FORM 2A)	○	●	☐	2. Does or will this facility *(either existing or proposed)* include a concentrated animal feeding operation or aquatic animal production facility which results in a discharge to state surface waters or waters of the U.S.? (FORM 2B)	○	●	☐
3. Is this a facility which currently results in a discharge of industrial wastewater to state surface water other than those described in 1 or 2 above? (FORM 2C)	●	○	✓	4. Is this a proposed facility *(other than those described in 1 or 2 above)* which will result in a discharge of industrial wastewater to state surface waters? (FORM 2D)	○	●	☐
5. Does this facility discharge only non-process wastewater, not subject to federal effluent guidelines or new source performance standards to state surface waters? (FORM 2E)	○	●	☐	6. Does this facility discharge or propose to discharge storm water associated with industrial activity either alone or in combination with non-storm water discharges? (FORM 2F)	○	●	☐

Montana Ground Water Pollution Control System (MGWPCS)

SPECIFIC QUESTIONS	YES	NO	FORM ATTACHED	SPECIFIC QUESTIONS	YES	NO	FORM ATTACHED
7. Does this facility discharge sewage to ground water through infiltration, percolation or other methods of subsurface disposal? (GW-1)	○	○	☐	8. Does this facility discharge industrial wastes, or other wastes, to ground water through infiltration, percolation, or other methods of subsurface disposal? (GW-2)	○	○	☐

Section B – Facility or Activity Information

ENTERED JAN 21 2015 JP

Facility Name: Rosebud Mine

Facility Location: Castle Rock Road

City, State, Zip: Colstrip, MT, 59323

Telephone Number: (406) 748-5198 County: Rosebud

Township: 1 North Range: 41 East Section: 4 ; NW 1/4 SW 1/4 NE 1/4

Latitude: 45 Deg 52' 13.00" North Longitude: 106 Deg 38' 14.00" West

Is the facility located on Indian lands? ☐ YES ■ NO

Section C – Facility Contact

Facility Contact Name/Title: Philip Kent Salitros/President and General Manager

Mailing Address: PO Box 99

City, State, Zip: Colstrip, MT, 59323

Telephone Number: (406) 748-5198 Email: ksalitros@westmoreland.com

Section D – Existing or Pending Permits, Certifications, or Approvals

- [x] MPDES Permit MT0023965
- [ ] 404 Permit (dredge & fill)
- [ ] UIC #
- [ ] MGWPCS #
- [ ] Plat Approval EQ #
- [ ] Other

Section E – Nature of Business (provide a brief description)

Western Energy's Rosebud Mine is a surface coal mine producing an average of 10-12 million tons per year. Approximately 350 surface acres are disturbed each year to facilitate mining coal.

SIC CODES (4-digit, in order of priority)

	Code	A. First		Code	B. Second
1	1221	Sub-Bituminus Coal - Surface	2		
	Code	C. Third		Code	D. Fourth
3			4		

MAP: Attach to this application a topographic map of the area extending to at least one mile beyond property boundaries. The map must show the outline of the facility, the location of each of its existing and proposed intake and discharge structures (outfalls), each of its hazardous waste treatment, storage, or disposal facilities, and each well where it injects fluids underground. Include all springs, rivers and other surface water bodies in the map area.

Section F – Applicant (Owner/Operator) Information

Applicant (Operator) Name: Western Energy Company

Mailing Address: PO Box 99

City, State, Zip: Colstrip, MT, 59323

Telephone Numbers: (406) 748-5156

Is the 'Operator' listed above also the owner? [x] YES [ ] NO

Status of Applicant *(Check One)*

[ ] Federal [ ] State [x] Private [ ] Public [ ] Other *(specify)* ____________

CERTIFICATION

Section G – Applicant Information: This application must be completed, signed, and certified as follows:

- For a corporation, by a principal officer of at least the level of vice president;
- For a partnership or sole proprietorship, by a general partner or the proprietor, respectively; or
- For a municipality, state, federal, or other public facility, by either a principal executive officer or ranking elected official.

All Applicants Must Complete the Following Certification.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the persons who manage the system or those persons directly responsible for gathering the information, it is to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violation.

A. Name and Official Title (Type or Print)	B. Phone No.
Philip Kent Salitros - President and General Manager	(406) 748-5198
C. Signature [signature]	**D. Date Signed** 12/17/14

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INSTRUCTIONS FOR
Form 1 – GENERAL INFORMATION

Who Must Apply?
Except as provided in 75-5-401(5), MCA, the Montana Water Quality Act (MWQA) prohibits any of the following activities without a valid permit from the Department:
1) construct, modify or operate a disposal system that discharges to any state waters;
2) construct or use any outlet for the discharge of sewage, industrial wastes that discharges into any state waters or;
3) discharge sewage, industrial or other wastes into any state waters.

State waters includes any body of water, either on the surface or underground (ground water) and includes irrigation systems, drainage systems, ephemeral and intermittent drainage ways. Treatment works used to collect, treat, transport, or impound pollutants are not state waters.

*Do **not** leave blank spaces; if a question does not apply, put "NA" in the space provided.* Please type or print legibly; applications that are not legible will be returned.

Section A – Additional Forms:
Complete Section A (Items 1- 8) to determine which additional forms must be submitted to the Department. If you answer 'yes' to any questions, you must submit this form and the supplemental form listed in the parentheses following the question. Mark 'X' in the box in the third column if the supplemental form is attached.

Section B – Facility Information:
Give the facility's official or legal name. Do not use a colloquial name. The facility name means the building, structure (manufacturing, commercial or residential), process, source, or physical site, from which pollutants or wastes are, or will be, collected, generated, stored, treated (treatment works) or discharged (disposal system). The facility may be public or privately owned property, such as, a manufacturing plant, municipal wastewater treatment plant, animal feeding operation or community drain field. Give the address or location of this facility and the most accurate geographic information; latitude and longitude must be accurate to nearest 15 seconds. *See ARM 17.30.1304, ARM 17.30.1001(13) or 75-5-103(24), MCA.* Geographic information may be obtained at http://nris.state.mt.us

Section C – Facility Contact:
Give the name, title and work telephone number of a person who is thoroughly familiar with the operation of the facility and with the facts reported in this application and who can be contacted by the Department for additional information if necessary.

Section D – Existing or Pending Permits, Certifications, or Approvals
Give the permit or approval number for all permits, including general permits that have been issued to the facility, including those permit or approvals which have not been issued.

Section E – Nature of Business:
Provide a brief description of the nature of the business *(e.g., products produced or services provided).*
SIC Codes: List, in descending order of significance, the four 4-digit standard industrial classification (SIC) codes which best describe your facility in terms of the principal products or services you produce or provide. Also, provide a brief description in the space provided. Applicants are encouraged to consult the Standard Industrial Classification Manual for a complete listing of SIC Codes. Copies of the Manual are available through the Government Printing Office in Washington D.C., or on-line at: http://www.osha.gov/pls/imis/sicsearch.html

MAP: Maps & well locations may be obtained at http://nris.state.mt.us . Provide a topographic map or maps of the area extending at least one mile beyond the property boundaries of the facility which clearly show the following: the legal boundaries of the facility; the location and serial number of each of your existing and proposed intake and discharge structures; all hazardous waste management facilities; each well where you inject fluids underground; and all springs and surface water bodies in the area, plus all drinking water wells within ¼ mile of the facility which are identified in the public record or otherwise known to you.

If an intake or discharge structure, hazardous waste disposal site, or injection well associated with the facility is located more than one mile from the plant, include it on the map, if possible. If not, attach additional sheets describing the location of the structure, disposal site, or well, and identify the U.S. Geological Survey (or other) map corresponding to the location.

Section F – Applicant (Owner/Operator) Information:
Give the name, as it is legally referred to, of the person, business, public organization, or other entity that owns or operates the facility described in Section B of this application. The operator is the legal entity which controls the facility's operation. The permit will be issued to the entity identified in this section (Section F). The owner/operator is the entity which is responsible for compliance with the permit, statute and applicable regulations.

Section G – Certification:
This form must be signed and certified by the appropriate official as given in Section G and ARM 17.30.1323. The Montana Water Quality Act provides for penalties of not more than $25,000 or imprisonment for not more than 6 months, or both, for any person that knowingly make a false statement, representation, or certification in any application, record, report, plan or other document filed or required to be maintained by the Act, or who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required under the Act. 75-5-633, MCA.

Fees:
The MWQA requires that the Department collect fees sufficient to cover the cost of issuing permits as well as the administrative costs associated with these activities. The Department collects both application and annual fees. Fees vary depending upon the complexity, type and strength of wastewater and the number of discharge points. Fee information is available on the Departments' website: www.deq.mt.gov or by contacting the Water Protection Bureau at (406) 444-3080. *The Department will not process this application until all of the requested information is supplied, the application is complete, and the appropriate fees are paid.* Return this application form [Form 1] and any supplemental forms, and fee to:

Department of Environmental Quality
Water Protection Bureau
PO Box 200901
Helena MT 59620-0901

Disclaimer

This is an updated PDF document that allows you to type your information directly into the form, print it, and save the completed form.

Note: This form can be viewed and saved only using Adobe Acrobat Reader version 7.0 or higher, or if you have the full Adobe Professional version.

Instructions:

1. Type in your information
2. Save file (if desired)
3. Print the completed form
4. Sign and date the printed copy
5. Mail it to the directed contact.

United States
Environmental Protection
Agency

Office of
Enforcement
Washington, DC 20460

EPA Form 3510-2C
Revised August 1990
Previous editions
are obsolete

Permits Division

EPA

Application Form 2C – Wastewater Discharge Information

Consolidated Permits Program

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DEQ/WPB
PERMITTING & COMPLIANCE DIV.

This form must be completed by all persons applying for an EPA permit to discharge wastewater *(existing manufacturing, commercial, mining, and silvicultural operations).*

Printed on recycled paper

Paperwork Reduction Act Notice

The public reporting burden for this collection of information is estimated to average 33 hours per response. This estimate includes time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information to the Chief, Information Policy Branch (PM-223), US Environmental Protection Agency, 1200 Pennsylvania Avenue, NW, Washington, DC 20460, and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503, marked **Attention:** Desk Officer for EPA.

This form must be completed by all applicants who check "yes" to item II-C in Form 1.

Public Availability of Submitted Information.

Your application will not be considered complete unless you answer every question on this form and on Form 1. If an item does not apply to you, enter "NA" (*for not applicable*) to show that you considered the question.

You may not claim as confidential any information required by this form or Form 1, whether the information is reported on the forms or in an attachment. This information will be made available to the public upon request.

Any information you submit to EPA which goes beyond that required by this form or Form 1 you may claim as confidential, but claims for information which is effluent data will be denied. If you do not assert a claim of confidentiality at the time of submitting the information, EPA may make the information public without further notice to you. Claims of confidentiality will be handled in accordance with EPA's business confidentiality regulations at 40 CFR Part 2.

Definitions

All significant terms used in these instructions and in the form are defined in the glossary found in the General Instructions which accompany Form 1.

EPA ID Number

Fill in your EPA Identification Number at the top of each page of Form 2c. You may copy this number directly from item I of Form 1.

Item I

You may use the map you provided for item XI of Form 1 to determine the latitude and longitude of each of your outfalls and the name of the receiving water.

Item II-A

The line drawing should show generally the route taken by water in your facility from intake to discharge. Show all operations contributing wastewater, including process and production areas, sanitary flows, cooling water, and stormwater runoff. You may group similar operations into a single unit, labeled to correspond to the more detailed listing in item II-B. The water balance should show average flows. Show all significant losses of water to products, atmosphere, and discharge. You should use actual measurements whenever available; otherwise use your best estimate. An example of an acceptable line drawing appears in Figure 2c-1 to these instructions.

Item II-B

List all sources of wastewater to each outfall. Operations may be described in general terms (*for example, "dye-making reactor" or "distillation tower")*. You may estimate the flow contributed by each source if no date are available. For stormwater discharges you may estimate the average flow, but you must indicate the rainfall event upon which the estimate is based and the method of estimation. For each treatment unit, indicate its size, flow rate, and retention time, and describe the ultimate disposal of any solid or liquid wastes not discharged. Treatment units should be listed in order and you should select the proper code from Table 2c-1 to fill in column 3-b for each treatment unit. Insert "XX" into column 3-b if no code corresponds to a treatment unit you list. If you are applying for a permit for a privately owned treatment works, you must also identify all of your contributors in an attached listing.

Item II-C

A discharge is intermittent unless it occurs without interruption during the operating hours of the facility, except for infrequent shutdowns for maintenance, process changes, or other similar activities. A discharge is seasonal if it occurs only during certain parts of the year. Fill in every applicable column in this item for each source of intermittent or seasonal discharges. Base your answers on actual data whenever available; otherwise, provide your best estimate. Report the highest daily value for flow rate and total volume in the "Maximum Daily" columns (*columns 4-a-2 and 4-b-2*). Report the average of all daily values measured during days when discharge occurred within the last year in the "Long Term Average" columns (*columns 4-a-1 and 4-b-1*).

Item III-A

All effluent guidelines promulgated by EPA appear in the Federal Register and are published annually in 40 CFR Subchapter N. A guideline applies to you if you have any operations contributing process wastewater in any subcategory covered by a BPT, BCT, or BAT guideline. If you are unsure whether you are covered by a promulgated effluent guideline, check with your EPA Regional office (*Table 1 in the Form 1 instructions*). You must check "yes" if an applicable effluent guideline has been promulgated, even if the guideline limitations are being contested in court. If you believe that a promulgated effluent guideline has been remanded for reconsideration by a court and does not apply to your operations, you may check "no."

Item III-B

An effluent guideline is expressed in terms of production (*or other measure of operation*) if the limitation is expressed as mass of pollutant per operational parameter; for example, "pounds of BOD per cubic foot of logs from which bark is removed," or "pounds of TSS per megawatt hour of electrical energy consumed by smelting furnace." An example of a guideline not expressed in terms of a measure of operation is one which limits the concentration of pollutants.

Item III-C

This item must be completed only if you checked "yes" to item III-B. The production information requested here is necessary to apply effluent guidelines to your facility and you cannot claim it as confidential. However, you do not have to indicate how the reported information was calculated. Report quantities in the units of measurement used in the applicable effluent guideline. The production figures provided must be based on actual daily production and not on design capacity or on predictions of future operations. To obtain alternate limits under 40 CFR 122.45(b)(2)(ii), you must define your maximum production capability and demonstrate to the Director that your actual production is substantially below maximum production capability and that there is a reasonable potential for an increase above actual production during the duration of the permit.

Item IV-A

If you check "yes" to this question, complete all parts of the chart, or attach a copy of any previous submission you have made to EPA containing same information.

Item IV-B

You are not required to submit a description of future pollution control projects if you do not wish to or if none is planned.

Item V-A, B, C, and D

The items require you to collect and report data on the pollutants discharged for each of your outfalls. Each part of this item addresses a different set of pollutants and must be completed in accordance with the specific instructions for that part. The following general instructions apply to the entire item.

General Instructions

Part A requires you to report at least one analysis for each pollutant listed. Parts B and C require you to report analytical data in two ways. For some pollutants, you may be required to mark "X" in the "Testing Required" column (*column 2-a, Part C*), and test (*sample and analyze*) and report the levels of the pollutants in your discharge whether or not you expect them to be present in your discharge. For all others, you must mark "X" in either the "Believe Present" column or the "Believe Absent" column (*columns 2-a or 2-b, Part B, and columns 2-b or 2-c, Part C*) based on your best estimate, and test for those which you believe to be present. (*See specific instructions on the form and below for Parts A through D.*) Base your determination that a pollutant is present in or absent from your discharge on your

Item V-A, B, C, and D (continued)

knowledge of your raw materials, maintenance chemicals, intermediate and final products and byproducts, and any previous analyses known to you of your effluent or similar effluent. (*For example, if you manufacture pesticides, you should expect those pesticides to be present in contaminated stormwater runoff.*) If you would expect a pollutant to be present solely as a result of its presence in your intake water, you must mark "Believe Present" but you are not required to analyze for that pollutant. Instead, mark an 'X' In the "Intake" column.

A. Reporting. All levels must be reported as concentration and as total mass. You may report some or all of the required data by attaching separate sheets of paper instead of filling out pages V-l to V-9 if the separate sheets contain all the required information in a format which is consistent with pages V-l to V-9 in spacing and in identification of pollutants and columns. (*For example, the data system used in your GC/MS analysis may be able to print data in the proper format.*) Use the following abbreviations in the columns headed "Units" (*column 3, Part A, and column 4, Parts B and C*).

Concentration	**Mass**
ppm.......parts per million	lbs.........................pounds
mg/l ...milligrams per liter	ton............tons *(English tons)*
ppb..........parts per billion	mg.........................milligrams
ug/l ...micrograms per liter	g..................................grams
	kg......................kilograms
	T...........tonnes *(metric tons)*

All reporting of values for metals must be in terms of "total recoverable metal," unless:

(1) An applicable, promulgated effluent limitation or standard specifies the limitation for the metal in dissolved, valent, or total form; or

(2) All approved analytical methods for the metal inherently measure only its dissolved form (e.g., hexavalent chromium); or

(3) The permitting authority has determined that in establishing case-by-case limitations it is necessary to express the limitations on the metal in dissolved, valent, or total form to carry out the provisions of the CWA.

If you measure only one daily value, complete only the "Maximum Daily Values" columns and insert '1' into the "Number of Analyses" column (*columns 2-a and 2-d, Part A, and column 3-a, 3-d, Parts B and C*). The permitting authority may require you to conduct additional analyses to further characterize your discharges. For composite samples, the daily value is the total mass or average concentration found in a composite sample taken over the operating hours of the facility during a 24-hour period; for grab samples, the daily value is the arithmetic or flow-weighted total mass or average concentration found in a series of at least four grab samples taken over the operating hours of the facility during a 24-hour period.

If you measure more than one daily value for a pollutant and those values are representative of your wastestream, you must report them. You must describe your method of testing and data analysis. You also must determine the average of all values within the last year and report the concentration and mass under the "Long Term Average Values" columns (*column 2-c, Part A, and column 3-c, Parts B and C*), and the total number of daily values under the "Number of Analyses" columns (*column 2-d, Part A, and columns 3-d, Parts B and C*). Also, determine the average of all daily values taken during each calendar month, and report the highest average under the "Maximum 30-day Values" columns (*column 2-c, Part A, and column 3-b, Parts B and C*).

B. Sampling: The collection of the samples for the reported analyses should be supervised by a person experienced in performing sampling of industrial wastewater. You may contact your EPA or State permitting authority for detailed guidance on sampling techniques and for answers to specific questions. Any specific requirements contained in the applicable analytical methods should be followed for sample containers, sample preservation, holding times, the collection of duplicate samples, etc. The time when you sample should be representative of your normal operation, to the extent feasible, with all processes which contribute wastewater in normal operation, and with your treatment system operating properly with no system upsets. Samples should be collected from the center of the flow channel, where turbulence is at a maximum, at a site specified in your present permit, or at any site adequate for the collection of a representative sample.

For pH, temperature, cyanide, total phenols, residual chlorine, oil and grease, and fecal coliform, grab samples must be used. For all other pollutants 24-hour composite samples must be used. However, a minimum of one grab sample may be taken for effluents from holding ponds or other impoundments with a retention period of greater than 24 hours. For stormwater discharges a minimum of one to four grab samples may be taken, depending on the duration of the discharge. One grab must be taken in the first hour (*or less*) of discharge, with one additional grab (*up to a minimum of four*) taken in each succeeding hour of discharge for discharges lasting four or more hours. The Director may waive composite sampling for any outfall for which you demonstrate that use of an automatic sampler is infeasible and that a minimum of four grab samples will be representative of your discharge.

Grab and composite samples are defined as follows:

Grab sample: An individual sample of at least 100 milliliters collected at a randomly-selected time over a period not exceeding 15 minutes.

Composite sample: A combination of at least 8 sample aliquots of at least 100 milliliters, collected at periodic intervals during the operating hours of a facility over a 24 hour period. The composite must be flow proportional; either the time interval between each aliquot or the volume of each aliquot must be proportional to either the stream flow at the time of sampling or the total stream flow since the collection of the previous aliquot. Aliquots may be collected manually or automatically. For GC/MS Volatile Organic Analysis (VOA), aliquots must be combined in the laboratory immediately before analysis. Four (4) (*rather than eight*) aliquots or grab samples should be collected for VOA. These four samples should be collected during actual hours of discharge over a 24-hour period and need not be flow proportioned. Only one analysis is required.

The Agency is currently reviewing sampling requirements in light of recent research on testing methods. Upon completion of its review, the Agency plans to propose changes to the sampling requirements.

Data from samples taken in the past may be used, provided that:

All data requirements are met;

Sampling was done no more than three years before submission; and

All data are representative of the present discharge.

Among the factors which would cause the data to be unrepresentative are significant changes in production level, changes in raw materials, processes, or final products, and changes in wastewater treatment. When the Agency promulgates new analytical methods in 40 CFR Part 136, EPA will provide information as to when you should use the new methods to generate data on your discharges. Of course, the Director may request additional information, including current quantitative data, if she or he determines it to be necessary to assess your discharges.

C. Analysis: You must use test methods promulgated in 40 CFR Part 136; however, if none has been promulgated for a particular pollutant, you may use any suitable method for measuring the level of the pollutant in your discharge provided that you submit a description of the method or a reference to a published method. Your description should include the sample holding time, preservation techniques, and the quality control measures which you used. If you have two or more substantially identical outfalls, you may request permission from your permitting authority to sample and analyse only one outfall and submit the results of the analysis for other substantially identical outfalls. If your request is granted by the

Item V-A, B, C, and D (continued)

permitting authority, on a separate sheet attached to the application form, identify which outfall you did test, and describe why the outfalls which you did not test are substantially identical to the outfall which you did test.

D. Reporting of Intake Data: You are not required to report data under the "Intake" columns unless you wish to demonstrate your eligibility for a "net" effluent limitation for one or more pollutants, that is, an effluent limitation adjusted by subtracting the average level of the pollutant(s) present in your intake water, NPDES regulations allow net limitations only in certain circumstances. To demonstrate your eligibility, under the "Intake" columns report the average of the results of analyses on your intake water (*if your water is treated before use, test the water after it is treated*), and discuss the requirements for a net limitation with your permitting authority.

Part V-A

Part V-A must be completed by all applicants for all outfalls, including outfalls containing only noncontact cooling water or storm runoff. However, at your request, the Director may waive the requirement to test for one or more of these pollutants, upon a determination that available information is adequate to support issuance of the permit with less stringent reporting requirements for these pollutants. You also may request a waiver for one or more of these pollutants for your category or subcategory from the Director, Office of Water Enforcement and Permits. See discussion in General Instructions to item V for definitions of the columns in Part A. The "Long Term Average Values" column (*column 2-c*) and "Maximum 30-day Values" column (*column 2-b*) are not compulsory but should be filled out if data are available.

Use composite samples for all pollutants in this Part, except use grab samples for pH and temperature. See discussion in General Instructions to Item V for definitions of the columns in Part A. The "Long Term Average Values" column (*column 2-c*) and "Maximum 30-Day Values" column (*column 2-b*) are not compulsory but should be filled out if data are available.

Part V-B

Part V-B must be completed by all applicants for all outfalls, including outfalls containing only noncontact cooling water or storm runoff. You must report quantitative data if the pollutant(s) in question is limited in an effluent limitations guideline either directly, or indirectly but expressly through limitation on an indicator (*e.g., use of TSS as an indicator to control the discharge of iron and aluminum*). For other discharged pollutants you must provide quantitative data or explain their presence in your discharge. EPA will consider requests to the Director of the Office of Water Enforcement and Permits to eliminate the requirement to test for pollutants for an industrial category or subcategory. Your request must be supported by data representative of the industrial category or subcategory in question. The data must demonstrate that individual testing for each applicant is unnecessary, because the facilities in the category or subcategory discharge substantially identical levels of the pollutant or discharge the pollutant uniformly at sufficiently low levels. Use composite samples for all pollutants you analyze for in this part, except use grab samples for residual chlorine, oil and grease, and fecal coliform. The "Long Term Average Values" column (*column 3-c*) and "Maximum 30-day Values" column (*column 3-b*) are not compulsory but should be filled out if data are available.

Part V-C

Table 2c-2 lists the 34 "primary" industry categories in the lefthand column. For each outfall, if any of your processes which contribute wastewater falls into one of those categories, you must mark "X" in "Testing Required" column (*column 2-a*) and test for (l) all of the toxic metals, cyanide, and total phenols, and (2) the organic toxic pollutants contained in Table 2c-2 as applicable to your category, unless you qualify as a small business (*see below*). The organic toxic pollutants are listed by GC/MS fractions on pages V-4 to V-9 in Part V-C. For example, the Organic Chemicals Industry has an asterisk in all four fractions; therefore, applicants in this category must test for all organic toxic pollutants in Part V-C. The inclusion of total phenols in Part V-C is not intended to classify total phenols as a toxic pollutant. If you are applying for a permit for a privately owned treatment works, determine your testing requirements on the basis of the industry categories of your contributors. When you determine which industry category you are in to find your testing requirements, you are not determining your category for any other purpose and you are not giving up your right to challenge your inclusion in that category (*for example, for deciding whether an effluent guideline is applicable*) before your permit is issued. For all other cases (secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions), you must mark "X" in either the "Believed Present" column (*column 2-b*) or the "Believed Absent" column (*column 2-c*) for each pollutant. For every pollutant you know or have reason to believe is present in your discharge in concentrations of 10 ppb or greater, you must report quantitative data. For acrolein, acrylonitrile, 2, 4 dinitrophenol, and 2-methyl-4, 6 dinitrophenol, where you expect these four pollutants to be discharged in concentrations of 100 ppb or greater, you must report quantitative data. For every pollutant expected to be discharged in concentrations less than the thresholds specified above, you must either submit quantitative data or briefly describe the reasons the pollutant is expected to be discharged. At your request the Director, Office of Water Enforcement and Permits, may waive the requirement to test for pollutants for an industrial category or subcategory. Your request must be supported by data representatives of the industrial category or subcategory in question. The data must demonstrate that individual testing for each applicant is unnecessary, because the facilities in question discharge substantially identical levels of the pollutant, or discharge the pollutant uniformly at sufficiently low levels. If you qualify as a small business (*see below*) you are exempt from testing for the organic toxic pollutants, listed on pages V-4 to V-9 in Part C. For pollutants in intake water, see discussion in General Instructions to this item. The "Long Term Average Values" column (*column 3-c*) and "Maximum 30-day Values" column (*column 3-b*) are not compulsory but should be filled out if data are available. You are required to mark "Testing Required" for dioxin if you use or manufacture one of the following compounds:

(a) 2,4,5-trichlorophenoxy acetic acid, (2,4,5-T);

(b) 2-(2,4,5-trichlorophenoxy) propanoic acid, (Silvex, 2,4,5-TP)

(c) 2-(2,4,5-trichlorophenoxy) ethyl 2,2-dichloropropionate, (Erbon);

(d) 0,0-dimethyl 0-(2,4,5-trichlorophenyl) phosphorothioate, (Ronnel);

(e) 2,4,5,-trichlorophenol, (TCP); or

(f) hexachlorophene, (HCP).

If you mark "Testing Required" or "Believed Present," you must perform a screening analysis for dioxins, using gas chromotography with an electron capture detector. A TCDD standard for quantitation is not required. Describe the results of this analysis in the space provided; for example, "no measurable baseline deflection at the retention time of TCDD" or "a measurable peak within the tolerances of the retention time of TCDD." The permitting authority may require you to perform a quantitative analysis if you report a positive result. The Effluent Guidelines Division of EPA has collected and analyzed samples from some plants for the pollutants listed in Part C in the course of its BAT guidelines development program. If your effluents are sampled and analyzed as part of this program in the last three years, you may use these data to answer Part C provided that the permitting authority approves, and provided that no process change or change in raw materials or operating practices has occurred since the samples were taken that would make the analyses unrepresentative of your current discharge.

Small Business Exemption: If you qualify as a "small business", you are exempt from the reporting requirements for the organic toxic pollutants, listed on pages V-4 to V-9 in Part C. There are two ways in which you can qualify as a "small business." If your facility is a coal mine, and if your probable total annual production is less than 100,000 tons per year, you may submit past production data or estimated future production *(such as a schedule of estimated total production under 30 CFR § 795.14(c))* instead of conducting analyses for the organic toxic pollutants. If your facility is not a coal mine, and if your gross total annual sales for the most recent three years average less than $100,000 per year *(in second quarter 1980*

Item V-A, B, C, and D (continued)

dollars), you may submit sales data for those years instead of conducting analyses for the organic toxic pollutants. The production or sales data must be for the facility which is the source of the discharge. The data should not be limited to production or sales for the process or processes which contribute to the discharge, unless those are the only processes at your facility. For sales data, in situations involving intracorporate transfer of goods and services, the transfer price per unit should approximate market prices for those goods and services as closely as possible. Sales figures for years after 1980 should be indexed to the second quarter of 1980 by using the gross national product price deflator (*second quarter of 1980=100*). This index is available in *National Income and Product Accounts of the United States (Department of Commerce, Bureau of Economic Analysis).*

Part V-D

List any pollutants in Table 2c-3 that you believe to be present and explain why you believe them to be present. No analysis is required, but if you have analytical data, you must report it.

Note: Under 40 CFR 117.12(a)(2), certain discharges of hazardous substances (*listed in Table 2c-4 of these instructions*) may be exempted from the requirements of section 311 of CWA, which establishes reporting requirements, civil penalties and liability for cleanup costs for spills of oil and hazardous substances. A discharge of a particular substance may be exempted if the origin, source, and amount of the discharged substances are identified in the NDPES permit application or in the permit, if the permit contains a requirement for treatment of the discharge, and if the treatment is in place. To apply for an exclusion of the discharge of any hazardous substance from the requirements of section 311, attach additional sheets of paper to your form, setting forth the following information:

1. The substance and the amount of each substance which may be discharged.
2. The origin and source of the discharge of the substance.
3. The treatment which is to be provided for the discharge by:
   a. An onsite treatment system separate from any treatment system treating your normal discharge;
   b. A treatment system designed to treat your normal discharge and which is additionally capable of treating the amount of the substance identified under paragraph 1 above; or
   c. Any combination of the above.

See 40 CFR §117.12(a)(2) and (c) published on August 29, 1979, in 44 FR 50766, or contact your Regional Office (*Table 1 on Form 1, Instructions*), for further information on exclusions from section 311.

Item VI

This requirement applies to current use or manufacture of a toxic pollutant as an intermediate or final product or byproduct. The Director may waive or modify the requirement if you demonstrate that it would be unduly burdensome to identify each toxic pollutant and the Director has adequate information to issue your permit. You may not claim this information as confidential; however, you do not have to distinguish between use or production of the pollutants or list the amounts.

Item VII

Self explanatory. The permitting authority may ask you to provide additional details after your application is received.

Item IX

The Clean Water Act provides for severe penalties for submitting false information on this application form.

Section 309(c)(2) of the Clean Water Act provides that "Any person who knowingly makes any false statement, representation, or certification in any application,... shall upon conviction, be punished by a fine of not more than $10,000 or by imprisonment for not more than six months, or by both."

40 CFR Part 122.22 requires the certification to be signed as follows:

(A) For a corporation: by a responsible corporate official. For purposes of this section, a responsible corporate official means (i) a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation, or (ii) the manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or having gross annual sales or expenditures exceeding $25,000,000 (*in second-quarter 1980 dollars*), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

Note: EPA does not require specific assignments or delegation of authority to responsible corporate officers identified in §122.22(a)(1)(i). The Agency will presume that these responsible corporate officers have the requisite authority to sign permit applications unless the corporation has notified the director to the contrary. Corporate procedures governing authority to sign permit applications may provide for assignment or delegation to applicable corporate position under §122.22(a)(1)(ii) rather than to specific individuals.

(B) *For a partnership or sole proprietorship*: by a general partner or the proprietor, respectively; or

(C) For a municipality, State, Federal, or other public agency: by either a principal executive officer or ranking elected official. For purposes of this section, a principal executive officer of a Federal Agency includes (i) the chief executive officer of the Agency, or (ii) a senior executive officer having responsibility for the overall operations of a principal geographic unit of the Agency (*e.g., Regional Administrators of EPA*). Applications for Group II stormwater dischargers may be signed by a duly authorized representative *(as defined in 40 CFR 122.22(b))* of the individuals identified above.

CODES FOR TREATMENT UNITS

PHYSICAL TREATMENT PROCESSES

1–A	Ammonia Stripping	1–M	Grit Removal
1–B	Dialysis	1–N	Microstraining
1–C	Diatomaceous Earth Filtration	1–O	Mixing
1–D	Distillation	1–P	Moving Bed Filters
1–E	Electrodialysis	1–Q	Multimedia Filtration
1–F	Evaporation	1–R	Rapid Sand Filtration
1–G	Flocculation	1–S	Reverse Osmosis (*Hyperfiltration*)
1–H	Flotation	1–T	Screening
1–I	Foam Fractionation	1–U	Sedimentation (*Settling*)
1–J	Freezing	1–V	Slow Sand Filtration
1–K	Gas–Phase Separation	1–W	Solvent Extraction
1–L	Grinding (*Comminutors*)	1–X	Sorption

CHEMICAL TREATMENT PROCESSES

2–A	Carbon Adsorption	2–G	Disinfection (*Ozone*)
2–B	Chemical Oxidation	2–H	Disinfection (*Other*)
2–C	Chemical Precipitation	2–I	Electrochemical Treatment
2–D	Coagulation	2–J	Ion Exchange
2–E	Dechlorination	2–K	Neutralization
2–F	Disinfection (*Chlorine*)	2–L	Reduction

BIOLOGICAL TREATMENT PROCESSES

3–A	Activated Sludge	3–E	Pre-Aeration
3–B	Aerated Lagoons	3–F	Spray Irrigation/Land Application
3–C	Anaerobic Treatment	3–G	Stabilization Ponds
3–D	Nitrification–Denitrification	3–H	Trickling Filtration

OTHER PROCESSES

4–A	Discharge to Surface Water	4–C	Reuse/Recycle of Treated Effluent
4–B	Ocean Discharge Through Outfall	4-D	Underground Injection

SLUDGE TREATMENT AND DISPOSAL PROCESSES

5–A	Aerobic Digestion	5–M	Heat Drying
5–B	Anaerobic Digestion	5–N	Heat Treatment
5–C	Belt Filtration	5–O	Incineration
5–D	Centrifugation	5–P	Land Application
5–E	Chemical Conditioning	5–Q	Landfill
5–F	Chlorine Treatment	5–R	Pressure Filtration
5–G	Composting	5–S	Pyrolysis
5–H	Drying Beds	5–T	Sludge Lagoons
5–I	Elutriation	5–U	Vacuum Filtration
5–J	Flotation Thickening	5–V	Vibration
5–K	Freezing	5–W	Wet Oxidation
5–L	Gravity Thickening		

Table 2C-1

TESTING REQUIREMENTS FOR ORGANIC TOXIC POLLUTANTS INDUSTRY CATEGORY*

INDUSTRY CATEGORY	GC/MS FRACTION[1]			
	Volatile	Acid	Base/Neutral	Pesticide
Adhesives and sealants	X	X	X	–
Aluminum forming	X	X	X	–
Auto and other laundries	X	X	X	X
Battery manufacturing	X	–	X	–
Coal mining	X	X	X	X
Coil coating	X	X	X	–
Copper forming	X	X	X	–
Electric and electronic compounds	X	X	X	X
Electroplating	X	X	X	–
Explosives manufacturing	–	X	X	–
Foundries	X	X	X	–
Gum and wood chemicals	X	X	X	X
Inorganic chemicals manufacturing	X	X	X	–
Iron and steel manufacturing	X	X	X	–
Leather tanning and finishing	X	X	X	X
Mechanical products manufacturing	X	X	X	–
Nonferrous metals manufacturing	X	X	X	X
Ore mining	X	X	X	X
Organic chemicals manufacturing	X	X	X	X
Paint and ink formulation	X	X	X	X
Pesticides	X	X	X	X
Petroleum refining	X	X	X	X
Pharmaceutical preparations	X	X	X	–
Photographic equipment and supplies	X	X	X	X
Plastic and synthetic materials manufacturing	X	X	X	X
Plastic processing	X	–	–	–
Porcelain enameling	X	–	X	X
Printing and publishing	X	X	X	X
Pulp and paperboard mills	X	X	X	X
Rubber processing	X	X	X	–
Soap and detergent manufacturing	X	X	X	–
Steam electric power plants	X	X	X	–
Textile mills	X	X	X	X
Timber products processing	X	X	X	X

*See note at conclusion of 40 CFR Part 122, Appendix D (1983) for explanation of effect of suspensions on testing requirements for primary industry categories.

[1]The pollutants in each fraction are listed in Item V-C.

X = Testing required.

– = Testing not required.

TOXIC POLLUTANTS AND HAZARDOUS SUBSTANCES REQUIRED TO BE IDENTIFIED BY APPLICANTS IF EXPECTED TO BE PRESENT

TOXIC POLLUTANT

Asbestos

HAZARDOUS SUBSTANCES

Acetaldehyde
Allyl alcohol
Allyl chloride
Amyl acetate
Aniline
Benzonitrile
Benzyl chloride
Butyl acetate
Butylamine
Captan
Carbaryl
Carbofuran
Carbon disulfide
Chlorpyrifos
Coumaphos
Cresol
Crotonaldehyde
Cyclohexane
2,4-D (2,4-Dichlorophenoxyacetic acid)
Diazinon
Dicamba
Dichlobenil
Dichlone
2,2-Dichloropropionic acid

HAZARDOUS SUBSTANCES

Dichlorvos
Diethyl amine
Dimethyl amine
Dintrobenzene
Diquat
Disulfoton
Diuron
Epichlorohydrin
Ethion
Ethylene diamine
Ethylene dibromide
Formaldehyde
Furfural
Guthion
Isoprene
Isopropanolamine
Kelthane
Kepone
Malathion
Mercaptodimethur
Methoxychlor
Methyl mercaptan
Methyl methacrylate
Methyl parathion
Mevinphos
Mexacarbate
Monoethyl amine
Monomethyl amine

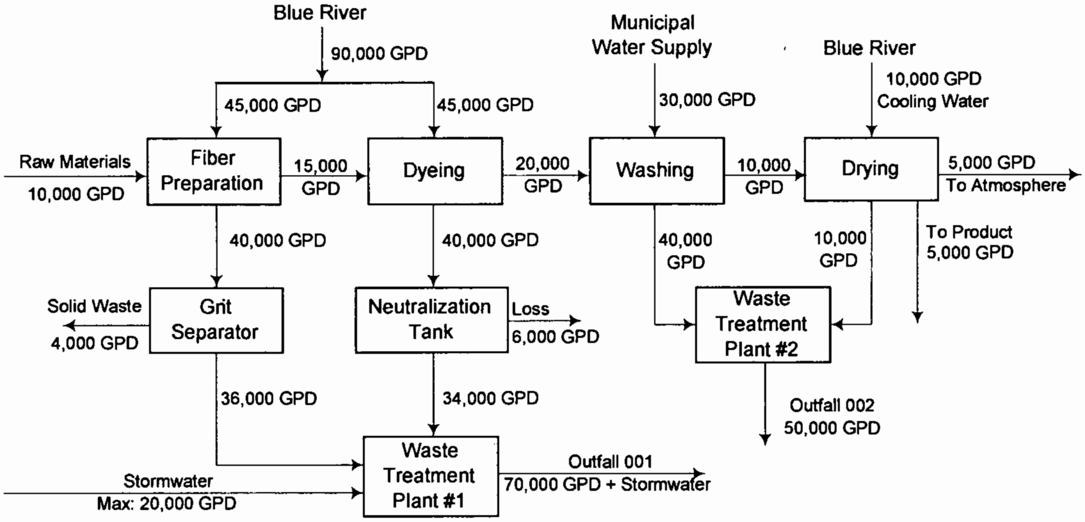
HAZARDOUS SUBSTANCES

Naled
Napthenic acid
Nitrotoluene
Parathion
Phenolsulfonate
Phosgene
Propargite
Propylene oxide
Pyrethrins
Quinoline
Resorcinol
Strontium
Strychnine
Styrene
2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)
TDE (Tetrachlorodiphenyl ethane)
2,4,5-TP [2-(2,4,5-Trichlorophenoxy) propanoic acid]
Trichlorofon
Triethanolamine
Triethylamine
Trimethylamine
Uranium
Vanadium
Vinyl acetate
Xylene
Xylenol
Zirconium

1. Acetaldehyde
2. Acetic acid
3. Acetic anhydride
4. Acetone cyanohydrin
5. Acetyl bromide
6. Acetyl chloride
7. Acrolein
8. Acrylonitrile
9. Adipic acid
10. Aldrin
11. Allyl alcohol
12. Allyl chloride
13. Aluminum sulfate
14. Ammonia
15. Ammonium acetate
16. Ammonium benzoate
17. Ammonium bicarbonate
18. Ammonium bichromate
19. Ammonium bifluoride
20. Ammonium bisulfite
21. Ammonium carbamate
22. Ammonium carbonate
23. Ammonium chloride
24. Ammonium chromate
25. Ammonium citrate
26. Ammonium fluoroborate
27. Ammonium fluoride
28. Ammonium hydroxide
29. Ammonium oxalate
30. Ammonium silicofluoride
31. Ammonium sulfamate
32. Ammonium sulfide
33. Ammonium sulfite
34. Ammonium tartrate
35. Ammonium thiocyanate
36. Ammonium thiosulfate
37. Amyl acetate
38. Aniline
39. Antimony pentachloricle
40. Antimony potassium tartrate
41. Antimony tribromide
42. Antimony trichloride
43. Antimony trifluoride
44. Antimony trioxide
45. Arsenic disulfide
46. Arsenic pentoxide
47. Arsenic trichloride
48. Arsenic trioxide
49. Arsenic trisulfide
50. Barium cyanide
51. Benzene
52. Benzoic acid
53. Benzonitrile
54. Benzoyl chloride
55. Benzyl chloride
56. Beryllium chloride
57. Beryllium fluoride
58. Beryllium nitrate
59. Butylacetate
60. n-Butylphthalate
61. Butylamine
62. Butyric acid
63. Cadmium acetate
64. Cadmium bromide
65. Cadmium chloride
66. Calcium arsenate
67. Calcium arsenite
69. Calcium carbide
69. Calcium chromate
70. Calcium cyanide
71. Calcium dodecylbenzenesulfonate
72. Calcium hypochlorite
73. Captan
74. Carbaryl
75. Carbofuran
76. Carbon disulfide
77. Carbon tetrachloride
78. Chlordane
79. Chlorine
80. Chlorobenzene
81. Chloroform
82. Chloropyrifos
83. Chlorosulfonic acid
84. Chromic acetate
85. Chromic acid
86. Chromic sulfate
87. Chromous chloride
88. Cobaltous bromide
89. Cobaltous formate
90. Cobaltous sulfamate
91. Coumaphos
92. Cresol
93. Crotonaldehyde
94. Cupric acetate
95. Cupric acetoarsenite
96. Cupric chloride
97. Cupric nitrate
98. Cupric oxalate
99. Cupric sulfate
100. Cupric sulfate ammoniated
101. Cupric tartrate
102. Cyanogen chloride
103. Cyclohexane
104. 2,4-D acid (2,4- Dichlorophenoxyacetic acid)
105. 2,4-D esters (2,4- Dichlorophenoxyacetic acid esters)
106. DDT
107. Diazinon
108. Dicamba
109. Dichlobenil
110. Dichlone
111. Dichlorobenzene
112. Dichloropropane
113. Dichloropropene
114. Dichloropropene-dichlororopane mix
115. 2,2-Dichloropropionic acid
116. Dichlorvos
117. Dieldrin
118. Diethylamine
119. Dimethylamine
120. Dinitrobenzene
121. Dinitrophenol
122. Dinitrotoluene
123. Diquat
124. Disulfoton
125. Diuron
126. Dodecylbenzesulfonic acid
127. Endosulfan
128. Endrin
129. Epichlorohydrin
130. Ethion
131. Ethylbenzene
132. Ethylenediamine
133. Ethylene dibromide
134. Ethylene dichloride
135. Ethylene diaminetetracetic acid (EDTA)
136. Ferric ammonium citrate
137. Ferric ammonium oxalate
138. Ferric chloride
139. Ferric fluoride
140. Ferric nitrate
141. Ferric sulfate
142. Ferrous ammonium sulfate
143. Ferrous chloride
144. Ferrous sulfate
145. Formaldehyde
146. Formic acid
147. Fumaric acid
148. Furfural
149. Guthion
150. Heptachlor
151. Hexachlorocyclopentadiene
152. Hydrochloric acid
153. Hydrofluoric acid
154. Hydrogen cyanide
155. Hydrogen sulfide
156. Isoprene
157. Isopropanolamine dodecylbenzenesulfonate
158. Kelthane
159. Kepone
160. Lead acetate
161. Lead arsenate
162. Lead chloride
163. Lead fluoborate
164. Lead flourite
165. Lead iodide
166. Lead nitrate
167. Lead stearate
168. Lead sulfate
169. Lead sulfide
170. Lead thiocyanate
171. Lindane
172. Lithium chromate
173. Malathion
174. Maleic acid
175. Maleic anhydride
176. Mercaptodimethur
177. Mercuric cyanide
178. Mercuric nitrate
179. Mercuric sulfate
180. Mercuric thiocyanate
181. Mercurous nitrate
182. Methoxychlor
183. Methyl mercaptan
184. Methyl methacrylate
185. Methyl parathion
186. Mevinphos
187. Mexacarbate
188. Monoethylamine
189. Monomethylamine
190. Naled
191. Naphthalene
192. Naphthenic acid
193. Nickel ammonium sulfate
194. Nickel chloride
195. Nickel hydroxide
196. Nickel nitrate
197. Nickel sulfate
198. Nitric acid
199. Nitrobenzene
200. Nitrogen dioxide
201. Nitrophenol
202. Nitrotoluene
203. Paraformaldehyde
204. Parathion
205. Pentachlorophenol
206. Phenol
207. Phosgene
208. Phosphoric acid
209. Phosphorus
210. Phosphorus oxychloride
211. Phosphorus pentasulfide
212. Phosphorus trichloride
213. Polychlorinated biphenyls (PCB)
214. Potassium arsenate
215. Potassium arsenite
216. Potassium bichromate

217. Potassium chromate
218. Potassium cyanide
219. Potassium hydroxide
220. Potassium permanganate
221. Propargite
222. Propionic acid
223. Propionic anhydride
224. Propylene oxide
225. Pyrethrins
226. Quinoline
227. Resorcinol
228. Selenium oxide
229. Silver nitrate
230. Sodium
231. Sodium arsenate
232. Sodium arsenite
233. Sodium bichromate
234. Sodium bifluoride
235. Sodium bisulfite
236. Sodium chromate
237. Sodium cyanide
238. Sodium dodecylbenzenesulfonate
239. Sodium fluoride
240. Sodium hydrosulfide
241. Sodium hydroxide
242. Sodium hypochlorite
243. Sodium methylate
244. Sodium nitrite
245. Sodium phosphate (dibasic)
246. Sodium phosphate (tribasic)
247. Sodium selenite
248. Strontium chromate
249. Strychnine
250. Styrene
251. Sulfuric acid
252. Sulfur monochloride
253. 2,4,5-T acid (2,4,5-Trichlorophenoxyacetic acid)
254. 2,4,5-T amines (2,4,5-Trichlorophenoxy acetic acid amines)
255. 2,4,5-T esters (2,4,5 Trichlorophenoxy acetic acid esters)
256. 2,4,5-T salts (2,4,5-Trichlorophenoxy acetic acid salts)
257. 2,4,5-TP acid (2,4,5-Trichlorophenoxy propanoic acid)
258. 2,4,5-TP acid esters (2,4,5-Trichlorophenoxy propanoic acid esters)
259. TDE (Tetrachlorodiphenyl ethane)
260. Tetraethyl lead
261. Tetraethyl pyrophosphate
262. Thallium sulfate
263. Toluene
264. Toxaphene
265. Trichlorofon
266. Trichloroethylene
267. Trichlorophenol
268. Triethanolamine dodecylbenzenesulfonate
269. Triethylamine
270. Trimethylamine
271. Uranyl acetate
272. Uranyl nitrate
273. Vanadium penoxide
274. Vanadyl sulfate
275. Vinyl acetate
276. Vinylidene chloride
277. Xylene
278. Xylenol
279. Zinc acetate
280. Zinc ammonium chloride
281. Zinc borate
282. Zinc bromide
283. Zinc carbonate
284. Zinc chloride
285. Zinc cyanide
286. Zinc fluoride
287. Zinc formate
288. Zinc hydrosulfite
289. Zinc nitrate
290. Zinc phenolsulfonate
291. Zinc phosphide
292. Zinc silicofluoride
293. Zinc sulfate
294. Zirconium nitrate
295. Zirconium potassium flouride
296. Zirconium sulfate
297. Zirconium tetrachloride

Table 2C-4 *(continued)*



Schematic of Water Flow
Brown Mills, Inc.
City, County, State

Please print or type in the unshaded areas only.

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)
MTD093301836

Form Approved.
OMB No. 2040-0086.
Approval expires 3-31-98.

FORM **2C** NPDES

EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY
APPLICATION FOR PERMIT TO DISCHARGE WASTEWATER
EXISTING MANUFACTURING, COMMERCIAL, MINING AND SILVICULTURE OPERATIONS
Consolidated Permits Program

I. OUTFALL LOCATION

For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

A. OUTFALL NUMBER (*list*)	B. LATITUDE			C. LONGITUDE			D. RECEIVING WATER (*name*)
	1. DEG.	2. MIN.	3. SEC.	1. DEG.	2. MIN.	3. SEC.	
Appendix A							

II. FLOWS, SOURCES OF POLLUTION, AND TREATMENT TECHNOLOGIES

A. Attach a line drawing showing the water flow through the facility. Indicate sources of intake water, operations contributing wastewater to the effluent, and treatment units labeled to correspond to the more detailed descriptions in Item B. Construct a water balance on the line drawing by showing average flows between intakes, operations, treatment units, and outfalls. If a water balance cannot be determined (e.g., *for certain mining activities*), provide a pictorial description of the nature and amount of any sources of water and any collection or treatment measures.

B. For each outfall, provide a description of: (1) All operations contributing wastewater to the effluent, including process wastewater, sanitary wastewater, cooling water, and storm water runoff; (2) The average flow contributed by each operation; and (3) The treatment received by the wastewater. Continue on additional sheets if necessary.

1. OUT-FALL NO. (*list*)	2. OPERATION(S) CONTRIBUTING FLOW		3. TREATMENT		
	a. OPERATION (*list*)	b. AVERAGE FLOW (*include units*)	a. DESCRIPTION	b. LIST CODES FROM TABLE 2C-1	
	See Appendix C				

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C. Except for storm runoff, leaks, or spills, are any of the discharges described in Items II-A or B intermittent or seasonal?

☐ YES (*complete the following table*) ☑ NO (*go to Section III*)

1. OUTFALL NUMBER (*list*)	2. OPERATION(s) CONTRIBUTING FLOW (*list*)	3. FREQUENCY a. DAYS PER WEEK (*specify average*)	3. FREQUENCY b. MONTHS PER YEAR (*specify average*)	4. FLOW a. FLOW RATE (*in mgd*) 1. LONG TERM AVERAGE	4. FLOW a. FLOW RATE (*in mgd*) 2. MAXIMUM DAILY	4. FLOW B. TOTAL VOLUME (*specify with units*) 1. LONG TERM AVERAGE	4. FLOW B. TOTAL VOLUME (*specify with units*) 2. MAXIMUM DAILY	4. FLOW C. DURATION (*in days*)

III. PRODUCTION

A. Does an effluent guideline limitation promulgated by EPA under Section 304 of the Clean Water Act apply to your facility?

☑ YES (*complete Item III-B*) ☐ NO (*go to Section IV*)

B. Are the limitations in the applicable effluent guideline expressed in terms of production (*or other measure of operation*)?

☐ YES (*complete Item III-C*) ☑ NO (*go to Section IV*)

C. If you answered "yes" to Item III-B, list the quantity which represents an actual measurement of your level of production, expressed in the terms and units used in the applicable effluent guideline, and indicate the affected outfalls.

1. AVERAGE DAILY PRODUCTION a. QUANTITY PER DAY	b. UNITS OF MEASURE	c. OPERATION, PRODUCT, MATERIAL, ETC. (*specify*)	2. AFFECTED OUTFALLS (*list outfall numbers*)

IV. IMPROVEMENTS

A. Are you now required by any Federal, State or local authority to meet any implementation schedule for the construction, upgrading or operations of wastewater treatment equipment or practices or any other environmental programs which may affect the discharges described in this application? This includes, but is not limited to, permit conditions, administrative or enforcement orders, enforcement compliance schedule letters, stipulations, court orders, and grant or loan conditions.

☐ YES (*complete the following table*) ☑ NO (*go to Item IV-B*)

1. IDENTIFICATION OF CONDITION, AGREEMENT, ETC.	2. AFFECTED OUTFALLS a. NO.	2. AFFECTED OUTFALLS b. SOURCE OF DISCHARGE	3. BRIEF DESCRIPTION OF PROJECT	4. FINAL COMPLIANCE DATE a. REQUIRED	4. FINAL COMPLIANCE DATE b. PROJECTED

B. OPTIONAL: You may attach additional sheets describing any additional water pollution control programs (*or other environmental projects which may affect your discharges*) you now have underway or which you plan. Indicate whether each program is now underway or planned, and indicate your actual or planned schedules for construction.

☐ MARK "X" IF DESCRIPTION OF ADDITIONAL CONTROL PROGRAMS IS ATTACHED

 CONTINUE ON PAGE 3

CONTINUED FROM PAGE 2	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)
	MTD093301836

V. INTAKE AND EFFLUENT CHARACTERISTICS

A, B, & C: See instructions before proceeding – Complete one set of tables for each outfall – Annotate the outfall number in the space provided.
NOTE: Tables V-A, V-B, and V-C are included on separate sheets numbered V-1 through V-9.

D. Use the space below to list any of the pollutants listed in Table 2c-3 of the instructions, which you know or have reason to believe is discharged or may be discharged from any outfall. For every pollutant you list, briefly describe the reasons you believe it to be present and report any analytical data in your possession.

1. POLLUTANT	2. SOURCE	1. POLLUTANT	2. SOURCE
See Appendix D			

VI. POTENTIAL DISCHARGES NOT COVERED BY ANALYSIS

Is any pollutant listed in Item V-C a substance or a component of a substance which you currently use or manufacture as an intermediate or final product or byproduct?

☐ YES (*list all such pollutants below*) ☑ NO (*go to Item VI-B*)

CONTINUED FROM THE FRONT

VII. BIOLOGICAL TOXICITY TESTING DATA

Do you have any knowledge or reason to believe that any biological test for acute or chronic toxicity has been made on any of your discharges or on a receiving water in relation to your discharge within the last 3 years?

☑ YES (*identify the test(s) and describe their purposes below*) ☐ NO (*go to Section VIII*)

Outfall 021 was subject to an acute whole effluent toxicity test collected 8/5/2014 becuase of the classification as a coal preparation area per 40 CFR 434.11. The report is attached as Appendix E.

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VIII. CONTRACT ANALYSIS INFORMATION

Were any of the analyses reported in Item V performed by a contract laboratory or consulting firm?

☑ YES (*list the name, address, and telephone number of, and pollutants analyzed by, each such laboratory or firm below*) ☐ NO (*go to Section IX*)

A. NAME	B. ADDRESS	C. TELEPHONE (*area code & no.*)	D. POLLUTANTS ANALYZED (*list*)
Energy Laboratories Inc.	1120 South 27th Street Billings, MT 59101	406-525-6325	pH, Conductivity, Total Suspended Solids, Total Dissolved Solids, Total Settleable Solids, Chloride, Sulfate, SAR, Nitrate+Nitrite, Aluminum (Dissolved), Calcium (Dissolved), Magnesium (Dissolved), Sodium (Dissolved), Boron (Tot Rec), Iron (Total), Selenium (Tot Rec), Arsenic (Tot Rec), Cadmium (Tot Rec), Copper (Tot Rec), Lead (Tot Rec), Mercury (Tot Rec), Silver (Tot Rec), Zinc (Tot Rec), Oil & Grease
Pace Analytical Services, Inc.	602 South 25th Street Billings, MT 59101	406-254-7226	pH, Conductivity, Total Suspended Solids, Total Dissolved Solids, Total Settleable Solids, Iron (Total), Sulfate, Boron (Tot Rec), Oil & Grease

IX. CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. NAME & OFFICIAL TITLE (*type or print*)	B. PHONE NO. (*area code & no.*)
Philip Kent Salitros - President and General Manager	(406) 748-5198
C. SIGNATURE	D. DATE SIGNED
[signature]	12/17/14

PLEASE PRINT OR TYPE IN THE UNSHADED AREAS ONLY. You may report some or all of this information on separate sheets (*use the same format*) instead of completing these pages.
SEE INSTRUCTIONS.

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)

V. INTAKE AND EFFLUENT CHARACTERISTICS *(continued from page 3 of Form 2-C)* [redacted] OUTFALL NO.

PART A –You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

1. POLLUTANT	2. EFFLUENT							3. UNITS (*specify if blank*)		4. INTAKE (*optional*)		
	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
a. Biochemical Oxygen Demand (*BOD*)	See											
b. Chemical Oxygen Demand (*COD*)	Appendix D											
c. Total Organic Carbon (*TOC*)												
d. Total Suspended Solids (*TSS*)												
e. Ammonia (*as N*)												
f. Flow	VALUE		VALUE		VALUE					VALUE		
g. Temperature (*winter*)	VALUE		VALUE		VALUE			°C		VALUE		
h. Temperature (*summer*)	VALUE		VALUE		VALUE			°C		VALUE		
i. pH	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM				STANDARD UNITS				

PART B – Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1. POLLUTANT AND CAS NO. (*if available*)	2. MARK "X"		3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. BELIEVED PRESENT	b. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
			(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
a. Bromide (24959-67-9)			See											
b. Chlorine, Total Residual			Appendix D											
c. Color														
d. Fecal Coliform														
e. Fluoride (16984-48-8)														
f. Nitrate-Nitrite (*as N*)														

ITEM V-B CONTINUED FROM FRONT

1. POLLUTANT AND CAS NO. (*if available*)	2. MARK "X"		3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. BELIEVED PRESENT	b. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
			(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
g. Nitrogen, Total Organic (*as N*)														
h. Oil and Grease														
i. Phosphorus (as P), Total (7723-14-0)														
j. Radioactivity														
(1) Alpha, Total														
(2) Beta, Total														
(3) Radium, Total														
(4) Radium 226, Total														
k. Sulfate (*as SO_4*) (14808-79-8)														
l. Sulfide (*as S*)														
m. Sulfite (*as SO_3*) (14265-45-3)														
n. Surfactants														
o. Aluminum, Total (7429-90-5)														
p. Barium, Total (7440-39-3)														
q. Boron, Total (7440-42-8)														
r. Cobalt, Total (7440-48-4)														
s. Iron, Total (7439-89-6)														
t. Magnesium, Total (7439-95-4)														
u. Molybdenum, Total (7439-98-7)														
v. Manganese, Total (7439-96-5)														
w. Tin, Total (7440-31-5)														
x. Titanium, Total (7440-32-6)														

CONTINUE ON PAGE V-3

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	OUTFALL NUMBER

CONTINUED FROM PAGE 3 OF FORM 2-C

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (*secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions*), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (*all 7 pages*) for each outfall. See instructions for additional details and requirements.

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)															
2M. Arsenic, Total (7440-38-2)															
3M. Beryllium, Total (7440-41-7)															
4M. Cadmium, Total (7440-43-9)															
5M. Chromium, Total (7440-47-3)															
6M. Copper, Total (7440-50-8)															
7M. Lead, Total (7439-92-1)															
8M. Mercury, Total (7439-97-6)															
9M. Nickel, Total (7440-02-0)															
10M. Selenium, Total (7782-49-2)															
11M. Silver, Total (7440-22-4)															
12M. Thallium, Total (7440-28-0)															
13M. Zinc, Total (7440-66-6)															
14M. Cyanide, Total (57-12-5)															
15M. Phenols, Total															
DIOXIN															
2,3,7,8-Tetra-chlorodibenzo-P-Dioxin (1764-01-6)				DESCRIBE RESULTS											

CONTINUE ON REVERSE

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1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – VOLATILE COMPOUNDS															
1V. Accrolein (107-02-8)															
2V. Acrylonitrile (107-13-1)															
3V. Benzene (71-43-2)															
4V. Bis (*Chloro-methyl*) Ether (542-88-1)															
5V. Bromoform (75-25-2)															
6V. Carbon Tetrachloride (56-23-5)															
7V. Chlorobenzene (108-90-7)															
8V. Chlorodi-bromomethane (124-48-1)															
9V. Chloroethane (75-00-3)															
10V. 2-Chloro-ethylvinyl Ether (110-75-8)															
11V. Chloroform (67-66-3)															
12V. Dichloro-bromomethane (75-27-4)															
13V. Dichloro-difluoromethane (75-71-8)															
14V. 1,1-Dichloro-ethane (75-34-3)															
15V. 1,2-Dichloro-ethane (107-06-2)															
16V. 1,1-Dichloro-ethylene (75-35-4)															
17V. 1,2-Dichloro-propane (78-87-5)															
18V. 1,3-Dichloro-propylene (542-75-6)															
19V. Ethylbenzene (100-41-4)															
20V. Methyl Bromide (74-83-9)															
21V. Methyl Chloride (74-87-3)															

CONTINUE ON PAGE V-5

CONTINUED FROM PAGE V-4

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – VOLATILE COMPOUNDS (*continued*)															
22V. Methylene Chloride (75-09-2)															
23V. 1,1,2,2-Tetrachloroethane (79-34-5)															
24V. Tetrachloro-ethylene (127-18-4)															
25V. Toluene (108-88-3)															
26V. 1,2-Trans-Dichloroethylene (156-60-5)															
27V. 1,1,1-Trichloro-ethane (71-55-6)															
28V. 1,1,2-Trichloro-ethane (79-00-5)															
29V Trichloro-ethylene (79-01-6)															
30V. Trichloro-fluoromethane (75-69-4)															
31V. Vinyl Chloride (75-01-4)															
GC/MS FRACTION – ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)															
2A. 2,4-Dichloro-phenol (120-83-2)															
3A. 2,4-Dimethyl-phenol (105-67-9)															
4A. 4,6-Dinitro-O-Cresol (534-52-1)															
5A. 2,4-Dinitro-phenol (51-28-5)															
6A. 2-Nitrophenol (88-75-5)															
7A. 4-Nitrophenol (100-02-7)															
8A. P-Chloro-M-Cresol (59-50-7)															
9A. Pentachloro-phenol (87-86-5)															
10A. Phenol (108-95-2)															
11A. 2,4,6-Trichloro-phenol (88-05-2)															

 CONTINUE ON REVERSE

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1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – BASE/NEUTRAL COMPOUNDS															
1B. Acenaphthene (83-32-9)															
2B. Acenaphtylene (208-96-8)															
3B. Anthracene (120-12-7)															
4B. Benzidine (92-87-5)															
5B. Benzo (*a*) Anthracene (56-55-3)															
6B. Benzo (*a*) Pyrene (50-32-8)															
7B. 3,4-Benzo-fluoranthene (205-99-2)															
8B. Benzo (*ghi*) Perylene (191-24-2)															
9B. Benzo (*k*) Fluoranthene (207-08-9)															
10B. Bis (*2-Chloro-ethoxy*) Methane (111-91-1)															
11B. Bis (*2-Chloro-ethyl*) Ether (111-44-4)															
12B. Bis (*2-Chloroisopropyl*) Ether (102-80-1)															
13B. Bis (*2-Ethyl-hexyl*) Phthalate (117-81-7)															
14B. 4-Bromophenyl Phenyl Ether (101-55-3)															
15B. Butyl Benzyl Phthalate (85-68-7)															
16B. 2-Chloro-naphthalene (91-58-7)															
17B. 4-Chloro-phenyl Phenyl Ether (7005-72-3)															
18B. Chrysene (218-01-9)															
19B. Dibenzo (*a,h*) Anthracene (53-70-3)															
20B. 1,2-Dichloro-benzene (95-50-1)															
21B. 1,3-Di-chloro-benzene (541-73-1)															

 CONTINUE ON PAGE V-7

CONTINUED FROM PAGE V-6

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – BASE/NEUTRAL COMPOUNDS (*continued*)															
22B. 1,4-Dichloro-benzene (106-46-7)															
23B. 3,3-Dichloro-benzidine (91-94-1)															
24B. Diethyl Phthalate (84-66-2)															
25B. Dimethyl Phthalate (131 -11-3)															
26B. Di-N-Butyl Phthalate (84-74-2)															
27B. 2,4-Dinitro-toluene (121-14-2)															
28B. 2,6-Dinitro-toluene (606-20-2)															
29B. Di-N-Octyl Phthalate (117-84-0)															
30B. 1,2-Diphenyl-hydrazine (*as Azo-benzene*) (122-66-7)															
31B. Fluoranthene (206-44-0)															
32B. Fluorene (86-73-7)															
33B. Hexachloro-benzene (118-74-1)															
34B. Hexachloro-butadiene (87-68-3)															
35B. Hexachloro-cyclopentadiene (77-47-4)															
36B Hexachloro-ethane (67-72-1)															
37B. Indeno (*1,2,3-cd*) Pyrene (193-39-5)															
38B. Isophorone (78-59-1)															
39B. Naphthalene (91-20-3)															
40B. Nitrobenzene (98-95-3)															
41B. N-Nitro-sodimethylamine (62-75-9)															
42B. N-Nitrosodi-N-Propylamine (621-64-7)															

 CONTINUE ON REVERSE

CONTINUED FROM THE FRONT

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – BASE/NEUTRAL COMPOUNDS (*continued*)															
43B. N-Nitro-sodiphenylamine (86-30-6)															
44B. Phenanthrene (85-01-8)															
45B. Pyrene (129-00-0)															
46B. 1,2,4-Tri-chlorobenzene (120-82-1)															
GC/MS FRACTION – PESTICIDES															
1P. Aldrin (309-00-2)															
2P. α-BHC (319-84-6)															
3P. β-BHC (319-85-7)															
4P. γ-BHC (58-89-9)															
5P. δ-BHC (319-86-8)															
6P. Chlordane (57-74-9)															
7P. 4,4'-DDT (50-29-3)															
8P. 4,4'-DDE (72-55-9)															
9P. 4,4'-DDD (72-54-8)															
10P. Dieldrin (60-57-1)															
11P. α-Enosulfan (115-29-7)															
12P. β-Endosulfan (115-29-7)															
13P. Endosulfan Sulfate (1031-07-8)															
14P. Endrin (72-20-8)															
15P. Endrin Aldehyde (7421-93-4)															
16P. Heptachlor (76-44-8)															

CONTINUE ON PAGE V-9

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	OUTFALL NUMBER

CONTINUED FROM PAGE V-8

1. POLLUTANT AND CAS NUMBER (*if available*)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (*optional*)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (*if available*)		c. LONG TERM AVRG. VALUE (*if available*)		d. NO. OF ANALYSES	a. CONCEN-TRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION – PESTICIDES (*continued*)															
17P. Heptachlor Epoxide (1024-57-3)															
18P. PCB-1242 (53469-21-9)															
19P. PCB-1254 (11097-69-1)															
20P. PCB-1221 (11104-28-2)															
21P. PCB-1232 (11141-16-5)															
22P. PCB-1248 (12672-29-6)															
23P. PCB-1260 (11096-82-5)															
24P. PCB-1016 (12674-11-2)															
25P. Toxaphene (8001-35-2)															

Appendix A

Outfall Location, Status, and Proposed Changes

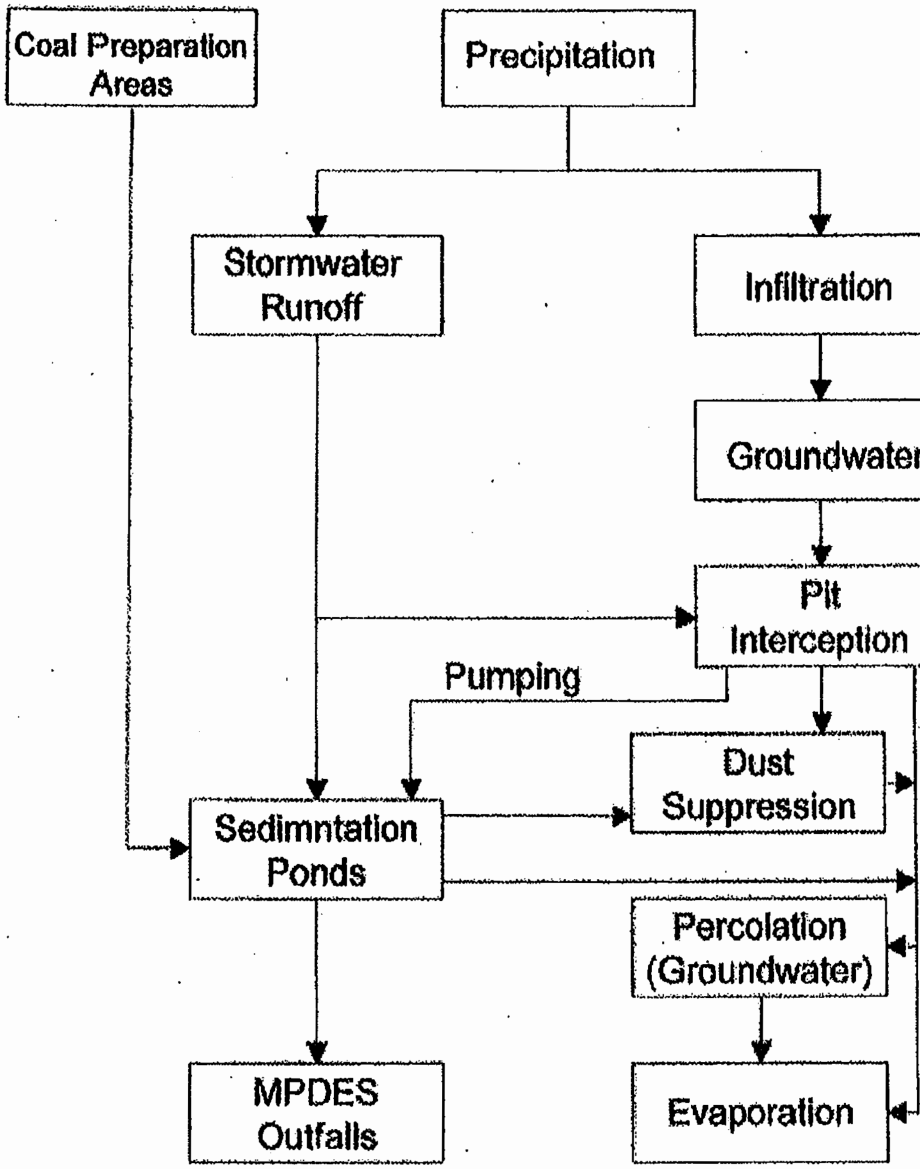
Outfall	Mine Area	Latitude	Longitude	Receiving Water	Current Status	Proposed Change	Comments
08D	A	45°55'07.54"N	106°35'25.86"W	East Fork Armells Creek	Active		
009	A	45°52'32.07"N	106°37'43.04"W	East Fork Armells Creek	Active		Per this modification WECO proposes that this Outfall flows into an intermittent portion of the receiving water
09A	A	45°52'20.24"N	106°37'54.51"W	East Fork Armells Creek	Active		Per this modification WECO proposes that this Outfall flows into an intermittent portion of the receiving water
13A	A	45°52'07.74"N	106°38'18.66"W	East Fork Armells Creek	Active		Per this modification WECO proposes that this Outfall flows into an intermittent portion of the receiving water
014	A	45°51'57.46"N	106°38'46.04"W	East Fork Armells Creek	Active		Per this modification WECO proposes that this Outfall flows into an intermittent portion of the receiving water
016	A	45°51'51.96"N	106°38'58.45"W	East Fork Armells Creek	Active		Per this modification WECO proposes that this Outfall flows into an intermittent portion of the receiving water
16A	A	45°51'41.63"N	106°39'26.47"W	East Fork Armells Creek	Active		Per this modification WECO proposes that this Outfall flows into an intermittent portion of the receiving water
023	A	45°51'38.54"N	106°40'22.36"W	East Fork Armells Creek	Active		
024	A	45°51'36.25"N	106°40'49.67"W	East Fork Armells Creek	Active		
069	A	45°52'52.27"N	106°42'08.78"W	Stocker Creek	Active		
070	A	45°53'06.14"N	106°41'57.75"W	Stocker Creek	Active		
071	A	45°53'21.63"N	106°41'15.25"W	Stocker Creek	Active		
71C	A	45°53'30.68"N	106°40'51.29"W	Stocker Creek	Active		
072	A	45°53'44.52"N	106°40'05.27"W	Stocker Creek	Active		
073	A	45°53'42.82"N	106°39'47.94"W	Stocker Creek	Western Alkaline		
73A	A	45°53'41.42"N	106°39'44.54"W	Stocker Creek	Western Alkaline		
074	A	45°53'40.81"N	106°39'28.20"W	Stocker Creek	Western Alkaline		
075	A	45°53'32.77"N	106°39'04.81"W	East Fork Armells Creek	Active		
10C	B-East	45°52'00.79"N	106°36'33.27"W	East Fork Armells Creek	Active	Remove	The current flow path of Outfall 10C runs to Outfall 010. Per this modification WECO proposes that Outfall 010 be active and Outfall 10C be removed altogether.
011	B-East	45°52'05.58"N	106°37'41.89"W	East Fork Armells Creek	Active		Per this modification WECO proposes that this Outfall flows into an intermittent portion of the receiving water
012	B-East	45°52'01.49"N	106°38'02.54"W	East Fork Armells Creek	Active		Per this modification WECO proposes that this Outfall flows into an intermittent portion of the receiving water
015	B-East	45°51'50.96"N	106°38'35.06"W	East Fork Armells Creek	Active		Per this modification WECO proposes that this Outfall flows into an intermittent portion of the receiving water
018	B-East	45°51'35.98"N	106°39'12.49"W	East Fork Armells Creek	Active		Per this modification WECO proposes that this Outfall flows into an intermittent portion of the receiving water
019	B-East	45°51'42.01"N	106°39'06.64"W	East Fork Armells Creek	Active		Per this modification WECO proposes that this Outfall flows into an intermittent portion of the receiving water
020	B-East	45°51'29.58"N	106°39'44.17"W	East Fork Armells Creek	Active		
021	B-East	45°51'30.22"N	106°39'54.40"W	East Fork Armells Creek	Active	Not a Coal Preparation Area	The drainage that contributes to this Outfall does not contain any activities contained in 40 CFR 434.11
022	B-East	45°51'30.98"N	106°39'56.35"W	East Fork Armells Creek	Active		
025	B-East	45°51'15.98"N	106°41'10.74"W	East Fork Armells Creek	Active		
026	B-West	45°51'07.26"N	106°41'36.91"W	East Fork Armells Creek	Active		
048	B-West	45°51'01.15"N	106°42'20.53"W	East Fork Armells Creek	Active		
056	B-West	45°50'42.13"N	106°44'04.97"W	East Fork Armells Creek	Active		
061	B-West	45°50'35.05"N	106°45'10.86"W	East Fork Armells Creek	Active		

Outfall	Mine Area	Latitude	Longitude	Receiving Water	Current Status	Proposed Change	Comments
127	B-West	45°50'38.66"N	106°46'49.00"W	East Fork Armells Creek	Active		
128	B-West	45°50'31.87"N	106°45'32.31"W	East Fork Armells Creek	Active		
128A	B-West	45°50'34.08"N	106°45'38.26"W	East Fork Armells Creek	Active		
128B	B-West	45°50'34.81"N	106°45'46.23"W	East Fork Armells Creek	Active		
128C	B-West	45°50'38.81"N	106°45'54.30"W	East Fork Armells Creek	Active		
128D	B-West	45°50'47.96"N	106°46'22.90"W	East Fork Armells Creek	Active		
129	B-West	45°50'38.45"N	106°44'26.24"W	East Fork Armells Creek	Active		
133	B-West	45°50'36.76"N	106°43'50.01"W	East Fork Armells Creek	Active		
136	B-West	45°50'38.29"N	106°43'31.85"W	East Fork Armells Creek	Active		
137	B-West	45°50'52.10"N	106°42'52.53"W	East Fork Armells Creek	Active		
139	B-West	45°50'59.84"N	106°42'07.16"W	East Fork Armells Creek	Active		
130	B-West	45°49'55.94"N	106°45'06.47"W	Lee Coulee	Active		
130A	B-West	45°49'55.93"N	106°44'31.72"W	Lee Coulee	Active		
130B	B-West	45°49'55.83"N	106°44'26.12"W	Lee Coulee	Active		
131	B-West	45°49'55.88"N	106°44'02.06"W	Lee Coulee	Active		
131A	B-West	45°49'55.95"N	106°43'54.32"W	Lee Coulee	Active		
132	B-West	45°49'56.11"N	106°43'42.38"W	Lee Coulee	Active		
134	B-West	45°49'56.10"N	106°43'05.84"W	Lee Coulee	Active		
030	C-East	45°52'36.96"N	106°46'06.14"W	Stocker Creek	Active		
032	C-East	45°52'19.00"N	106°45'47.23"W	Stocker Creek	Active		
033	C-East	45°52'31.74"N	106°45'14.89"W	Stocker Creek	Active		
034	C-East	45°52'31.68"N	106°45'08.32"W	Stocker Creek	Active		
035	C-East	45°52'20.96"N	106°44'06.26"W	Stocker Creek	Active		
036	C-East	45°52'30.83"N	106°43'26.38"W	Stocker Creek	Western Alkaline		
037	C-East	45°52'32.24"N	106°43'09.49"W	Stocker Creek	Western Alkaline		
038	C-East	45°52'31.49"N	106°42'51.82"W	Stocker Creek	Western Alkaline		
039	C-East	45°52'29.39"N	106°42'20.73"W	Stocker Creek	Western Alkaline		
040	C-East	45°52'25.06"N	106°42'12.23"W	Stocker Creek	Western Alkaline		
041	C-East	45°52'20.67"N	106°42'07.31"W	Stocker Creek	Western Alkaline		
042	C-East	45°51'53.75"N	106°41'30.62"W	East Fork Armells Creek	Western Alkaline		
043	C-East	45°51'24.42"N	106°41'24.81"W	East Fork Armells Creek	Active		
044	C-East	45°51'15.98"N	106°41'39.21"W	East Fork Armells Creek	Active		
046	C-East	45°51'26.75"N	106°42'11.71"W	East Fork Armells Creek	Active		
049	C-East	45°51'10.96"N	106°42'54.96"W	East Fork Armells Creek	Active		
051	C-East	45°51'06.15"N	106°43'17.06"W	East Fork Armells Creek	Active		
052	C-East	45°50'57.26"N	106°43'41.63"W	East Fork Armells Creek	Active		
054	C-East	45°50'52.05"N	106°43'47.21"W	East Fork Armells Creek	Active		
058	C-East	45°50'50.79"N	106°44'24.22"W	East Fork Armells Creek	Active		
059	C-East	45°50'48.65"N	106°44'47.60"W	East Fork Armells Creek	Active		
59A	C-East	45°50'40.95"N	106°45'16.11"W	East Fork Armells Creek	Active		
060	C-East	45°50'39.79"N	106°45'44.60"W	East Fork Armells Creek	Active		
063	C-East	45°50'46.26"N	106°46'05.19"W	East Fork Armells Creek	Active		
064	C-East	45°50'58.75"N	106°46'33.31"W	East Fork Armells Creek	Active		
116	C-North	45°53'35.82"N	106°46'34.19"W	Stocker Creek	Western Alkaline		
116A	C-North	45°53'31.76"N	106°46'19.29"W	Stocker Creek	Western Alkaline		
119	C-North	45°53'08.08"N	106°45'48.84"W	Stocker Creek	Western Alkaline		
121	C-North	45°52'44.18"N	106°46'08.98"W	Stocker Creek	Western Alkaline		
121A	C-North	45°52'53.13"N	106°46'02.02"W	Stocker Creek	Western Alkaline		

Outfall	Mine Area	Latitude	Longitude	Receiving Water	Current Status	Proposed Change	Comments
109	C-North	45°52'27.56"N	106°48'51.92"W	West Fork Armells Creek	Active		
112	C-North	45°53'23.54"N	106°48'15.03"W	West Fork Armells Creek	Western Alkaline		
112A	C-North	45°53'24.12"N	106°47'24.00"W	West Fork Armells Creek	Western Alkaline		
112B	C-North	45°53'30.74"N	106°47'08.03"W	West Fork Armells Creek	Western Alkaline		
113	C-North	45°53'25.58"N	106°47'30.84"W	West Fork Armells Creek	Western Alkaline		
028-2A	C-North	45°52'32.91"N	106°48'01.94"W	Stocker Creek		New Internal Western Alkaline Outfall	Please refer to Sediment Control Plan dated April 2011
028-1A	C-North	45°52'34.60"N	106°47'46.53"W	Stocker Creek		New Internal Western Alkaline Outfall	Please refer to Sediment Control Plan dated April 2011
028B	C-North	45°52'37.09"N	106°47'34.87"W	Stocker Creek		New Internal Western Alkaline Outfall	Please refer to Sediment Control Plan dated April 2011
028A	C-North	45°52'39.79"N	106°47'29.61"W	Stocker Creek		New Internal Western Alkaline Outfall	Please refer to Sediment Control Plan dated April 2011
113D	C-North	45°52'37.16"N	106°46'53.39"W	Stocker Creek		New Internal Western Alkaline Outfall	Please refer to Sediment Control Plan dated April 2011
120A	C-North	45°52'46.59"N	106°46'35.97"W	Stocker Creek		New Internal Western Alkaline Outfall	Please refer to Sediment Control Plan dated April 2011
096	C-West	45°53'16.74"N	106°52'30.57"W	Black Hank Creek	Active		
098	C-West	45°53'29.64"N	106°51'55.76"W	Donley Creek	Active		
095	C-West	45°53'13.99"N	106°51'30.80"W	West Fork Armells Creek	Active		
95A	C-West	45°53'20.03"N	106°51'35.24"W	West Fork Armells Creek	Active		
100	C-West	45°53'03.80"N	106°51'15.05"W	West Fork Armells Creek	Active		
101	C-West	45°52'55.77"N	106°50'57.26"W	West Fork Armells Creek	Active		
103	C-West	45°52'49.42"N	106°50'41.34"W	West Fork Armells Creek	Active		
104	C-West	45°52'45.78"N	106°50'30.14"W	West Fork Armells Creek	Active		
104A	C-West	45°52'41.11"N	106°47'39.94"W	West Fork Armells Creek	Active		
105	C-West	45°52'31.32"N	106°49'56.43"W	West Fork Armells Creek	Active		
106	C-West	45°52'33.21"N	106°49'42.00"W	West Fork Armells Creek	Active		
107	C-West	45°52'30.39"N	106°49'35.37"W	West Fork Armells Creek	Active		
108	C-West	45°52'33.16"N	106°49'26.97"W	West Fork Armells Creek	Active		
006	D	45°53'48.32"N	106°35'10.13"W	Cow Creek	Western Alkaline		
007	D	45°54'14.87"N	106°36'48.10"W	East Fork Armells Creek	Western Alkaline		
077	D	45°55'06.57"N	106°36'35.71"W	East Fork Armells Creek	Western Alkaline		
079	D	45°55'13.15"N	106°36'08.19"W	East Fork Armells Creek	Western Alkaline		
080	D	45°55'18.56"N	106°35'36.78"W	Spring Creek	Active		
082	D	45°55'21.56"N	106°35'07.92"W	Spring Creek	Western Alkaline		
083	D	45°55'17.69"N	106°34'51.79"W	Spring Creek	Western Alkaline		
090	D	45°53'52.24"N	106°34'00.13"W	Cow Creek	Western Alkaline		
091	D	45°53'50.76"N	106°34'25.62"W	Cow Creek	Western Alkaline		
092	D	45°53'50.38"N	106°34'37.70"W	Cow Creek	Western Alkaline		
093	D	45°53'28.95"N	106°35'05.66"W	Cow Creek	Western Alkaline		
141	D	45°54'53.18"N	106°36'51.03"W	East Fork Armells Creek	Western Alkaline		

Outfall	Mine Area	Latitude	Longitude	Receiving Water	Current Status	Proposed Change	Comments
142	D	45°54'41.31"N	106°36'42.86"W	East Fork Armells Creek	Western Alkaline		
143	D	45°54'32.92"N	106°36'46.36"W	East Fork Armells Creek	Western Alkaline		
144	D	45°54'02.64"N	106°36'45.56"W	East Fork Armells Creek	Western Alkaline		
151	D	45°52'56.29"N	106°35'31.64"W	Cow Creek	Western Alkaline		
152	D	45°52'51.68"N	106°35'20.68"W	Cow Creek	Western Alkaline		
153	D	45°53'07.09"N	106°35'22.24"W	Cow Creek	Western Alkaline		
154	D	45°53'13.55"N	106°35'13.54"W	Cow Creek	Western Alkaline		
155	D	45°53'23.19"N	106°35'11.24"W	Cow Creek	Western Alkaline		
194	D	45°53'04.86"N	106°36'28.22"W	East Fork Armells Creek	Active		
195	D	45°53'04.57"N	106°36'13.69"W	East Fork Armells Creek	Western Alkaline		
173	D-East	45°53'57.75"N	106°32'00.13"W	Cow Creek	Western Alkaline		
175	D-East	45°53'50.23"N	106°32'35.82"W	Cow Creek	Western Alkaline		
176	D-East	45°53'54.21"N	106°33'04.49"W	Cow Creek	Western Alkaline		
177	D-East	45°53'52.02"N	106°35'18.38"W	Cow Creek	Western Alkaline		
178	D-East	45°53'49.59"N	106°33'30.32"W	Cow Creek	Western Alkaline		
179	D-East	45°53'50.86"N	106°33'52.65"W	Cow Creek	Western Alkaline		
165	D-East	45°54'44.68"N	106°32'59.42"W	Pony Creek	Western Alkaline		
166	D-East	45°54'44.69"N	106°33'04.25"W	Pony Creek	Western Alkaline		
167	D-East	45°54'44.90"N	106°33'08.88"W	Pony Creek	Western Alkaline		
168	D-East	45°54'44.71"N	106°33'19.72"W	Pony Creek	Western Alkaline		
169	D-East	45°54'36.85"N	106°33'25.23"W	Pony Creek	Western Alkaline		
169A	D-East	45°54'30.32"N	106°33'24.93"W	Pony Creek	Western Alkaline		
170	D-East	45°54'19.05"N	106°33'06.14"W	Pony Creek	Western Alkaline		
171	D-East	45°54'14.03"N	106°32'58.49"W	Pony Creek	Western Alkaline		
172	D-East	45°54'14.93"N	106°32'38.96"W	Pony Creek	Western Alkaline		
084	D-East	45°55'06.41"N	106°34'20.86"W	Spring Creek	Western Alkaline		
085	D-East	45°55'02.18"N	106°34'11.91"W	Spring Creek	Western Alkaline		
086	D-East	45°55'07.26"N	106°34'00.12"W	Spring Creek	Western Alkaline		
160A	D-East	45°55'07.65"N	106°33'42.39"W	Spring Creek	Western Alkaline		
160B	D-East	45°55'07.50"N	106°33'48.45"W	Spring Creek	Western Alkaline		
161	D-East	45°55'07.08"N	106°33'29.29"W	Spring Creek	Western Alkaline		
161A	D-East	45°55'07.62"N	106°33'34.39"W	Spring Creek	Western Alkaline		
162	D-East	45°55'07.73"N	106°33'25.15"W	Spring Creek	Western Alkaline		
163	D-East	45°55'07.04"N	106°33'01.10"W	Spring Creek	Western Alkaline		
164	D-East	45°55'02.77"N	106°32'56.35"W	Spring Creek	Western Alkaline		
010	E	45°52'12.48"N	106°37'05.52"W	East Fork Armells Creek	Western Alkaline	Active	The current flow path of Outfall 10C runs to Outfall 010. Per this modification WECO proposes that Outfall 010 be active and Outfall 10C be removed altogether.
10A	E	45°52'30.01"N	106°36'42.14"W	East Fork Armells Creek	Active		
003	E	45°51'20.85"N	106°34'00.17"W	Cow Creek	Western Alkaline		
004	E	45°52'10.22"N	106°34'54.76"W	Cow Creek	Western Alkaline		
005	E	45°52'35.11"N	106°35'24.77"W	Cow Creek	Western Alkaline		
027	E	45°51'56.32"N	106°34'28.47"W	Cow Creek	Western Alkaline		

Appendix B



Coal Preparation Areas
Precipitation
Stormwater Runoff
Infiltration
Groundwater
Pit Interception
Pumping
Dust Suppression
Sedimntation Ponds
Percolation (Groundwater)
MPDES Outfalls
Evaporation

Appendix C

II. Flows, Sources of Pollution, and Treatment Technologies

EPA I.D. Number: MTD093301836

Outfall	Operation Contributing Flow		Treatment	
	Operation	Average Flow	Description	List Codes From Table 2C-1
08D	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
009	Precipitation Event Runoff, Mine Pit Dewatering, Coal Preparation Area	Varies	Sedimentation Pond	1-U
09A	Precipitation Event Runoff, Mine Pit Dewatering, Coal Preparation Area	Varies	Sedimentation Pond	1-U
13A	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
014	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
016	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
16A	Precipitation Event Runoff, Mine Pit Dewatering, Coal Preparation Area	Varies	Sedimentation Pond	1-U
023	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
024	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
069	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
070	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
071	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
71C	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
072	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
073	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
73A	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
074	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
075	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
011	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
012	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
015	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
018	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
019	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
020	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
021	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
022	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
025	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
026	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
048	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
056	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
061	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
127	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
128	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
128A	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
128B	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
128C	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
128D	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
129	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
133	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
136	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U

EPA I.D. Number: MTD093301836

Outfall	Operation Contributing Flow		Treatment	
	Operation	Average Flow	Description	List Codes From Table 2C-1
137	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
139	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
130	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
130A	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
130B	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
131	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
131A	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
132	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
134	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
030	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
032	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
033	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
034	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
035	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
036	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
037	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
038	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
039	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
040	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
041	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
042	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
043	Precipitation Event Runoff, Mine Pit Dewatering, Coal Preparation Area	Varies	Sedimentation Pond	1-U
044	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
046	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
049	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
051	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
052	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
054	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
058	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
059	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
59A	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
060	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
063	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
064	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
116	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
116A	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
119	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
121	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
121A	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
109	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
112	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U

EPA I.D. Number: MTD093301836

Outfall	Operation Contributing Flow		Treatment	
	Operation	Average Flow	Description	List Codes From Table 2C-1
112A	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
112B	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
113	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
028-2A	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
028-1A	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
028B	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
028A	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
113D	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
120A	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
096	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
098	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
095	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
95A	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
100	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
101	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
103	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
104	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
104A	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
105	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
106	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
107	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
108	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
006	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
007	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
077	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
079	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
080	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
082	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
083	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
090	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
091	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
092	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
093	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
141	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
142	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
143	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
144	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
151	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
152	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
153	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
154	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U

EPA I.D. Number: MTD093301836

Outfall	Operation Contributing Flow		Treatment	
	Operation	Average Flow	Description	List Codes From Table 2C-1
155	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
194	Precipitation Event Runoff, Mine Pit Dewatering, Coal Preparation Area	Varies	Sedimentation Pond	1-U
195	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
173	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
175	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
176	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
177	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
178	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
179	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
165	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
166	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
167	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
168	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
169	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
169A	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
170	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
171	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
172	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
084	Precipitation Event Runoff	Varies	Sedimentation Pond	1-U
085	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
086	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
160A	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
160B	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
161	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
161A	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
162	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
163	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
164	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
010	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
10A	Precipitation Event Runoff, Mine Pit Dewatering	Varies	Sedimentation Pond	1-U
003	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
004	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
005	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U
027	Precipitation Event Runoff	Varies	BMP Per Sediment Cotrol Plan*	1-U

* These outfalls were previously permitted as Western Alkaline Outfalls and therefore only require Best Management Practice (BMP's) for precipitation based runoff events. These BMP's are contained in each outfall's respective Sediment Control Plan (Please refer to Sediment Control Plans dated April 2011-previously submitted to Montana DEQ, March 2012-previously submitted to Montana DEQ, and February 2013-previously submitted to Montana DEQ)

Appendix D

EPA I.D. Number: **MTD093301836**

Outfall No.: **046**

Part A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall.												
	2.Effluent							3.Units		4.Intake (optional)		
	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses			a.Long Term Average Value		b.No. of Analyses
1.Pollutant	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass		a.Concentration	b.Mass	(1)Concentration	(2)Mass	
a.Biochemical Oxygen Demand (BOD)												
b.Chemical Oxygen Demand (COD)												
c.Total Organic Carbon (TOC)												
d.Total Suspended Solids (TSS)	35	35			1.7	1.7	50	mg/L	kg			
e.Ammonia (as N)												
f.Flow	**1053588 gal/day											
g.Temperature (winter)									°C			
h.Temperature (summer)									°C			
i.pH	Minimum 7.4	Maximum 8.95	N/A	N/A			50	Standard Units				

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

** Flow is gal/day that this outfall was discharging. Episodic and non-uniform flow is a result of dewatering need.

EPA I.D. Number: **MTD093301836**

Outfall No.: **046**

PART B – Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Bromide (24959-67-9)		X												
b.Chlorine, Total Residual		X												
c.Color		X												
d.Fecal Coliform		X												
e.Fluoride (16984-48-8)		X												
Nitrate-Nitrate (as N)	X		0.25	0.25	N/A	N/A	0.14	0.14	4	mg/L	kg			
g.Nitrogen, Total Organic (as N)		X												
h.Oil and Grease	X		3	3	N/A	N/A	0.5	0.5	10	mg/L	kg			
i.Phosphorus (as P), Total (7723-14-0)		X												
j.Radioactivity		X												
(1)Alpha, Total		X												
(2)Beta, Total		X												
(3)Radium, Total		X												
(4)Radium 226, Total		X												
k.Sulfate (as SO_4) (14808-79-8)	X		1080	1080	N/A	N/A	779	779	4	mg/L	kg			
l.Sulfide (as S)		X												
m.Sulfite (as SO_3) (14265-45-3)		X												
n.Surfactants		X												
o.Aluminum, Total (7429-90-5)	X		0.06	0.06	N/A	N/A	0.03	0.03	4	mg/L	kg			
p.Barium, Total (7440-39-3)		X												
q.Boron, Total (7440-42-8)	X		0.27	0.27	N/A	N/A	0.19	0.19	4	mg/L	kg			

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
r.Cobalt, Total (7440-48-4)		X												
s.Iron, Total (7439-89-6)	X		1.41	1.41	N/A	N/A	0.21	0.21	10	mg/L	kg			
t.Magnesium, Total (7439-95-4)	X		165	165	N/A	N/A	115	115	4	mg/L	kg			
u.Molybdenum, Total (7439-98-7)		X												
v.Manganese, Total (7439-96-5)		X												
w.Tin, Total (7440-31-5)		X												
x.Titanium, Total (7440-32-6)		X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **046**

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (all 7 pages) for each outfall. See instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)			X												
2M. Arsenic, Total (7440-38-2)		X		0.003	0.003	N/A	N/A	0.0018	0.0018	4	mg/L	kg			
3M. Beryllium, Total (7440-41-7)			X												
4M. Cadmium, Total (7440-43-9)		X		0.00003	3E-05	N/A	N/A	0	0	4	mg/L	kg			
5M. Chromium, Total (7440-47-3)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	4	mg/L	kg			
6M. Copper, Total (7440-50-8)		X		0.004	0.004	N/A	N/A	0.001	0.001	4	mg/L	kg			
7M. Lead, Total (7439-92-1)		X		0.0012	0.0012	N/A	N/A	0.0003	0.0003	4	mg/L	kg			
8M. Mercury, Total (7439-97-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	4	mg/L	kg			
9M. Nickel, Total (7440-02-0)		X		0.003	0.003	N/A	N/A	0.0008	0.0008	4	mg/L	kg			
10M. Selenium, Total (7782-49-2)		X		0.002	0.002	N/A	N/A	0.001	0.001	4	mg/L	kg			
11M. Silver, Total (7440-22-4)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	4	mg/L	kg			
12M. Thallium, Total (7440-28-0)			X												
13M. Zinc, Total (7440-66-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	4	mg/L	kg			
14M. Cyanide, Total (57-12-5)			X												
15M. Phenols, Total			X												
DIOXIN															
2,3,7,8-Tetrachlorodibenzo-P-Dioxin (1764-01-6)			X												
GC/MS FRACTION – VOLATILE COMPOUNDS															
1V. Accrolein (107-02-8)			X												
2V. Acrylonitrile (107-13-1)			X												
3V. Benzene (71-43-2)			X												
4V. Bis (*Chloromethyl*) Ether (542-88-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
5V. Bromoform (75-25-2)			X												
6V. Carbon Tetrachloride (56-23-5)			X												
7V. Chlorobenzene (108-90-7)			X												
8V. Chlorodibromomethane (124-48-1)			X												
9V. Chloroethane (75-00-3)			X												
10V. 2-Chloroethylvinyl Ether (110-75-8)			X												
11V. Chloroform (67-66-3)			X												
12V. Dichlorobromomethane (75-27-4)			X												
13V. Dichlorodifluoromethane (75-71-8)			X												
14V. 1,1-Dichloroethane (75-34-3)			X												
15V. 1,2-Dichloroethane (107-06-2)			X												
16V. 1,1-Dichloroethylene (75-35-4)			X												
17V. 1,2-Dichloropropane (78-87-5)			X												
18V. 1,3-Dichloropropylene (542-75-6)			X												
19V. Ethylbenzene (100-41-4)			X												
20V. Methyl Bromide (74-83-9)			X												
21V. Methyl Chloride (74-87-3)			X												
22V. Methylene Chloride (75-09-2)			X												
23V. 1,1,2,2-Tetrachloroethane (79-34-5)			X												
24V. Tetrachloroethylene (127-18-4)			X												
25V. Toluene (108-88-3)			X												
26V. 1,2-Trans-Dichloroethylene (156-60-5)			X												
27V. 1,1,1-Trichloroethane (71-55-6)			X												
28V. 1,1,2-Trichloroethane (79-00-5)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
29V Trichloroethylene (79-01-6)			X												
30V. Trichlorofluoromethane (75-69-4)			X												
31V. Vinyl Chloride (75-01-4)			X												
GC/MS FRACTION – ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)			X												
2A. 2,4-Dichlorophenol (120-83-2)			X												
3A. 2,4-Dimethylphenol (105-67-9)			X												
4A. 4,6-Dinitro-OCresol (534-52-1)			X												
5A. 2,4-Dinitrophenol (51-28-5)			X												
6A. 2-Nitrophenol (88-75-5)			X												
7A. 4-Nitrophenol (100-02-7)			X												
8A. P-Chloro-MCresol (59-50-7)			X												
9A. Pentachlorophenol (87-86-5)			X												
10A. Phenol (108-95-2)			X												
11A. 2,4,6-Trichlorophenol (88-05-2)			X												
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (*a*) Anthracene (56-55-3)			X												
6B. Benzo (*a*) Pyrene (50-32-8)			X												
7B. 3,4-Benzofluoranthene (205-99-2)			X												
8B. Benzo (*ghi*) Perylene (191-24-2)			X												
9B. Benzo (*k*) Fluoranthene (207-08-9)			X												
10B. Bis (*2-Chloroethoxy*) Methane (111-91-1)			X												
11B. Bis (*2-Chloroethyl*) Ether (111-44-4)			X												
12B. Bis (*2-Chloroisopropyl*) Ether (102-80-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
13B. Bis (*2-Ethylhexyl*) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloronaphthalene (91-58-7)			X												
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (*a,h*) Anthracene (53-70-3)			X												
20B. 1,2-Dichlorobenzene (95-50-1)			X												
21B. 1,3-Di-chlorobenzene (541-73-1)			X												
22B. 1,4-Dichlorobenzene (106-46-7)			X												
23B. 3,3-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131 -11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B.1,2-Diphenylhydrazine (*as Azobenzene*) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno (*1,2,3-cd*) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi- N-Propylamine (621-64-7)			X												
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
45B. Pyrene (129-00-0)			X												
46B. 1,2,4-Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION – PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Enosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												
17P. Heptachlor Epoxide (1024-57-3)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **052**

Part A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall.

1.Pollutant	2.Effluent							3.Units		4.Intake (optional)		
	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Biochemical Oxygen Demand (BOD)												
b.Chemical Oxygen Demand (COD)												
c.Total Organic Carbon (TOC)												
d.Total Suspended Solids (TSS)	38	38			9.2	9.2	25	mg/L	kg			
e.Ammonia (as N)												
f.Flow	**2183040 gal/day											
g.Temperature (winter)									°C			
h.Temperature (summer)									°C			
i.pH	Minimum 7.15	Maximum 8.49	N/A	N/A			25	Standard Units				

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

** Flow is gal/day that this outfall was discharging. Episodic and non-uniform flow is a result of dewatering need.

EPA I.D. Number: **MTD093301836**

Outfall No.: **052**

PART B – Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Bromide (24959-67-9)		X												
b.Chlorine, Total Residual		X												
c.Color		X												
d.Fecal Coliform		X												
e.Fluoride (16984-48-8)		X												
Nitrate-Nitrate (as N)	X		0.4	0.4	N/A	N/A	0.27	0.27	3	mg/L	kg			
g.Nitrogen, Total Organic (as N)		X												
h.Oil and Grease	X		*<1	*<1	N/A	N/A	*<1	*<1	9	mg/L	kg			
i.Phosphorus (as P), Total (7723-14-0)		X												
j.Radioactivity		X												
(1)Alpha, Total		X												
(2)Beta, Total		X												
(3)Radium, Total		X												
(4)Radium 226, Total		X												
k.Sulfate (as SO_4) (14808-79-8)	X		1700	1700	N/A	N/A	1185	1185	3	mg/L	kg			
l.Sulfide (as S)		X												
m.Sulfite (as SO_3) (14265-45-3)		X												
n.Surfactants		X												
o.Aluminum, Total (7429-90-5)	X		0.1	0.1	N/A	N/A	0.04	0.04	3	mg/L	kg			
p.Barium, Total (7440-39-3)		X												
q.Boron, Total (7440-42-8)	X		0.54	0.54	N/A	N/A	0.3	0.3	3	mg/L	kg			

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
r.Cobalt, Total (7440-48-4)		X												
s.Iron, Total (7439-89-6)	X		0.28	0.28	N/A	N/A	0.15	0.15	9	mg/L	kg			
t.Magnesium, Total (7439-95-4)	X		205	205	N/A	N/A	141.3	141.3	3	mg/L	kg			
u.Molybdenum, Total (7439-98-7)		X												
v.Manganese, Total (7439-96-5)		X												
w.Tin, Total (7440-31-5)		X												
x.Titanium, Total (7440-32-6)		X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **052**

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (all 7 pages) for each outfall. See instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)			X												
2M. Arsenic, Total (7440-38-2)		X		0.002	0.002	N/A	N/A	0.0007	0.0007	3	mg/L	kg			
3M. Beryllium, Total (7440-41-7)			X												
4M. Cadmium, Total (7440-43-9)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	3	mg/L	kg			
5M. Chromium, Total (7440-47-3)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	3	mg/L	kg			
6M. Copper, Total (7440-50-8)		X		0.007	0.007	N/A	N/A	0.0023	0.0023	3	mg/L	kg			
7M. Lead, Total (7439-92-1)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	3	mg/L	kg			
8M. Mercury, Total (7439-97-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	3	mg/L	kg			
9M. Nickel, Total (7440-02-0)		X		0.008	0.008	N/A	N/A	0.0027	0.0027	3	mg/L	kg			
10M. Selenium, Total (7782-49-2)		X		0.005	0.005	N/A	N/A	0.0027	0.0027	3	mg/L	kg			
11M. Silver, Total (7440-22-4)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	3	mg/L	kg			
12M. Thallium, Total (7440-28-0)			X												
13M. Zinc, Total (7440-66-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	3	mg/L	kg			
14M. Cyanide, Total (57-12-5)			X												
15M. Phenols, Total			X												
DIOXIN															
2,3,7,8-Tetrachlorodibenzo-P-Dioxin (1764-01-6)			X												
GC/MS FRACTION – VOLATILE COMPOUNDS															
1V. Accrolein (107-02-8)			X												
2V. Acrylonitrile (107-13-1)			X												
3V. Benzene (71-43-2)			X												
4V. Bis (*Chloromethyl*) Ether (542-88-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X" a.Testing Required	2.Mark "X" a.Believed Present	2.Mark "X" b.Believed Absent	3.Effluent a.Maximum Daily Value (1)Concentration	3.Effluent a.Maximum Daily Value (2)Mass	3.Effluent b.Maximum 30 Day Value (1)Concentration	3.Effluent b.Maximum 30 Day Value (2)Mass	3.Effluent c.Long Term Avrg. Value (1)Concentration	3.Effluent c.Long Term Avrg. Value (2)Mass	3.Effluent d.No. of Analyses	4.Units a.Concentration	4.Units b.Mass	5.Intake (optional) a.Long Term Average Value (1)Concentration	5.Intake (optional) a.Long Term Average Value (2)Mass	5.Intake (optional) b.No. of Analyses
5V. Bromoform (75-25-2)			X												
6V. Carbon Tetrachloride (56-23-5)			X												
7V. Chlorobenzene (108-90-7)			X												
8V. Chlorodibromomethane (124-48-1)			X												
9V. Chloroethane (75-00-3)			X												
10V. 2-Chloroethylvinyl Ether (110-75-8)			X												
11V. Chloroform (67-66-3)			X												
12V. Dichlorobromomethane (75-27-4)			X												
13V. Dichlorodifluoromethane (75-71-8)			X												
14V. 1,1-Dichloroethane (75-34-3)			X												
15V. 1,2-Dichloroethane (107-06-2)			X												
16V. 1,1-Dichloroethylene (75-35-4)			X												
17V. 1,2-Dichloropropane (78-87-5)			X												
18V. 1,3-Dichloropropylene (542-75-6)			X												
19V. Ethylbenzene (100-41-4)			X												
20V. Methyl Bromide (74-83-9)			X												
21V. Methyl Chloride (74-87-3)			X												
22V. Methylene Chloride (75-09-2)			X												
23V. 1,1,2,2-Tetrachloroethane (79-34-5)			X												
24V. Tetrachloroethylene (127-18-4)			X												
25V. Toluene (108-88-3)			X												
26V. 1,2-Trans-Dichloroethylene (156-60-5)			X												
27V. 1,1,1-Trichloroethane (71-55-6)			X												
28V. 1,1,2-Trichloroethane (79-00-5)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
29V Trichloroethylene (79-01-6)			X												
30V. Trichlorofluoromethane (75-69-4)			X												
31V. Vinyl Chloride (75-01-4)			X												
GC/MS FRACTION – ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)			X												
2A. 2,4-Dichlorophenol (120-83-2)			X												
3A. 2,4-Dimethylphenol (105-67-9)			X												
4A. 4,6-Dinitro-OCresol (534-52-1)			X												
5A. 2,4-Dinitrophenol (51-28-5)			X												
6A. 2-Nitrophenol (88-75-5)			X												
7A. 4-Nitrophenol (100-02-7)			X												
8A. P-Chloro-MCresol (59-50-7)			X												
9A. Pentachlorophenol (87-86-5)			X												
10A. Phenol (108-95-2)			X												
11A. 2,4,6-Trichlorophenol (88-05-2)			X												
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (*a*) Anthracene (56-55-3)			X												
6B. Benzo (*a*) Pyrene (50-32-8)			X												
7B. 3,4-Benzofluoranthene (205-99-2)			X												
8B. Benzo (*ghi*) Perylene (191-24-2)			X												
9B. Benzo (*k*) Fluoranthene (207-08-9)			X												
10B. Bis (*2-Chloroethoxy*) Methane (111-91-1)			X												
11B. Bis (*2-Chloroethyl*) Ether (111-44-4)			X												
12B. Bis (*2-Chloroisopropyl*) Ether (102-80-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
13B. Bis (*2-Ethylhexyl*) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloronaphthalene (91-58-7)			X												
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (*a,h*) Anthracene (53-70-3)			X												
20B. 1,2-Dichlorobenzene (95-50-1)			X												
21B. 1,3-Di-chlorobenzene (541-73-1)			X												
22B. 1,4-Dichlorobenzene (106-46-7)			X												
23B. 3,3-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131 -11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B.1,2-Diphenylhydrazine (*as Azobenzene*) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno (*1,2,3-cd*) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi- N-Propylamine (621-64-7)			X												
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
45B. Pyrene (129-00-0)			X												
46B. 1,2,4-Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION – PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Enosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												
17P. Heptachlor Epoxide (1024-57-3)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **101**

Part A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall.												
	2.Effluent							3.Units		4.Intake (optional)		
	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
1.Pollutant	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Biochemical Oxygen Demand (BOD)												
b.Chemical Oxygen Demand (COD)												
c.Total Organic Carbon (TOC)												
d.Total Suspended Solids (TSS)	27	27			9.7	9.7	12	mg/L	kg			
e.Ammonia (as N)												
f.Flow	**1244160 gal/day											
g.Temperature (winter)									°C			
h.Temperature (summer)									°C			
i.pH	Minimum 7.35	Maximum 8.44	N/A	N/A			12	Standard Units				

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

** Flow is gal/day that this outfall was discharging. Episodic and non-uniform flow is a result of dewatering need.

EPA I.D. Number: **MTD093301836**

Outfall No.: **101**

PART B – Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Bromide (24959-67-9)		X												
b.Chlorine, Total Residual		X												
c.Color		X												
d.Fecal Coliform		X												
e.Fluoride (16984-48-8)		X												
Nitrate-Nitrate (as N)	X		0.8	0.8	N/A	N/A	0.8	0.8	1	mg/L	kg			
g.Nitrogen, Total Organic (as N)		X												
h.Oil and Grease	X		*<1	*<1	N/A	N/A	*<1	*<1	3	mg/L	kg			
i.Phosphorus (as P), Total (7723-14-0)		X												
j.Radioactivity		X												
(1)Alpha, Total		X												
(2)Beta, Total		X												
(3)Radium, Total		X												
(4)Radium 226, Total		X												
k.Sulfate (as SO_4) (14808-79-8)	X		930	930	N/A	N/A	930	930	1	mg/L	kg			
l.Sulfide (as S)		X												
m.Sulfite (as SO_3) (14265-45-3)		X												
n.Surfactants		X												
o.Aluminum, Total (7429-90-5)	X		*<0.03	*<0.03	N/A	N/A	*<0.03	*<0.03	1	mg/L	kg			
p.Barium, Total (7440-39-3)		X												
q.Boron, Total (7440-42-8)	X		0.22	0.22	N/A	N/A	0.22	0.22	1	mg/L	kg			

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
r.Cobalt, Total (7440-48-4)		X												
s.Iron, Total (7439-89-6)	X		0.46	0.46	N/A	N/A	0.23	0.23	3	mg/L	kg			
t.Magnesium, Total (7439-95-4)	X		110	110	N/A	N/A	110	110	1	mg/L	kg			
u.Molybdenum, Total (7439-98-7)		X												
v.Manganese, Total (7439-96-5)		X												
w.Tin, Total (7440-31-5)		X												
x.Titanium, Total (7440-32-6)		X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **101**

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (all 7 pages) for each outfall. See instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)			X												
2M. Arsenic, Total (7440-38-2)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
3M. Beryllium, Total (7440-41-7)			X												
4M. Cadmium, Total (7440-43-9)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
5M. Chromium, Total (7440-47-3)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
6M. Copper, Total (7440-50-8)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
7M. Lead, Total (7439-92-1)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
8M. Mercury, Total (7439-97-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
9M. Nickel, Total (7440-02-0)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
10M. Selenium, Total (7782-49-2)		X		0.004	0.004	N/A	N/A	0.004	0.004	1	mg/L	kg			
11M. Silver, Total (7440-22-4)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
12M. Thallium, Total (7440-28-0)			X												
13M. Zinc, Total (7440-66-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
14M. Cyanide, Total (57-12-5)			X												
15M. Phenols, Total			X												
DIOXIN															
2,3,7,8-Tetrachlorodibenzo-P-Dioxin (1764-01-6)			X												
GC/MS FRACTION – VOLATILE COMPOUNDS															
1V. Accrolein (107-02-8)			X												
2V. Acrylonitrile (107-13-1)			X												
3V. Benzene (71-43-2)			X												
4V. Bis (*Chloromethyl*) Ether (542-88-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
5V. Bromoform (75-25-2)			X												
6V. Carbon Tetrachloride (56-23-5)			X												
7V. Chlorobenzene (108-90-7)			X												
8V. Chlorodibromomethane (124-48-1)			X												
9V. Chloroethane (75-00-3)			X												
10V. 2-Chloroethylvinyl Ether (110-75-8)			X												
11V. Chloroform (67-66-3)			X												
12V. Dichlorobromomethane (75-27-4)			X												
13V. Dichlorodifluoromethane (75-71-8)			X												
14V. 1,1-Dichloroethane (75-34-3)			X												
15V. 1,2-Dichloroethane (107-06-2)			X												
16V. 1,1-Dichloroethylene (75-35-4)			X												
17V. 1,2-Dichloropropane (78-87-5)			X												
18V. 1,3-Dichloropropylene (542-75-6)			X												
19V. Ethylbenzene (100-41-4)			X												
20V. Methyl Bromide (74-83-9)			X												
21V. Methyl Chloride (74-87-3)			X												
22V. Methylene Chloride (75-09-2)			X												
23V. 1,1,2,2-Tetrachloroethane (79-34-5)			X												
24V. Tetrachloroethylene (127-18-4)			X												
25V. Toluene (108-88-3)			X												
26V. 1,2-Trans-Dichloroethylene (156-60-5)			X												
27V. 1,1,1-Trichloroethane (71-55-6)			X												
28V. 1,1,2-Trichloroethane (79-00-5)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
29V Trichloroethylene (79-01-6)			X												
30V. Trichlorofluoromethane (75-69-4)			X												
31V. Vinyl Chloride (75-01-4)			X												
GC/MS FRACTION – ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)			X												
2A. 2,4-Dichlorophenol (120-83-2)			X												
3A. 2,4-Dimethylphenol (105-67-9)			X												
4A. 4,6-Dinitro-OCresol (534-52-1)			X												
5A. 2,4-Dinitrophenol (51-28-5)			X												
6A. 2-Nitrophenol (88-75-5)			X												
7A. 4-Nitrophenol (100-02-7)			X												
8A. P-Chloro-MCresol (59-50-7)			X												
9A. Pentachlorophenol (87-86-5)			X												
10A. Phenol (108-95-2)			X												
11A. 2,4,6-Trichlorophenol (88-05-2)			X												
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (*a*) Anthracene (56-55-3)			X												
6B. Benzo (*a*) Pyrene (50-32-8)			X												
7B. 3,4-Benzofluoranthene (205-99-2)			X												
8B. Benzo (*ghi*) Perylene (191-24-2)			X												
9B. Benzo (*k*) Fluoranthene (207-08-9)			X												
10B. Bis (*2-Chloroethoxy*) Methane (111-91-1)			X												
11B. Bis (*2-Chloroethyl*) Ether (111-44-4)			X												
12B. Bis (*2-Chloroisopropyl*) Ether (102-80-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
13B. Bis (*2-Ethylhexyl*) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloronaphthalene (91-58-7)			X												
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (*a,h*) Anthracene (53-70-3)			X												
20B. 1,2-Dichlorobenzene (95-50-1)			X												
21B. 1,3-Di-chlorobenzene (541-73-1)			X												
22B. 1,4-Dichlorobenzene (106-46-7)			X												
23B. 3,3-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131 -11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B.1,2-Diphenylhydrazine (*as Azobenzene*) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno (*1,2,3-cd*) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value (1)Concentration	a.Maximum Daily Value (2)Mass	b.Maximum 30 Day Value (1)Concentration	b.Maximum 30 Day Value (2)Mass	c.Long Term Avrg. Value (1)Concentration	c.Long Term Avrg. Value (2)Mass	d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value (1)Concentration	a.Long Term Average Value (2)Mass	b.No. of Analyses
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi- N-Propylamine (621-64-7)			X												
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
45B. Pyrene (129-00-0)			X												
46B. 1,2,4-Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION – PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Enosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												
17P. Heptachlor Epoxide (1024-57-3)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **139**

Part A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall.												
	2.Effluent							3.Units		4.Intake (optional)		
	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
1.Pollutant	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Biochemical Oxygen Demand (BOD)												
b.Chemical Oxygen Demand (COD)												
c.Total Organic Carbon (TOC)												
d.Total Suspended Solids (TSS)	20	20			3.4	3.4	13	mg/L	kg			
e.Ammonia (as N)												
f.Flow	**1661760 gal/day											
g.Temperature (winter)									°C			
h.Temperature (summer)									°C			
i.pH	Minimum 7.77	Maximum 8.07	N/A	N/A			13	Standard Units				

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

** Flow is gal/day that this outfall was discharging. Episodic and non-uniform flow is a result of dewatering need.

EPA I.D. Number: **MTD093301836**

Outfall No.: **139**

PART B – Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Bromide (24959-67-9)		X												
b.Chlorine, Total Residual		X												
c.Color		X												
d.Fecal Coliform		X												
e.Fluoride (16984-48-8)		X												
Nitrate-Nitrate (as N)	X		0.34	0.34	N/A	N/A	0.34	0.34	1	mg/L	kg			
g.Nitrogen, Total Organic (as N)		X												
h.Oil and Grease	X		*<1	*<1	N/A	N/A	*<1	*<1	3	mg/L	kg			
i.Phosphorus (as P), Total (7723-14-0)		X												
j.Radioactivity		X												
(1)Alpha, Total		X												
(2)Beta, Total		X												
(3)Radium, Total		X												
(4)Radium 226, Total		X												
k.Sulfate (as SO_4) (14808-79-8)	X		1330	1330	N/A	N/A	1330	1330	1	mg/L	kg			
l.Sulfide (as S)		X												
m.Sulfite (as SO_3) (14265-45-3)		X												
n.Surfactants		X												
o.Aluminum, Total (7429-90-5)	X		0.1	0.1	N/A	N/A	0.06	0.06	5	mg/L	kg			
p.Barium, Total (7440-39-3)		X												
q.Boron, Total (7440-42-8)	X		0.46	0.46	N/A	N/A	0.46	0.46	1	mg/L	kg			

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
r.Cobalt, Total (7440-48-4)		X												
s.Iron, Total (7439-89-6)	X		0.37	0.37	N/A	N/A	0.24	0.24	3	mg/L	kg			
t.Magnesium, Total (7439-95-4)	X		143	143	N/A	N/A	143	143	1	mg/L	kg			
u.Molybdenum, Total (7439-98-7)		X												
v.Manganese, Total (7439-96-5)		X												
w.Tin, Total (7440-31-5)		X												
x.Titanium, Total (7440-32-6)		X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **139**

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (all 7 pages) for each outfall. See instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)			X												
2M. Arsenic, Total (7440-38-2)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
3M. Beryllium, Total (7440-41-7)			X												
4M. Cadmium, Total (7440-43-9)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
5M. Chromium, Total (7440-47-3)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
6M. Copper, Total (7440-50-8)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
7M. Lead, Total (7439-92-1)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
8M. Mercury, Total (7439-97-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
9M. Nickel, Total (7440-02-0)		X		0.016	0.016	N/A	N/A	0.016	0.016	1	mg/L	kg			
10M. Selenium, Total (7782-49-2)		X		0.002	0.002	N/A	N/A	0.002	0.002	1	mg/L	kg			
11M. Silver, Total (7440-22-4)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
12M. Thallium, Total (7440-28-0)			X												
13M. Zinc, Total (7440-66-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
14M. Cyanide, Total (57-12-5)			X												
15M. Phenols, Total			X												
DIOXIN															
2,3,7,8-Tetrachlorodibenzo-P-Dioxin (1764-01-6)			X												
GC/MS FRACTION – VOLATILE COMPOUNDS															
1V. Accrolein (107-02-8)			X												
2V. Acrylonitrile (107-13-1)			X												
3V. Benzene (71-43-2)			X												
4V. Bis (*Chloromethyl*) Ether (542-88-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
5V. Bromoform (75-25-2)			X												
6V. Carbon Tetrachloride (56-23-5)			X												
7V. Chlorobenzene (108-90-7)			X												
8V. Chlorodibromomethane (124-48-1)			X												
9V. Chloroethane (75-00-3)			X												
10V. 2-Chloroethylvinyl Ether (110-75-8)			X												
11V. Chloroform (67-66-3)			X												
12V. Dichlorobromomethane (75-27-4)			X												
13V. Dichlorodifluoromethane (75-71-8)			X												
14V. 1,1-Dichloroethane (75-34-3)			X												
15V. 1,2-Dichloroethane (107-06-2)			X												
16V. 1,1-Dichloroethylene (75-35-4)			X												
17V. 1,2-Dichloropropane (78-87-5)			X												
18V. 1,3-Dichloropropylene (542-75-6)			X												
19V. Ethylbenzene (100-41-4)			X												
20V. Methyl Bromide (74-83-9)			X												
21V. Methyl Chloride (74-87-3)			X												
22V. Methylene Chloride (75-09-2)			X												
23V. 1,1,2,2-Tetrachloroethane (79-34-5)			X												
24V. Tetrachloroethylene (127-18-4)			X												
25V. Toluene (108-88-3)			X												
26V. 1,2-Trans-Dichloroethylene (156-60-5)			X												
27V. 1,1,1-Trichloroethane (71-55-6)			X												
28V. 1,1,2-Trichloroethane (79-00-5)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
29V Trichloroethylene (79-01-6)			X												
30V. Trichlorofluoromethane (75-69-4)			X												
31V. Vinyl Chloride (75-01-4)			X												
GC/MS FRACTION – ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)			X												
2A. 2,4-Dichlorophenol (120-83-2)			X												
3A. 2,4-Dimethylphenol (105-67-9)			X												
4A. 4,6-Dinitro-OCresol (534-52-1)			X												
5A. 2,4-Dinitrophenol (51-28-5)			X												
6A. 2-Nitrophenol (88-75-5)			X												
7A. 4-Nitrophenol (100-02-7)			X												
8A. P-Chloro-MCresol (59-50-7)			X												
9A. Pentachlorophenol (87-86-5)			X												
10A. Phenol (108-95-2)			X												
11A. 2,4,6-Trichlorophenol (88-05-2)			X												
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (*a*) Anthracene (56-55-3)			X												
6B. Benzo (*a*) Pyrene (50-32-8)			X												
7B. 3,4-Benzofluoranthene (205-99-2)			X												
8B. Benzo (*ghi*) Perylene (191-24-2)			X												
9B. Benzo (*k*) Fluoranthene (207-08-9)			X												
10B. Bis (*2-Chloroethoxy*) Methane (111-91-1)			X												
11B. Bis (*2-Chloroethyl*) Ether (111-44-4)			X												
12B. Bis (*2-Chloroisopropyl*) Ether (102-80-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
13B. Bis (*2-Ethylhexyl*) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloronaphthalene (91-58-7)			X												
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (*a,h*) Anthracene (53-70-3)			X												
20B. 1,2-Dichlorobenzene (95-50-1)			X												
21B. 1,3-Di-chlorobenzene (541-73-1)			X												
22B. 1,4-Dichlorobenzene (106-46-7)			X												
23B. 3,3-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131 -11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B.1,2-Diphenylhydrazine (*as Azobenzene*) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno (*1,2,3-cd*) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi- N-Propylamine (621-64-7)			X												
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
45B. Pyrene (129-00-0)			X												
46B. 1,2,4-Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION – PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Enosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												
17P. Heptachlor Epoxide (1024-57-3)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **032**

Part A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall.												
	2.Effluent							3.Units		4.Intake (optional)		
	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
1.Pollutant	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Biochemical Oxygen Demand (BOD)												
b.Chemical Oxygen Demand (COD)												
c.Total Organic Carbon (TOC)												
d.Total Suspended Solids (TSS)	39	39			17.6	17.6	14	mg/L	kg			
e.Ammonia (as N)												
f.Flow	**1991520 gal/day											
g.Temperature (winter)									°C			
h.Temperature (summer)									°C			
i.pH	Minimum 7.27	Maximum 8.05	N/A	N/A			14	Standard Units				

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

** Flow is gal/day that this outfall was discharging. Episodic and non-uniform flow is a result of dewatering need.

EPA I.D. Number: **MTD093301836**

Outfall No.: **032**

PART B – Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Bromide (24959-67-9)		X												
b.Chlorine, Total Residual		X												
c.Color		X												
d.Fecal Coliform		X												
e.Fluoride (16984-48-8)		X												
Nitrate-Nitrate (as N)	X		0.14	0.14	N/A	N/A	0.14	0.14	1	mg/L	kg			
g.Nitrogen, Total Organic (as N)		X												
h.Oil and Grease	X		4	4	N/A	N/A	2	2	3	mg/L	kg			
i.Phosphorus (as P), Total (7723-14-0)		X												
j.Radioactivity		X												
(1)Alpha, Total		X												
(2)Beta, Total		X												
(3)Radium, Total		X												
(4)Radium 226, Total		X												
k.Sulfate (as SO_4) (14808-79-8)	X		397	397	N/A	N/A	397	397	1	mg/L	kg			
l.Sulfide (as S)		X												
m.Sulfite (as SO_3) (14265-45-3)		X												
n.Surfactants		X												
o.Aluminum, Total (7429-90-5)	X		0.03	0.03	N/A	N/A	0.03	0.03	1	mg/L	kg			
p.Barium, Total (7440-39-3)		X												
q.Boron, Total (7440-42-8)	X		0.16	0.16	N/A	N/A	0.16	0.16	1	mg/L	kg			

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses			a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass		a.Concentration	b.Mass	(1)Concentration	(2)Mass	
r.Cobalt, Total (7440-48-4)		X												
s.Iron, Total (7439-89-6)	X		0.64	0.64	N/A	N/A	0.41	0.41	3	mg/L	kg			
t.Magnesium, Total (7439-95-4)	X		45	45	N/A	N/A	45	45	1	mg/L	kg			
u.Molybdenum, Total (7439-98-7)		X												
v.Manganese, Total (7439-96-5)		X												
w.Tin, Total (7440-31-5)		X												
x.Titanium, Total (7440-32-6)		X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **032**

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (all 7 pages) for each outfall. See instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)			X												
2M. Arsenic, Total (7440-38-2)		X		0.001	0.001	N/A	N/A	0.001	0.001	1	mg/L	kg			
3M. Beryllium, Total (7440-41-7)			X												
4M. Cadmium, Total (7440-43-9)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
5M. Chromium, Total (7440-47-3)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
6M. Copper, Total (7440-50-8)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
7M. Lead, Total (7439-92-1)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
8M. Mercury, Total (7439-97-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
9M. Nickel, Total (7440-02-0)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
10M. Selenium, Total (7782-49-2)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
11M. Silver, Total (7440-22-4)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
12M. Thallium, Total (7440-28-0)			X												
13M. Zinc, Total (7440-66-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
14M. Cyanide, Total (57-12-5)			X												
15M. Phenols, Total			X												
DIOXIN															
2,3,7,8-Tetrachlorodibenzo-P-Dioxin (1764-01-6)			X												
GC/MS FRACTION – VOLATILE COMPOUNDS															
1V. Accrolein (107-02-8)			X												
2V. Acrylonitrile (107-13-1)			X												
3V. Benzene (71-43-2)			X												
4V. Bis (*Chloromethyl*) Ether (542-88-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
5V. Bromoform (75-25-2)			X												
6V. Carbon Tetrachloride (56-23-5)			X												
7V. Chlorobenzene (108-90-7)			X												
8V. Chlorodibromomethane (124-48-1)			X												
9V. Chloroethane (75-00-3)			X												
10V. 2-Chloroethylvinyl Ether (110-75-8)			X												
11V. Chloroform (67-66-3)			X												
12V. Dichlorobromomethane (75-27-4)			X												
13V. Dichlorodifluoromethane (75-71-8)			X												
14V. 1,1-Dichloroethane (75-34-3)			X												
15V. 1,2-Dichloroethane (107-06-2)			X												
16V. 1,1-Dichloroethylene (75-35-4)			X												
17V. 1,2-Dichloropropane (78-87-5)			X												
18V. 1,3-Dichloropropylene (542-75-6)			X												
19V. Ethylbenzene (100-41-4)			X												
20V. Methyl Bromide (74-83-9)			X												
21V. Methyl Chloride (74-87-3)			X												
22V. Methylene Chloride (75-09-2)			X												
23V. 1,1,2,2-Tetrachloroethane (79-34-5)			X												
24V. Tetrachloroethylene (127-18-4)			X												
25V. Toluene (108-88-3)			X												
26V. 1,2-Trans-Dichloroethylene (156-60-5)			X												
27V. 1,1,1-Trichloroethane (71-55-6)			X												
28V. 1,1,2-Trichloroethane (79-00-5)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
29V Trichloroethylene (79-01-6)			X												
30V. Trichlorofluoromethane (75-69-4)			X												
31V. Vinyl Chloride (75-01-4)			X												
GC/MS FRACTION – ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)			X												
2A. 2,4-Dichlorophenol (120-83-2)			X												
3A. 2,4-Dimethylphenol (105-67-9)			X												
4A. 4,6-Dinitro-OCresol (534-52-1)			X												
5A. 2,4-Dinitrophenol (51-28-5)			X												
6A. 2-Nitrophenol (88-75-5)			X												
7A. 4-Nitrophenol (100-02-7)			X												
8A. P-Chloro-MCresol (59-50-7)			X												
9A. Pentachlorophenol (87-86-5)			X												
10A. Phenol (108-95-2)			X												
11A. 2,4,6-Trichlorophenol (88-05-2)			X												
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (*a*) Anthracene (56-55-3)			X												
6B. Benzo (*a*) Pyrene (50-32-8)			X												
7B. 3,4-Benzofluoranthene (205-99-2)			X												
8B. Benzo (*ghi*) Perylene (191-24-2)			X												
9B. Benzo (*k*) Fluoranthene (207-08-9)			X												
10B. Bis (*2-Chloroethoxy*) Methane (111-91-1)			X												
11B. Bis (*2-Chloroethyl*) Ether (111-44-4)			X												
12B. Bis (*2-Chloroisopropyl*) Ether (102-80-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
13B. Bis (*2-Ethylhexyl*) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloronaphthalene (91-58-7)			X												
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (*a,h*) Anthracene (53-70-3)			X												
20B. 1,2-Dichlorobenzene (95-50-1)			X												
21B. 1,3-Di-chlorobenzene (541-73-1)			X												
22B. 1,4-Dichlorobenzene (106-46-7)			X												
23B. 3,3-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131 -11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B.1,2-Diphenylhydrazine (*as Azobenzene*) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno (*1,2,3-cd*) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi- N-Propylamine (621-64-7)			X												
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
45B. Pyrene (129-00-0)			X												
46B. 1,2,4-Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION – PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Enosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												
17P. Heptachlor Epoxide (1024-57-3)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **026**

Part A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall.

1.Pollutant	2.Effluent							3.Units		4.Intake (optional)		
	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Biochemical Oxygen Demand (BOD)												
b.Chemical Oxygen Demand (COD)												
c.Total Organic Carbon (TOC)												
d.Total Suspended Solids (TSS)	27	27			12.1	12.1	15	mg/L	kg			
e.Ammonia (as N)												
f.Flow	**1398240 gal/day											
g.Temperature (winter)									°C			
h.Temperature (summer)									°C			
i.pH	Minimum 7.31	Maximum 8.24	N/A	N/A			15	Standard Units				

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

** Flow is gal/day that this outfall was discharging. Episodic and non-uniform flow is a result of dewatering need.

EPA I.D. Number: **MTD093301836**

Outfall No.: **026**

PART B – Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses			a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass		a.Concentration	b.Mass	(1)Concentration	(2)Mass	
a.Bromide (24959-67-9)		X												
b.Chlorine, Total Residual		X												
c.Color		X												
d.Fecal Coliform		X												
e.Fluoride (16984-48-8)		X												
Nitrate-Nitrate (as N)	X		0.11	0.11	N/A	N/A	0.09	0.09	2	mg/L	kg			
g.Nitrogen, Total Organic (as N)		X												
h.Oil and Grease	X		*<1	*<1	N/A	N/A	*<1	*<1	3	mg/L	kg			
i.Phosphorus (as P), Total (7723-14-0)		X												
j.Radioactivity		X												
(1)Alpha, Total		X												
(2)Beta, Total		X												
(3)Radium, Total		X												
(4)Radium 226, Total		X												
k.Sulfate (as SO_4) (14808-79-8)	X		1810	1810	N/A	N/A	1615	1615	2	mg/L	kg			
l.Sulfide (as S)		X												
m.Sulfite (as SO_3) (14265-45-3)		X												
n.Surfactants		X												
o.Aluminum, Total (7429-90-5)	X		0.14	0.14	N/A	N/A	0.11	0.11	2	mg/L	kg			
p.Barium, Total (7440-39-3)		X												
q.Boron, Total (7440-42-8)	X		0.71	0.71	N/A	N/A	0.59	0.59	3	mg/L	kg			

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
r.Cobalt, Total (7440-48-4)		X												
s.Iron, Total (7439-89-6)	X		0.74	0.74	N/A	N/A	0.55	0.55	2	mg/L	kg			
t.Magnesium, Total (7439-95-4)	X		279	279	N/A	N/A	243.5	243.5	2	mg/L	kg			
u.Molybdenum, Total (7439-98-7)		X												
v.Manganese, Total (7439-96-5)		X												
w.Tin, Total (7440-31-5)		X												
x.Titanium, Total (7440-32-6)		X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **026**

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (all 7 pages) for each outfall. See instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)			X												
2M. Arsenic, Total (7440-38-2)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	2	mg/L	kg			
3M. Beryllium, Total (7440-41-7)			X												
4M. Cadmium, Total (7440-43-9)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	2	mg/L	kg			
5M. Chromium, Total (7440-47-3)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	2	mg/L	kg			
6M. Copper, Total (7440-50-8)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	2	mg/L	kg			
7M. Lead, Total (7439-92-1)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	2	mg/L	kg			
8M. Mercury, Total (7439-97-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	2	mg/L	kg			
9M. Nickel, Total (7440-02-0)		X		0.005	0.005	N/A	N/A	0.0025	0.0025	2	mg/L	kg			
10M. Selenium, Total (7782-49-2)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	2	mg/L	kg			
11M. Silver, Total (7440-22-4)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	2	mg/L	kg			
12M. Thallium, Total (7440-28-0)			X												
13M. Zinc, Total (7440-66-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	2	mg/L	kg			
14M. Cyanide, Total (57-12-5)			X												
15M. Phenols, Total			X												
DIOXIN															
2,3,7,8-Tetrachlorodibenzo-P-Dioxin (1764-01-6)			X												
GC/MS FRACTION – VOLATILE COMPOUNDS															
1V. Accrolein (107-02-8)			X												
2V. Acrylonitrile (107-13-1)			X												
3V. Benzene (71-43-2)			X												
4V. Bis (*Chloromethyl*) Ether (542-88-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
5V. Bromoform (75-25-2)			X												
6V. Carbon Tetrachloride (56-23-5)			X												
7V. Chlorobenzene (108-90-7)			X												
8V. Chlorodibromomethane (124-48-1)			X												
9V. Chloroethane (75-00-3)			X												
10V. 2-Chloroethylvinyl Ether (110-75-8)			X												
11V. Chloroform (67-66-3)			X												
12V. Dichlorobromomethane (75-27-4)			X												
13V. Dichlorodifluoromethane (75-71-8)			X												
14V. 1,1-Dichloroethane (75-34-3)			X												
15V. 1,2-Dichloroethane (107-06-2)			X												
16V. 1,1-Dichloroethylene (75-35-4)			X												
17V. 1,2-Dichloropropane (78-87-5)			X												
18V. 1,3-Dichloropropylene (542-75-6)			X												
19V. Ethylbenzene (100-41-4)			X												
20V. Methyl Bromide (74-83-9)			X												
21V. Methyl Chloride (74-87-3)			X												
22V. Methylene Chloride (75-09-2)			X												
23V. 1,1,2,2-Tetrachloroethane (79-34-5)			X												
24V. Tetrachloroethylene (127-18-4)			X												
25V. Toluene (108-88-3)			X												
26V. 1,2-Trans-Dichloroethylene (156-60-5)			X												
27V. 1,1,1-Trichloroethane (71-55-6)			X												
28V. 1,1,2-Trichloroethane (79-00-5)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
29V Trichloroethylene (79-01-6)			X												
30V. Trichlorofluoromethane (75-69-4)			X												
31V. Vinyl Chloride (75-01-4)			X												
GC/MS FRACTION – ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)			X												
2A. 2,4-Dichlorophenol (120-83-2)			X												
3A. 2,4-Dimethylphenol (105-67-9)			X												
4A. 4,6-Dinitro-OCresol (534-52-1)			X												
5A. 2,4-Dinitrophenol (51-28-5)			X												
6A. 2-Nitrophenol (88-75-5)			X												
7A. 4-Nitrophenol (100-02-7)			X												
8A. P-Chloro-MCresol (59-50-7)			X												
9A. Pentachlorophenol (87-86-5)			X												
10A. Phenol (108-95-2)			X												
11A. 2,4,6-Trichlorophenol (88-05-2)			X												
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (*a*) Anthracene (56-55-3)			X												
6B. Benzo (*a*) Pyrene (50-32-8)			X												
7B. 3,4-Benzofluoranthene (205-99-2)			X												
8B. Benzo (*ghi*) Perylene (191-24-2)			X												
9B. Benzo (*k*) Fluoranthene (207-08-9)			X												
10B. Bis (*2-Chloroethoxy*) Methane (111-91-1)			X												
11B. Bis (*2-Chloroethyl*) Ether (111-44-4)			X												
12B. Bis (*2-Chloroisopropyl*) Ether (102-80-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
13B. Bis (*2-Ethylhexyl*) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloronaphthalene (91-58-7)			X												
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (*a,h*) Anthracene (53-70-3)			X												
20B. 1,2-Dichlorobenzene (95-50-1)			X												
21B. 1,3-Di-chlorobenzene (541-73-1)			X												
22B. 1,4-Dichlorobenzene (106-46-7)			X												
23B. 3,3-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131 -11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B.1,2-Diphenylhydrazine (*as Azobenzene*) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno (*1,2,3-cd*) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi- N-Propylamine (621-64-7)			X												
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
45B. Pyrene (129-00-0)			X												
46B. 1,2,4-Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION – PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Enosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												
17P. Heptachlor Epoxide (1024-57-3)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **023**

Part A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall.												
	2.Effluent							3.Units		4.Intake (optional)		
	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses			a.Long Term Average Value		b.No. of Analyses
1.Pollutant	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass		a.Concentration	b.Mass	(1)Concentration	(2)Mass	
a.Biochemical Oxygen Demand (BOD)												
b.Chemical Oxygen Demand (COD)												
c.Total Organic Carbon (TOC)												
d.Total Suspended Solids (TSS)	53	53			6.2	6.2	13	mg/L	kg			
e.Ammonia (as N)												
f.Flow	**4992480 gal/day											
g.Temperature (winter)									°C			
h.Temperature (summer)									°C			
i.pH	Minimum 7.23	Maximum 8	N/A	N/A			15	Standard Units				

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

** Flow is gal/day that this outfall was discharging. Episodic and non-uniform flow is a result of dewatering need.

EPA I.D. Number: **MTD093301836**

Outfall No.: **023**

PART B – Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Bromide (24959-67-9)		X												
b.Chlorine, Total Residual		X												
c.Color		X												
d.Fecal Coliform		X												
e.Fluoride (16984-48-8)		X												
Nitrate-Nitrate (as N)	X		0.02	0.02	N/A	N/A	0.02	0.02	1	mg/L	kg			
g.Nitrogen, Total Organic (as N)		X												
h.Oil and Grease	X		*<1	*<1	N/A	N/A	*<1	*<1	3	mg/L	kg			
i.Phosphorus (as P), Total (7723-14-0)		X												
j.Radioactivity		X												
(1)Alpha, Total		X												
(2)Beta, Total		X												
(3)Radium, Total		X												
(4)Radium 226, Total		X												
k.Sulfate (as SO_4) (14808-79-8)	X		1650	1650	N/A	N/A	1650	1650	1	mg/L	kg			
l.Sulfide (as S)		X												
m.Sulfite (as SO_3) (14265-45-3)		X												
n.Surfactants		X												
o.Aluminum, Total (7429-90-5)	X		*<0.03	*<0.03	N/A	N/A	*<0.03	*<0.03	1	mg/L	kg			
p.Barium, Total (7440-39-3)		X												
q.Boron, Total (7440-42-8)	X		0.5	0.5	N/A	N/A	0.48	0.48	2	mg/L	kg			

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
r.Cobalt, Total (7440-48-4)		X												
s.Iron, Total (7439-89-6)	X		0.96	0.96	N/A	N/A	0.38	0.38	3	mg/L	kg			
t.Magnesium, Total (7439-95-4)	X		298	298	N/A	N/A	298	298	1	mg/L	kg			
u.Molybdenum, Total (7439-98-7)		X												
v.Manganese, Total (7439-96-5)		X												
w.Tin, Total (7440-31-5)		X												
x.Titanium, Total (7440-32-6)		X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **023**

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (all 7 pages) for each outfall. See instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believe d Present	b.Believe d Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)			X												
2M. Arsenic, Total (7440-38-2)		X		0.001	0.001	N/A	N/A	0.001	0.001	1	mg/L	kg			
3M. Beryllium, Total (7440-41-7)			X												
4M. Cadmium, Total (7440-43-9)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
5M. Chromium, Total (7440-47-3)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
6M. Copper, Total (7440-50-8)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
7M. Lead, Total (7439-92-1)		X		0.001	0.001	N/A	N/A	0.001	0.001	1	mg/L	kg			
8M. Mercury, Total (7439-97-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
9M. Nickel, Total (7440-02-0)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
10M. Selenium, Total (7782-49-2)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
11M. Silver, Total (7440-22-4)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
12M. Thallium, Total (7440-28-0)			X												
13M. Zinc, Total (7440-66-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
14M. Cyanide, Total (57-12-5)			X												
15M. Phenols, Total			X												
DIOXIN															
2,3,7,8-Tetrachlorodibenzo-P-Dioxin (1764-01-6)			X												
GC/MS FRACTION – VOLATILE COMPOUNDS															
1V. Accrolein (107-02-8)			X												
2V. Acrylonitrile (107-13-1)			X												
3V. Benzene (71-43-2)			X												
4V. Bis (*Chloromethyl*) Ether (542-88-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
5V. Bromoform (75-25-2)			X												
6V. Carbon Tetrachloride (56-23-5)			X												
7V. Chlorobenzene (108-90-7)			X												
8V. Chlorodibromomethane (124-48-1)			X												
9V. Chloroethane (75-00-3)			X												
10V. 2-Chloroethylvinyl Ether (110-75-8)			X												
11V. Chloroform (67-66-3)			X												
12V. Dichlorobromomethane (75-27-4)			X												
13V. Dichlorodifluoromethane (75-71-8)			X												
14V. 1,1-Dichloroethane (75-34-3)			X												
15V. 1,2-Dichloroethane (107-06-2)			X												
16V. 1,1-Dichloroethylene (75-35-4)			X												
17V. 1,2-Dichloropropane (78-87-5)			X												
18V. 1,3-Dichloropropylene (542-75-6)			X												
19V. Ethylbenzene (100-41-4)			X												
20V. Methyl Bromide (74-83-9)			X												
21V. Methyl Chloride (74-87-3)			X												
22V. Methylene Chloride (75-09-2)			X												
23V. 1,1,2,2-Tetrachloroethane (79-34-5)			X												
24V. Tetrachloroethylene (127-18-4)			X												
25V. Toluene (108-88-3)			X												
26V. 1,2-Trans-Dichloroethylene (156-60-5)			X												
27V. 1,1,1-Trichloroethane (71-55-6)			X												
28V. 1,1,2-Trichloroethane (79-00-5)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
29V Trichloroethylene (79-01-6)			X												
30V. Trichlorofluoromethane (75-69-4)			X												
31V. Vinyl Chloride (75-01-4)			X												
GC/MS FRACTION – ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)			X												
2A. 2,4-Dichlorophenol (120-83-2)			X												
3A. 2,4-Dimethylphenol (105-67-9)			X												
4A. 4,6-Dinitro-OCresol (534-52-1)			X												
5A. 2,4-Dinitrophenol (51-28-5)			X												
6A. 2-Nitrophenol (88-75-5)			X												
7A. 4-Nitrophenol (100-02-7)			X												
8A. P-Chloro-MCresol (59-50-7)			X												
9A. Pentachlorophenol (87-86-5)			X												
10A. Phenol (108-95-2)			X												
11A. 2,4,6-Trichlorophenol (88-05-2)			X												
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (*a*) Anthracene (56-55-3)			X												
6B. Benzo (*a*) Pyrene (50-32-8)			X												
7B. 3,4-Benzofluoranthene (205-99-2)			X												
8B. Benzo (*ghi*) Perylene (191-24-2)			X												
9B. Benzo (*k*) Fluoranthene (207-08-9)			X												
10B. Bis (*2-Chloroethoxy*) Methane (111-91-1)			X												
11B. Bis (*2-Chloroethyl*) Ether (111-44-4)			X												
12B. Bis (*2-Chloroisopropyl*) Ether (102-80-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X" a.Testing Required	a.Believed Present	b.Believed Absent	3.Effluent a.Maximum Daily Value (1)Concentration	(2)Mass	b.Maximum 30 Day Value (1)Concentration	(2)Mass	c.Long Term Avrg. Value (1)Concentration	(2)Mass	d.No. of Analyses	4.Units a.Concentration	b.Mass	5.Intake (optional) a.Long Term Average Value (1)Concentration	(2)Mass	b.No. of Analyses
13B. Bis (*2-Ethylhexyl*) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloronaphthalene (91-58-7)			X												
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (*a,h*) Anthracene (53-70-3)			X												
20B. 1,2-Dichlorobenzene (95-50-1)			X												
21B. 1,3-Di-chlorobenzene (541-73-1)			X												
22B. 1,4-Dichlorobenzene (106-46-7)			X												
23B. 3,3-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131 -11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B.1,2-Diphenylhydrazine (*as Azobenzene*) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno (*1,2,3-cd*) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi- N-Propylamine (621-64-7)			X												
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
45B. Pyrene (129-00-0)			X												
46B. 1,2,4-Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION – PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Enosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												
17P. Heptachlor Epoxide (1024-57-3)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **022**

Part A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall.												
	2.Effluent							3.Units		4.Intake (optional)		
	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
1.Pollutant	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Biochemical Oxygen Demand (BOD)												
b.Chemical Oxygen Demand (COD)												
c.Total Organic Carbon (TOC)												
d.Total Suspended Solids (TSS)	18	18			3	3	6	mg/L	kg			
e.Ammonia (as N)												
f.Flow	**1064160 gal/day											
g.Temperature (winter)									°C			
h.Temperature (summer)									°C			
i.pH	Minimum 7.88	Maximum 8.02	N/A	N/A			5	Standard Units				

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

** Flow is gal/day that this outfall was discharging. Episodic and non-uniform flow is a result of dewatering need.

EPA I.D. Number: **MTD093301836**

Outfall No.: **022**

PART B – Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Bromide (24959-67-9)		X												
b.Chlorine, Total Residual		X												
c.Color		X												
d.Fecal Coliform		X												
e.Fluoride (16984-48-8)		X												
Nitrate-Nitrate (as N)	X		0.02	0.02	N/A	N/A	0.02	0.02	1	mg/L	kg			
g.Nitrogen, Total Organic (as N)		X												
h.Oil and Grease	X		*<1	*<1	N/A	N/A	*<1	*<1	1	mg/L	kg			
i.Phosphorus (as P), Total (7723-14-0)		X												
j.Radioactivity		X												
(1)Alpha, Total		X												
(2)Beta, Total		X												
(3)Radium, Total		X												
(4)Radium 226, Total		X												
k.Sulfate (as SO_4) (14808-79-8)	X		1770	1770	N/A	N/A	1770	1770	1	mg/L	kg			
l.Sulfide (as S)		X												
m.Sulfite (as SO_3) (14265-45-3)		X												
n.Surfactants		X												
o.Aluminum, Total (7429-90-5)	X		0.04	0.04	N/A	N/A	0.04	0.04	1	mg/L	kg			
p.Barium, Total (7440-39-3)		X												
q.Boron, Total (7440-42-8)	X		0.49	0.49	N/A	N/A	0.49	0.49	1	mg/L	kg			

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses			a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass		a.Concentration	b.Mass	(1)Concentration	(2)Mass	
r.Cobalt, Total (7440-48-4)		X												
s.Iron, Total (7439-89-6)	X		0.28	0.28	N/A	N/A	0.28	0.28	1	mg/L	kg			
t.Magnesium, Total (7439-95-4)	X		293	293	N/A	N/A	293	293	1	mg/L	kg			
u.Molybdenum, Total (7439-98-7)		X												
v.Manganese, Total (7439-96-5)		X												
w.Tin, Total (7440-31-5)		X												
x.Titanium, Total (7440-32-6)		X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **022**

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (all 7 pages) for each outfall. See instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)			X												
2M. Arsenic, Total (7440-38-2)		X		0.001	0.001	N/A	N/A	0.001	0.001	1	mg/L	kg			
3M. Beryllium, Total (7440-41-7)			X												
4M. Cadmium, Total (7440-43-9)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
5M. Chromium, Total (7440-47-3)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
6M. Copper, Total (7440-50-8)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
7M. Lead, Total (7439-92-1)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
8M. Mercury, Total (7439-97-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
9M. Nickel, Total (7440-02-0)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
10M. Selenium, Total (7782-49-2)		X		0.001	0.001	N/A	N/A	0.001	0.001	1	mg/L	kg			
11M. Silver, Total (7440-22-4)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
12M. Thallium, Total (7440-28-0)			X												
13M. Zinc, Total (7440-66-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
14M. Cyanide, Total (57-12-5)			X												
15M. Phenols, Total			X												
DIOXIN															
2,3,7,8-Tetrachlorodibenzo-P-Dioxin (1764-01-6)			X												
GC/MS FRACTION – VOLATILE COMPOUNDS															
1V. Accrolein (107-02-8)			X												
2V. Acrylonitrile (107-13-1)			X												
3V. Benzene (71-43-2)			X												
4V. Bis (*Chloromethyl*) Ether (542-88-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X" a.Testing Required	2.Mark "X" a.Believed Present	2.Mark "X" b.Believed Absent	3.Effluent a.Maximum Daily Value (1)Concentration	3.Effluent a.Maximum Daily Value (2)Mass	3.Effluent b.Maximum 30 Day Value (1)Concentration	3.Effluent b.Maximum 30 Day Value (2)Mass	3.Effluent c.Long Term Avrg. Value (1)Concentration	3.Effluent c.Long Term Avrg. Value (2)Mass	3.Effluent d.No. of Analyses	4.Units a.Concentration	4.Units b.Mass	5.Intake (optional) a.Long Term Average Value (1)Concentration	5.Intake (optional) a.Long Term Average Value (2)Mass	5.Intake (optional) b.No. of Analyses
5V. Bromoform (75-25-2)			X												
6V. Carbon Tetrachloride (56-23-5)			X												
7V. Chlorobenzene (108-90-7)			X												
8V. Chlorodibromomethane (124-48-1)			X												
9V. Chloroethane (75-00-3)			X												
10V. 2-Chloroethylvinyl Ether (110-75-8)			X												
11V. Chloroform (67-66-3)			X												
12V. Dichlorobromomethane (75-27-4)			X												
13V. Dichlorodifluoromethane (75-71-8)			X												
14V. 1,1-Dichloroethane (75-34-3)			X												
15V. 1,2-Dichloroethane (107-06-2)			X												
16V. 1,1-Dichloroethylene (75-35-4)			X												
17V. 1,2-Dichloropropane (78-87-5)			X												
18V. 1,3-Dichloropropylene (542-75-6)			X												
19V. Ethylbenzene (100-41-4)			X												
20V. Methyl Bromide (74-83-9)			X												
21V. Methyl Chloride (74-87-3)			X												
22V. Methylene Chloride (75-09-2)			X												
23V. 1,1,2,2-Tetrachloroethane (79-34-5)			X												
24V. Tetrachloroethylene (127-18-4)			X												
25V. Toluene (108-88-3)			X												
26V. 1,2-Trans-Dichloroethylene (156-60-5)			X												
27V. 1,1,1-Trichloroethane (71-55-6)			X												
28V. 1,1,2-Trichloroethane (79-00-5)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
29V Trichloroethylene (79-01-6)			X												
30V. Trichlorofluoromethane (75-69-4)			X												
31V. Vinyl Chloride (75-01-4)			X												
GC/MS FRACTION – ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)			X												
2A. 2,4-Dichlorophenol (120-83-2)			X												
3A. 2,4-Dimethylphenol (105-67-9)			X												
4A. 4,6-Dinitro-OCresol (534-52-1)			X												
5A. 2,4-Dinitrophenol (51-28-5)			X												
6A. 2-Nitrophenol (88-75-5)			X												
7A. 4-Nitrophenol (100-02-7)			X												
8A. P-Chloro-MCresol (59-50-7)			X												
9A. Pentachlorophenol (87-86-5)			X												
10A. Phenol (108-95-2)			X												
11A. 2,4,6-Trichlorophenol (88-05-2)			X												
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (*a*) Anthracene (56-55-3)			X												
6B. Benzo (*a*) Pyrene (50-32-8)			X												
7B. 3,4-Benzofluoranthene (205-99-2)			X												
8B. Benzo (*ghi*) Perylene (191-24-2)			X												
9B. Benzo (*k*) Fluoranthene (207-08-9)			X												
10B. Bis (*2-Chloroethoxy*) Methane (111-91-1)			X												
11B. Bis (*2-Chloroethyl*) Ether (111-44-4)			X												
12B. Bis (*2-Chloroisopropyl*) Ether (102-80-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X" a.Testing Required	a.Believed Present	b.Believed Absent	3.Effluent a.Maximum Daily Value (1)Concentration	(2)Mass	b.Maximum 30 Day Value (1)Concentration	(2)Mass	c.Long Term Avrg. Value (1)Concentration	(2)Mass	d.No. of Analyses	4.Units a.Concentration	b.Mass	5.Intake (optional) a.Long Term Average Value (1)Concentration	(2)Mass	b.No. of Analyses
13B. Bis (*2-Ethylhexyl*) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloronaphthalene (91-58-7)			X												
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (*a,h*) Anthracene (53-70-3)			X												
20B. 1,2-Dichlorobenzene (95-50-1)			X												
21B. 1,3-Di-chlorobenzene (541-73-1)			X												
22B. 1,4-Dichlorobenzene (106-46-7)			X												
23B. 3,3-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131 -11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B.1,2-Diphenylhydrazine (*as Azobenzene*) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno (*1,2,3-cd*) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi- N-Propylamine (621-64-7)			X												
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
45B. Pyrene (129-00-0)			X												
46B. 1,2,4-Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION – PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Enosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												
17P. Heptachlor Epoxide (1024-57-3)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **022**

Part A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall.												
	2.Effluent							3.Units		4.Intake (optional)		
	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of			a.Long Term Average Value		b.No. of
1.Pollutant	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	Analyses	a.Concentration	b.Mass	(1)Concentration	(2)Mass	Analyses
a.Biochemical Oxygen Demand (BOD)												
b.Chemical Oxygen Demand (COD)												
c.Total Organic Carbon (TOC)												
d.Total Suspended Solids (TSS)	13	13			6	6	4	mg/L	kg			
e.Ammonia (as N)												
f.Flow	**255516 gal/day											
g.Temperature (winter)									°C			
h.Temperature (summer)									°C			
i.pH	Minimum 8.13	Maximum 8.51	N/A	N/A			4	Standard Units				

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

** Flow is gal/day that this outfall was discharging. Episodic and non-uniform flow is a result of dewatering need.

EPA I.D. Number: **MTD093301836**

Outfall No.: **022**

PART B – Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
a.Bromide (24959-67-9)		X												
b.Chlorine, Total Residual		X												
c.Color		X												
d.Fecal Coliform		X												
e.Fluoride (16984-48-8)		X												
Nitrate-Nitrate (as N)	X		0	0	N/A	N/A	0	0	1	mg/L	kg			
g.Nitrogen, Total Organic (as N)		X												
h.Oil and Grease	X		*<1	*<1	N/A	N/A	*<1	*<1	1	mg/L	kg			
i.Phosphorus (as P), Total (7723-14-0)		X												
j.Radioactivity		X												
(1)Alpha, Total		X												
(2)Beta, Total		X												
(3)Radium, Total		X												
(4)Radium 226, Total		X												
k.Sulfate (as SO_4) (14808-79-8)	X		50	50	N/A	N/A	50	50	1	mg/L	kg			
l.Sulfide (as S)		X												
m.Sulfite (as SO_3) (14265-45-3)		X												
n.Surfactants		X												
o.Aluminum, Total (7429-90-5)	X		0.023	0.023	N/A	N/A	0.02	0.02	1	mg/L	kg			
p.Barium, Total (7440-39-3)		X												
q.Boron, Total (7440-42-8)	X		0	0	N/A	N/A	0	0	1	mg/L	kg			

1.Pollutant and CAS No. (if available)	2.Mark "X"		3.Effluent							4.Units		5.Intake (optional)		
	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average		b.No. of Analyses
			(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
r.Cobalt, Total (7440-48-4)		X												
s.Iron, Total (7439-89-6)	X		0.63	0.63	N/A	N/A	0.63	0.63	1	mg/L	kg			
t.Magnesium, Total (7439-95-4)	X		13	13	N/A	N/A	13	13	1	mg/L	kg			
u.Molybdenum, Total (7439-98-7)		X												
v.Manganese, Total (7439-96-5)		X												
w.Tin, Total (7440-31-5)		X												
x.Titanium, Total (7440-32-6)		X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

EPA I.D. Number: **MTD093301836**

Outfall No.: **022**

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (all 7 pages) for each outfall. See instructions for additional details and requirements.

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)			X												
2M. Arsenic, Total (7440-38-2)		X		0.001	0.001	N/A	N/A	0.001	0.001	1	mg/L	kg			
3M. Beryllium, Total (7440-41-7)			X												
4M. Cadmium, Total (7440-43-9)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
5M. Chromium, Total (7440-47-3)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
6M. Copper, Total (7440-50-8)		X		0.002	0.002	N/A	N/A	0.002	0.002	1	mg/L	kg			
7M. Lead, Total (7439-92-1)		X		0.0006	0.0006	N/A	N/A	0.0006	0.0006	1	mg/L	kg			
8M. Mercury, Total (7439-97-6)		X		0.002	0.002	N/A	N/A	0.002	0.002	1	mg/L	kg			
9M. Nickel, Total (7440-02-0)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
10M. Selenium, Total (7782-49-2)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
11M. Silver, Total (7440-22-4)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
12M. Thallium, Total (7440-28-0)			X												
13M. Zinc, Total (7440-66-6)		X		*<0.001	*<0.001	N/A	N/A	*<0.001	*<0.001	1	mg/L	kg			
14M. Cyanide, Total (57-12-5)			X												
15M. Phenols, Total			X												
DIOXIN															
2,3,7,8-Tetrachlorodibenzo-P-Dioxin (1764-01-6)			X												
GC/MS FRACTION – VOLATILE COMPOUNDS															
1V. Accrolein (107-02-8)			X												
2V. Acrylonitrile (107-13-1)			X												
3V. Benzene (71-43-2)			X												
4V. Bis (*Chloromethyl*) Ether (542-88-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believe d Present	b.Believe d Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
5V. Bromoform (75-25-2)			X												
6V. Carbon Tetrachloride (56-23-5)			X												
7V. Chlorobenzene (108-90-7)			X												
8V. Chlorodibromomethane (124-48-1)			X												
9V. Chloroethane (75-00-3)			X												
10V. 2-Chloroethylvinyl Ether (110-75-8)			X												
11V. Chloroform (67-66-3)			X												
12V. Dichlorobromomethane (75-27-4)			X												
13V. Dichlorodifluoromethane (75-71-8)			X												
14V. 1,1-Dichloroethane (75-34-3)			X												
15V. 1,2-Dichloroethane (107-06-2)			X												
16V. 1,1-Dichloroethylene (75-35-4)			X												
17V. 1,2-Dichloropropane (78-87-5)			X												
18V. 1,3-Dichloropropylene (542-75-6)			X												
19V. Ethylbenzene (100-41-4)			X												
20V. Methyl Bromide (74-83-9)			X												
21V. Methyl Chloride (74-87-3)			X												
22V. Methylene Chloride (75-09-2)			X												
23V. 1,1,2,2-Tetrachloroethane (79-34-5)			X												
24V. Tetrachloroethylene (127-18-4)			X												
25V. Toluene (108-88-3)			X												
26V. 1,2-Trans-Dichloroethylene (156-60-5)			X												
27V. 1,1,1-Trichloroethane (71-55-6)			X												
28V. 1,1,2-Trichloroethane (79-00-5)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
29V Trichloroethylene (79-01-6)			X												
30V. Trichlorofluoromethane (75-69-4)			X												
31V. Vinyl Chloride (75-01-4)			X												
GC/MS FRACTION – ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)			X												
2A. 2,4-Dichlorophenol (120-83-2)			X												
3A. 2,4-Dimethylphenol (105-67-9)			X												
4A. 4,6-Dinitro-OCresol (534-52-1)			X												
5A. 2,4-Dinitrophenol (51-28-5)			X												
6A. 2-Nitrophenol (88-75-5)			X												
7A. 4-Nitrophenol (100-02-7)			X												
8A. P-Chloro-MCresol (59-50-7)			X												
9A. Pentachlorophenol (87-86-5)			X												
10A. Phenol (108-95-2)			X												
11A. 2,4,6-Trichlorophenol (88-05-2)			X												
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (*a*) Anthracene (56-55-3)			X												
6B. Benzo (*a*) Pyrene (50-32-8)			X												
7B. 3,4-Benzofluoranthene (205-99-2)			X												
8B. Benzo (*ghi*) Perylene (191-24-2)			X												
9B. Benzo (*k*) Fluoranthene (207-08-9)			X												
10B. Bis (*2-Chloroethoxy*) Methane (111-91-1)			X												
11B. Bis (*2-Chloroethyl*) Ether (111-44-4)			X												
12B. Bis (*2-Chloroisopropyl*) Ether (102-80-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
13B. Bis (*2-Ethylhexyl*) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloronaphthalene (91-58-7)			X												
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (*a,h*) Anthracene (53-70-3)			X												
20B. 1,2-Dichlorobenzene (95-50-1)			X												
21B. 1,3-Di-chlorobenzene (541-73-1)			X												
22B. 1,4-Dichlorobenzene (106-46-7)			X												
23B. 3,3-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131 -11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B.1,2-Diphenylhydrazine (*as Azobenzene*) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno (*1,2,3-cd*) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believe d Present	b.Believe d Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi- N-Propylamine (621-64-7)			X												
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
45B. Pyrene (129-00-0)			X												
46B. 1,2,4-Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION – PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Enosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												
17P. Heptachlor Epoxide (1024-57-3)			X												

1.Pollutant and CAS No. (if available)	2.Mark "X"			3.Effluent							4.Units		5.Intake (optional)		
	a.Testing Required	a.Believed Present	b.Believed Absent	a.Maximum Daily Value		b.Maximum 30 Day Value		c.Long Term Avrg. Value		d.No. of Analyses	a.Concentration	b.Mass	a.Long Term Average Value		b.No. of Analyses
				(1)Concentration	(2)Mass	(1)Concentration	(2)Mass	(1)Concentration	(2)Mass				(1)Concentration	(2)Mass	
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

* Any value that is shown as "<{value}" indicates that there was no detection above the reporting limit. The value is therefore shown as "<{reporting limit}".

Appendix E

ANALYTICAL SUMMARY REPORT

August 08, 2014

Western Energy Co
PO Box 99
Colstrip, MT 59323-0099

Work Order: B14080539

Project Name: 20140806 PD 021

Energy Laboratories Inc Billings MT received the following 1 sample for Western Energy Co on 8/6/2014 for analysis.

Lab ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
B14080539-001	PD 021 WET	08/05/14 13:30	08/06/14	Aqueous	Metals by ICP/ICPMS, Dissolved Alkalinity 48 Hr Ceriodaphnia dubia/96 Hr FH Minnow Conductivity Hardness as CaCO3 Nitrogen, Ammonia Preparation, Dissolved Filtration

The analyses presented in this report were performed by Energy Laboratories, Inc., 1120 S 27th St., Billings, MT 59101, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

If you have any questions regarding these test results, please call.

Report Approved By: Mary Elizabeth Bondurant
Aquatic Tox Supervisor

Digitally signed by
Mary Bondurant
Date: 2014.08.13 15:11:10 -06:00

REGION VIII ACUTE WHOLE EFFLUENT TOXICITY REPORTING FORM

PERMIT NAME Western Energy Co.- Rosebud Mine NPDES NO. MT0023965
EFFLUENT LAB NO. B14080539 OUTFALL 021

50% MORTALITY TEST: X PASS ____ FAIL LC_{50} >100 % Tu_a <1.0

Test Species: **Ceriodaphnia dubia**

Effluent sample date & time: Tue 08/05/14 @ 1330

Effluent sample temperature upon arrival at laboratory: 4.3℃

Analysis date & time: Begin 08/06/14 @ 1355 End 08/08/14 @ 1405

Dilution water used: Reconstituted moderately hard ID:AQ7-37-01
Initial TRC, mg/L, 100% effluent: <0.1
Initial NH_3 (as N), mg/L, 100% effluent: <0.05
Hardness as $CaCO_3$, mg/L, 100% effluent: 820
Alkalinity as $CaCO_3$, mg/L, 100% effluent: 284
Conductivity, μS, 100% effluent: 1440
pH, s.u., 100% effluent: Initial 7.88 After 24 Hours 8.43
pH, s.u., control: Initial 8.08 After 24 Hours 7.99

Dilutions (% Effluent)*

NUMBER ALIVE	0%	12.5%	25%	50%	75%	100%
Start of Test	20	20	20	20	20	20
After 24 hours	20	20	20	20	20	20
After 48 hours	20	20	20	20	20	20

*normally, a minimum of five plus control (0%)

COMMENTS:

PERMIT NAME: Western Energy Co.- Rosebud Mine
EFFLUENT LAB NO. B14080539

TEST CONDITIONS: *Ceriodaphnia dubia* toxicity test to estimate acute toxicity
EPA -821-R-02-012 Fifth Edition October 2002

Method:	2002.0 - *Ceriodaphnia dubia* Survival test
Type Test:	Daily renewal
Test Duration:	48 hours
Age of organisms at start:	< 24 hours Organism ID: 14072593A&B
Feeding:	YCT/Selenastrum 1-2 hrs prior to testing
End Point:	survival - LC50 TU_a = 100/LC50
Control Mortality:	≤ 10%
Type of exposure chamber:	30 mL disposable plastic cup
Volume used:	15 mL
Number of Animals exposed/chamber:	5
Number of replicates/treatment:	4
Test temperatures:	20°C ± 1°C
Light Quality:	ambient laboratory illumination
Photoperiod:	16 hours light, 8 hours dark
Light intensity:	50-100ft.-c
Aeration:	none unless dissolved oxygen below 4.0 or above10.0 mg/L and only effluent aerated before dilution series
Standard toxicant used:	NaCl
Most recent reference toxicant test date:	#265 on 08/01/14

REGION VIII ACUTE WHOLE EFFLUENT TOXICITY REPORTING FORM

PERMIT NAME Western Energy Co. – Rosebud Mine NPDES NO. MT0023965
EFFLUENT LAB NO. B14080539 OUTFALL 021

50% MORTALITY TEST: X PASS ____ FAIL LC_{50} >100 % Tu_a <1.0

Test Species: **Pimephales promelas**

Effluent sample date & time: Tue 08/05/14 @ 1330

Effluent sample temperature upon arrival at laboratory: 4.3°C

Analysis date & time: Begin 08/06/14 @ 1410 End 08/10/14 @ 1320

Dilution water used: Reconstituted moderately hard ID:AQ7-37-01
Initial TRC, mg/L, 100% effluent: <0.1
Initial NH_3 (as N), mg/L, 100% effluent: <0.05
Hardness as $CaCO_3$, mg/L, 100% effluent: 820
Alkalinity as $CaCO_3$, mg/L, 100% effluent: 284
Conductivity, µS, 100% effluent: 1440
pH, s.u., 100% effluent: Initial 7.88 After 24 Hours 8.35
pH, s.u., control: Initial 8.08 After 24 Hours 7.95

Dilutions (% Effluent)*

NUMBER ALIVE	0%	12.5%	25%	50%	75%	100%
Start of Test	20	20	20	20	20	20
After 24 hours	20	20	20	20	20	20
After 48 hours	20	20	20	20	20	20
After 72 hours	20	20	20	20	20	20
After 96 hours	20	20	20	19	19	20

*normally, a minimum of five plus control (0%)

Comments:

PERMIT NAME: Western Energy Co. – Rosebud Mine
EFFLUENT LAB NO. B14080539

TEST CONDITIONS: *Pimephales promelas* toxicity test to estimate acute toxicity
EPA-821-R-02-012 Fifth Edition October 2002

Method:	2000.0 – *Pimephales promelas* Survival test
Type Test:	Daily renewal
Test Duration:	96 hours
Age of organisms at start:	1 to 14 days old (born within 24hrs of each other) Organism ID: H072414 Age: 13 Days
Feeding:	*Artemia* prior to selection and 0.15mL at 48 hrs before change
End Point:	Survival - LC50 TU_a = 100/LC50
Control Mortality:	≤ 10%
Type of exposure chamber:	250 mL disposable plastic cup
Volume used:	200 mL
Number of Animals exposed/chamber:	10
Number of replicates/treatment:	2
Test temperatures:	20°C ± 1°C
Light Quality:	ambient laboratory illumination
Photoperiod:	16 hours light, 8 hours dark
Light intensity:	50-100 ft.-c
Aeration:	none unless dissolved oxygen below 4.0 or above10.0 mg/L and only effluent aerated before dilution series
Standard toxicant used:	NaCl
Most recent reference toxicant test date:	#265 on 08/01/14

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20140806 PD 021
Lab ID: B14080539-001
Client Sample ID: PD 021 WET

Report Date: 08/08/14
Collection Date: 08/05/14 13:30
DateReceived: 08/06/14
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Conductivity @ 25 C	1440	umhos/cm		5		A2510 B	08/06/14 17:27 / jwc
INORGANICS							
Alkalinity, Total as CaCO3	284	mg/L		4		A2320 B	08/06/14 18:41 / jwc
Bicarbonate as HCO3	347	mg/L		4		A2320 B	08/06/14 18:41 / jwc
Carbonate as CO3	ND	mg/L		4		A2320 B	08/06/14 18:41 / jwc
Hardness as CaCO3	820	mg/L		1		A2340 B	08/08/14 09:59 / sln
NUTRIENTS							
Nitrogen, Ammonia as N	ND	mg/L		0.05		E350.1	08/07/14 11:50 / jbm
METALS, DISSOLVED							
Calcium	111	mg/L		1		E200.7	08/07/14 16:17 / rlh
Magnesium	132	mg/L		1		E200.7	08/07/14 16:17 / rlh

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

ACUTE TOXICITY COVER SHEET

INDUSTRY/TOXICANT: Western Energy - ~~Savage Mine~~ Rosebud Mine

CONTACT: Rich Sprang 406-748-5189 Wade Steele @ 406-748-51

LAB NO.: BK10805 39

NPDES PERMIT NO.: MT0023965 Outfall 021

DILUTION WATER: NA RECEIVING: X RECONSTITUTED: AG7-37-01 / / / /

RECEIVED: 08 / 06 / 14 @ 1308 EFFLUENT RECEIVING TEMPERATURE 4.3 °C by RJR

@ NA RECEIVING H_2O TEMPERATURE °C by

SAMPLE TYPE
GRAB: EFFLUENT COLLECTED ~~Wed~~ Tue (JR 8/6/14) 08 / 05 / 14 @ 1330 cubies A, B

~~RECEIVING~~ / / @ NA cubies

COMPOSITE: EFFLUENT COLLECTED / / @ TO / / @ cubies

INT. TOTAL RESIDUAL Cl_2: (SM4500CLG) cubies

100% EFFLUENT: 0.0 mg/L 08 / 06 / 14 by AF DILUTION WATER mg/l / NA / by

SUBSAMPLED FOR CHEMISTRIES

100% effluent sample to water dept 08 / 06 / 14 @ 1330 by JR # 001

Receiving water sample to water dept / / NA @ by #

~0 NH_3 AS N: (E350.1) <0.05
100% EFFLUENT: ~~ND~~ mg/l MEB 8/13/14 DILUTION WATER = NA mg/l

HARDNESS AS $CaCO_3$: (A2340B or C)
100% EFFLUENT: 820 mg/l DILUTION WATER = mg/l

ALKALINITY AS $CaCO_3$: (A2320B)
100% EFFLUENT: 284 mg/l DILUTION WATER = mg/l

CONDUCTIVITY: (SM2510.B)
100% EFFLUENT: 1440 µs DILUTION WATER = µs

TEST: CERIODAPHNIA DUBIA (METHOD 2002.0) BEGINNING 08 / 06 / 14 @ 1355 ENDING 08 / 08 / 14 @ ~~1355~~ 1405 AF 8/10/14

PIMEPHALES PROMELAS (Method 2000.0) BEGINNING 08 / 06 / 14 @ 1410 ENDING 08 / 10 / 14 @ 13.20

TEST ORGANISMS:

CERIODAPHNIA DUBIA AGE <24hrs ID 14072593 A & B MEB

PIMEPHALES PROMELAS AGE 13 days ID H072414 JR 8/13/14

Control = 0% Effluent
Effluent Sample = 100 % Effluent
(See Permit) 75 % Effluent
50 % Effluent
25 % Effluent
12.5 % Effluent

DISPOSAL: 08 / 10 / 14 @ 1400 by AF

X CITY SEWER SYSTEM

Ceriodaphnia dubia: (PASS)/FAIL LC50 >100% Tu_a <1.0

Pimephales promelas: (PASS)/FAIL LC50 >100% Tu_a <1.0

PERSON(S) CONDUCTING TESTS:

Bob Reid JR 08/13/14 (Initials) Mary E Bondurant MEB 8/12/14 (Initials) Jie Robinson (Initials) Faith Painter (Initials) Kim Pohlman (initials)

My Documents/Aqu Tox Forms/Acute Toxicity Cover Sheet

ACUTE TOXICITY DATA SHEET

Industry[redacted]xicant: Wesern Energy

Effluent Lab #: B14080539

Spec[redacted]

X Ceriodaphnia dubia (CD)

X Pimephales promelas (FH)

Test conducted by: RJR/MEB/KP/JR

Temperature (°C) — Orion Model 525A+ s/n 077401, Probe s/n IR1 10793

Conc of Effl	0	24		48		72		96
Dup %	100	100		100		100		100
	New	New	Old	New	Old	New	Old	Old
Dup	20.0	20.9	19.9	19.6	20.0	19.4	20.3	20.0
100% Effl	19.9	20.7		19.5		19.7	20.3	
75% Effl	20.8	20.8		19.6		19.9	20.3	
50% Effl	21.0	20.6		19.2		19.6	20.3	
25% Effl	21.0	20.3		19.2		19.5	20.3	
12.5% Effl	21.0	20.2		19.0		19.5	20.3	
0% Effl	20.6	19.9		20.1		19.3	20.3	
Perf Cont	NA							

pH, s.u — SM4500.H+B OrionModel 525A+ s/n 077401, Probe s/n QS115233

Conc of Effl	0	24		48		72		96
Dup %	100	100		100		100		100
	New	New	Old	New	Old	New	Old	Old
Dup	7.86	7.95	8.35	8.02	7.55	7.98	8.33	~~7.88~~ MEB 8/10/14
			8.42		8.50			8.26
100% Effl	7.88	7.96	8.35	8.02	7.55	8.00	8.33	8.27
			8.43		8.50			
75% Effl	7.92	8.00	8.34	8.06	7.97	8.06	8.38	8.33
			8.42		8.59			
50% Effl	8.01	8.03	8.29	8.10	7.59	8.08	8.31	8.26
			8.35		8.53			
25% Effl	8.06	8.05	8.18	8.16	7.74	8.17	8.03	8.11
			8.21		8.39			
12.5% Effl	8.01	8.04	8.06	8.28	7.78	8.11	7.98	7.99
		7.95	8.10		8.29			
0% Effl	8.08	8.03	~~8.19~~ JR 8/7/14	8.01	8.05	8.10	7.78	7.88
			7.99		8.11			
Perf Cont	NA							

Dissolved Oxygen (mg/L) — SM4500.O.G Accumet 150 s/n E0000693, Probe s/n 970899WP

Conc of Effl	0	24		48		72		96
Dup %	100	100		100	JR 8/8/14	100		100
	New	New	Old	New	Old	New	Old	Old
Dup	8.27	7.04	6.48	7.99	5.04	7.21	6.29	6.30
	~~8.28~~ JR 8/6/14		6.74		7.07			
100% Effl	8.28	6.98	6.45	7.89	5.00	7.32	6.28	6.28
			6.79		7.03			
75% Effl	7.81	7.14	6.41	7.45	7.38	7.27	6.14	6.29
			6.83		7.03			
50% Effl	7.53	7.05	6.43	7.26	5.85	7.26	6.23	6.27
			6.84		7.08			
25% Effl	7.47	6.97	6.83	7.07	6.32	7.10	6.02	6.32
			6.80		7.00			
12.5% Effl	7.45	6.84	6.99	7.05	6.89	7.04	6.22	6.24
			6.88		7.03			
0% Effl	7.30	7.06	6.84	7.83	7.14	6.93	6.36	6.53
			6.71		7.02			
Perf Cont	NA							

	0	24	48	72	96
Date	8/6/14	8/7/14	8/8/14	8/9/14	8/10/14
Time	1400	1325	1440	0800	1320
Initials	JR	JR	RK	RK	MEB
Cubie	A	A.B	A	B	—

pH, QA/QC 7.00 Buffer

begin/end	begin	end	begin	end	begin	end	begin/end
7.00/7.03	7.02	7.03	7.00	6.99	7.00	7.00	7.00 7.02

Temperature, QA/QC 7.00 Buffer

begin/end	begin	end	begin	end	begin	end	begin/end
25.3/25.5	25.1	24.5	24.4	24.4	24.8	24.1	25.1 25.0

Rosebud Mine
PD021

ACUTE TOXICITY DATA SHEET

Industry/Toxicant: Western Energy

Species:
__X__ Ceriodaphnia dubia

Effluent Lab #: B14080539

Tests conducted by: RJR/MEB /KP/JR

Conc. Of Effluent	Test Replicate	Number of Surviving Organisms			
		0 Hours 8/6/14	24 Hours	48 Hours	Remarks
100% Effl	A	5	5	5	
	B				
	C				
	D				
75% Effl	A				
	B				
	C				
	D				
50% Effl	A				
	B				
	C				
	D				
25% Effl	A				
	B				
	C				
	D				
12.5% Effl	A				
	B				
	C				
	D				
0% Effl	A				
	B				
	C				
	D				
Perf. Control	A				
	B		NA		
	C				
	D				
	Date:	8/06/14	8/07/14	8/8/14	
	Time:	1355	1320	1405	
	Initials:	[illegible]	[illegible]	[illegible]	

ACUTE TOXICITY DATA SHEET

Industry/Toxicant: Western Energy

Species:
__X__ Pimephales promelas

Effluent Lab #: B14080539

Tests conducted by: RJR/MEB/KP/JR

Conc. Of Effluent	Test Replicate	Number of Surviving Organisms					
		0 Hours	24 Hours	48 Hours	72 Hours	96 Hours	Remarks
100% Effl	A	10	10	10	10	10	
	B					10	
75 % Effl	A					10	
	B					9	
50 % Effl	A					9	
	B					10	
25 % Effl	A						
	B						
125% Effl	A						
	B						
0% Effl	A						
	B						
Perf.Control	A			NA			
	B						
Date:		8/6/14	8/7/14	8/8/14	8/9/14	8/10/14	
Time:		1410	1330	1435	0800	1320	
Initials:		JR	RJR	RJR	MEB	RJR	

fed @ 0900 JR

J:/Office/Forms/Auqatic Toxicity/Acute Biological data 3.doc

Workorder Receipt Checklist

Western Energy Co B14080539

Login completed by:	Randa Nees	Date Received:	8/6/2014
Reviewed by:	BL2000\tedwards	Received by:	rjr
Reviewed Date:	8/7/2014	Carrier name:	Hand Del

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on all shipping container(s)/cooler(s)?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on all sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.)	Yes ☑	No ☐	
Temp Blank received in all shipping container(s)/cooler(s)?	Yes ☑	No ☐	Not Applicable ☐
Container/Temp Blank temperature:	°C On Ice		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☑	No ☐	Not Applicable ☐

Standard Reporting Procedures:

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as –dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

Contact and Corrective Action Comments:

Temp Blank temperature for Cooler 1 was 4.3°C and Cooler 2 was 3.6°C.

The sample container was received by the laboratory with zero headspace.

Sample for Ammonia was subsampled and preserved upon receipt with 2 ml sulfuric acid per 250 mL to pH<2.

Sample for Dissolved Metals/Hardness was subsampled, filtered, and preserved to pH <2 with 2 mL of nitric acid per 250 mL in the laboratory. According to 40CFR136, samples for Dissolved Metals should be filtered and preserved within 15 minutes of collection.

ENERGY

Chain of Custody and Analytical Request Record

PLEASE PRINT (Provide as much information as possible.)

Company Name: Western Energy Co. (Rosebud Mine)	Project Name, PWS, Permit, Etc. 20140806 P.D. 021	Sample Origin State: MT	EPA/State Compliance: Yes ☒ No ☐
Report Mail Address (Required): PO Box 99 Colstrip, MT 59323 ☒ No Hard Copy Email: wsteere@westmoreland.com	Contact Name: Wade Steere Phone/Fax: 406-748-5199	Cell: 406-839-8189	Sampler: (Please Print) Wade Steere
	Invoice Contact & Phone: Marti Murphy 406-748-5133	Purchase Order:	Quote/Bottle Order: 74260

Invoice Address (Required):
PO Box 99
Colstrip, MT 59323
☒ No Hard Copy Email: wsteere@westmoreland.com

Special Report/Formats:
- ☐ DW
- ☐ POTW/WWTP
- ☐ State: ____
- ☐ Other: ____
- ☐ EDD/EDT (Electronic Data) Format: ____
- ☐ LEVEL IV
- ☐ NELAC

Number of Containers; Sample Type: A W S V B O DW — Air Water Soils/Solids Vegetation Bioassay Other DW - Drinking Water

ANALYSIS REQUESTED: All Per Bottle Order 74260 | W.E.T. Per Attached | Total Suspended Solids | SEE ATTACHED

Contact ELI prior to RUSH sample submittal for charges and scheduling – See Instruction Page

Comments: TB Cooler 2 3.6°C

Shipped by: Hand Del
Cooler ID(s):
Receipt Temp TB 4.3 °C
On Ice: (Y) N
Custody Seal On Bottle Y (N); On Cooler (Y) N
Intact (Y) N
Signature Match (Y) N

#	SAMPLE IDENTIFICATION (Name, Location, Interval, etc.)	Collection Date	Collection Time	MATRIX	All Per Bottle Order 74260	W.E.T. Per Attached	Total Suspended Solids	Standard Turnaround (TAT)	RUSH		LABORATORY USE ONLY
1	P.D. 021	8/5/14	13:30	W	X		X	X		Logged in sep. - [illegible]	—
2	P.D. 021 WET	8/5/14	13:30	W		X		X			B14080539-001
3											
4											
5											
6											
7											
8											
9											
10											

Custody Record MUST be Signed

Relinquished by (print)	Date/Time	Signature	Received by (print)	Date/Time	Signature
Wade Steere	8/6/14 / 7:30 am	[signature]			
			Wade Steere	8/6/14 / 13:08	[signature]
Sample Disposal: Return to Client: ____		Lab Disposal: ____	Received by Laboratory: Robert Reid	8/6/14 13:08	Robert Reid

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested.

WHOLE EFFLUENT TOXICITY (W.E.T.) SAMPLE DATA SHEET		
Client: Western Energy **Address: Castlerock Road** **Colstrip, Montana 59323** **Contact: Wade Steere**	**NPDES Permit : MT0023965** **Outfall No.: 021** **Phone No.: ~~406-748-5189~~** 406-748-5199	
Sample Type: (circle one)		
Grab: (circled) **collected at** 13:30 **(am/pm)** (pm circled)	08 / 05 / 2014	**(date mm/dd/yr)**
Composite:		
collected from (am/pm)	/ /	**(date mm/dd/yr)**
To (am/pm)	/ /	**(date mm/dd/yr)**

2 SPECIES ACUTE WET TEST WITH FATHEAD MINNOWS and CERIODAPHNIA DUBIA

full dilution series

Reconstituted moderately hard water for dilution water

2 cubitainers of effluent to us to test on Wednesday, August 6th

Samples- zero headspace

Cooled and received at 4° C – extra ice may be necessary in warm weather

Do NOT freeze

Please complete the top of this "WET" sheet AND make any corrections or additions

Return this WET sheet and the COC with the sample

Thanks for using ELI!

Appendix F

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	11/30/12
Project:	12/11/26 P.D. 022	**Collection Date:**	11/26/12 12:00
Lab ID:	B12111955-001	**DateReceived:**	11/26/12
Client Sample ID	P.D. Outfall 022	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	11/26/12 16:55 / rjb
Conductivity @ 25 C	2980	umhos/cm		5		A2510 B	11/26/12 16:55 / rjb
Solids, Total Suspended TSS @ 105 C	18	mg/L		10		A2540 D	11/28/12 09:37 / qej
Solids, Total Dissolved TDS @ 180 C	2680	mg/L		10		A2540 C	11/27/12 09:00 / qej
INORGANICS							
Chloride	31	mg/L	D	2		E300.0	11/27/12 19:49 / jrs
Sulfate	1770	mg/L	D	10		E300.0	11/27/12 19:49 / jrs
Sodium Adsorption Ratio (SAR)	1.49	unitless		0.01		Calculation	11/30/12 09:49 / sln
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.02	mg/L		0.01		E353.2	11/27/12 10:03 / bls
METALS, DISSOLVED							
Aluminum	0.04	mg/L		0.03		E200.8	11/28/12 13:05 / mas
Calcium	186	mg/L		1		E200.7	11/27/12 20:18 / rlh
Magnesium	293	mg/L		1		E200.7	11/27/12 20:18 / rlh
Sodium	140	mg/L	D	2		E200.7	11/27/12 20:18 / rlh
METALS, TOTAL							
Boron	0.49	mg/L		0.05		E200.8	11/29/12 15:44 / jjw
Iron	0.28	mg/L		0.03		E200.7	11/28/12 20:58 / rlh
Selenium	0.001	mg/L		0.001		E200.8	11/29/12 15:44 / jjw
METALS, TOTAL RECOVERABLE							
Arsenic	0.001	mg/L		0.001		E200.8	11/29/12 15:44 / jjw
Cadmium	ND	mg/L		0.001		E200.8	11/29/12 15:44 / jjw
Chromium	ND	mg/L		0.005		E200.8	11/29/12 15:44 / jjw
Copper	ND	mg/L		0.005		E200.8	11/29/12 15:44 / jjw
Lead	ND	mg/L		0.001		E200.8	11/29/12 15:44 / jjw
Mercury	ND	mg/L		0.0001		E245.1	11/27/12 15:06 / ser
Nickel	ND	mg/L		0.005		E200.8	11/29/12 15:44 / jjw
Silver	ND	mg/L		0.001		E200.8	11/29/12 15:44 / jjw
Zinc	ND	mg/L		0.01		E200.7	11/28/12 20:58 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	11/28/12 14:36 / oil-g

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
H - Analysis performed past recommended holding time.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	11/29/12
Project:	121127 P.D. 022	**Collection Date:**	11/27/12 10:00
Lab ID:	B12112049-001	**DateReceived:**	11/27/12
Client Sample ID	121127 P.D. 022	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	11/28/12 09:38 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 121130 P.D. 022 11/27-11/30
Lab ID: B12112420-001
Client Sample ID 121128 P.D. 022

Report Date: 12/04/12
Collection Date: 11/28/12 08:30
DateReceived: 11/30/12
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/03/12 13:08 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/04/12
Project:	121130 P.D. 022 11/27-11/30	**Collection Date:**	11/29/12 08:15
Lab ID:	B12112420-002	**DateReceived:**	11/30/12
Client Sample ID	121129 P.D. 022	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/03/12 13:08 / qej

Report Definitions:	RL - Analyte reporting limit.	MCL - Maximum contaminant level.
	QCL - Quality control limit.	ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/04/12
Project:	121130 P.D. 022 11/27-11/30	**Collection Date:**	11/30/12 08:30
Lab ID:	B12112420-003	**DateReceived:**	11/30/12
Client Sample ID	121130 P.D. 022	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/03/12 13:08 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

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LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/19/12
Project:	121203 P.D. 023	**Collection Date:**	12/03/12 10:00
Lab ID:	B12120219-001	**DateReceived:**	12/04/12
Client Sample ID	121203 P.D. 023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	12/04/12 17:22 / rjb
Conductivity @ 25 C	2960	umhos/cm		5		A2510 B	12/04/12 17:22 / rjb
Solids, Total Suspended TSS @ 105 C	53	mg/L		10		A2540 D	12/06/12 10:34 / qej
Solids, Total Dissolved TDS @ 180 C	2650	mg/L		10		A2540 C	12/06/12 11:00 / ser
INORGANICS							
Chloride	30	mg/L	D	2		E300.0	12/06/12 06:02 / jrs
Sulfate	1650	mg/L	D	10		E300.0	12/06/12 06:02 / jrs
Sodium Adsorption Ratio (SAR)	1.55	unitless		0.01		Calculation	12/11/12 13:28 / sln
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.02	mg/L		0.01		E353.2	12/10/12 14:09 / djr
METALS, DISSOLVED							
Aluminum	ND	mg/L		0.03		E200.8	12/07/12 17:18 / jjw
Calcium	190	mg/L		1		E200.7	12/05/12 22:23 / rlh
Magnesium	298	mg/L		1		E200.7	12/05/12 22:23 / rlh
Sodium	147	mg/L	D	2		E200.7	12/05/12 22:23 / rlh
METALS, TOTAL							
Boron	0.45	mg/L		0.05		E200.7	12/05/12 23:09 / rlh
Iron	0.96	mg/L		0.03		E200.7	12/05/12 23:09 / rlh
Selenium	ND	mg/L		0.001		E200.8	12/06/12 18:44 / mas
METALS, TOTAL RECOVERABLE							
Arsenic	0.001	mg/L		0.001		E200.8	12/05/12 18:22 / mas
Cadmium	ND	mg/L		0.001		E200.8	12/05/12 18:22 / mas
Chromium	ND	mg/L		0.005		E200.8	12/05/12 18:22 / mas
Copper	ND	mg/L		0.005		E200.8	12/05/12 18:22 / mas
Lead	0.001	mg/L		0.001		E200.8	12/05/12 18:22 / mas
Mercury	ND	mg/L		0.0001		E245.1	12/05/12 16:46 / ser
Nickel	ND	mg/L		0.005		E200.8	12/05/12 18:22 / mas
Silver	ND	mg/L		0.001		E200.8	12/05/12 18:22 / mas
Zinc	ND	mg/L		0.01		E200.8	12/05/12 18:22 / mas
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	12/07/12 13:22 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
H - Analysis performed past recommended holding time.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/11/12
Project:	121206 P.D. 023	**Collection Date:**	12/04/12 07:40
Lab ID:	B12120686-001	**DateReceived:**	12/07/12
Client Sample ID	121204 P.D. 023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/10/12 13:09 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/11/12
Project:	121206 P.D. 023	**Collection Date:**	12/05/12 09:30
Lab ID:	B12120686-002	**DateReceived:**	12/07/12
Client Sample ID	121205 P.D. 023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/10/12 13:09 / qcj

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/11/12
Project:	121206 P.D. 023	**Collection Date:**	12/06/12 09:45
Lab ID:	B12120686-003	**DateReceived:**	12/07/12
Client Sample ID	121206 P.D. 023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Solids, Total Suspended TSS @ 105 C	27	mg/L		10		A2540 D	12/10/12 13:09 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/26/12
Project:	121207-121210 P.D. 023	**Collection Date:**	12/07/12 08:45
Lab ID:	B12120920-001	**DateReceived:**	12/11/12
Client Sample ID	121207 P.D. 023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	12/12/12 12:19 / rjb
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/12/12 10:37 / gej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/26/12
Project:	121207-121210 P.D. 023	**Collection Date:**	12/08/12 08:45
Lab ID:	B12120920-002	**DateReceived:**	12/11/12
Client Sample ID	121208 P.D. 023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	12/12/12 12:38 / rjb
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/12/12 10:37 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/26/12
Project:	121207-121210 P.D. 023	**Collection Date:**	12/09/12 08:45
Lab ID:	B12120920-003	**DateReceived:**	12/11/12
Client Sample ID	121209 P.D. 023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	12/12/12 12:41 / rjb
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/12/12 10:37 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 121207-121210 P.D. 023
Lab ID: B12120920-004
Client Sample ID 121210 P.D. 023

Report Date: 12/26/12
Collection Date: 12/10/12 09:00
DateReceived: 12/11/12
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Solids, Total Dissolved TDS @ 180 C	2670	mg/L	H	10		A2540 C	12/20/12 12:05 / ser
METALS, TOTAL							
Iron	0.10	mg/L		0.03		E200.8	12/14/12 03:03 / mas
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	12/17/12 15:07 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/17/12
Project:	121211-121213 P.D. 023	**Collection Date:**	12/11/12 13:30
Lab ID:	B12121151-001	**DateReceived:**	12/13/12
Client Sample ID	121211 P.D. 023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	12/14/12 12:13 / rjb
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/14/12 11:30 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 121211-121213 P.D. 023
Lab ID: B12121151-002
Client Sample ID 121212 P.D. 023

Report Date: 12/17/12
Collection Date: 12/12/12 10:30
DateReceived: 12/13/12
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	12/14/12 12:16 / rjb
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/14/12 11:30 / gej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/17/12
Project:	121211-121213 P.D. 023	**Collection Date:**	12/13/12 09:00
Lab ID:	B12121151-003	**DateReceived:**	12/13/12
Client Sample ID	121213 P.D. 023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	12/14/12 12:19 / rjb
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/14/12 11:30 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/28/12
Project:	Area A Discharge	**Collection Date:**	12/14/12 09:01
Lab ID:	B12121526-004	**DateReceived:**	12/18/12
Client Sample ID	121214 P.D.023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	12/18/12 18:19 / rjb
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/19/12 12:02 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/28/12
Project:	Area A Discharge	**Collection Date:**	12/15/12 15:18
Lab ID:	B12121526-003	**DateReceived:**	12/18/12
Client Sample ID	121215 P.D.023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	12/18/12 18:15 / rjb
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/19/12 12:02 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/28/12
Project:	Area A Discharge	**Collection Date:**	12/16/12 15:30
Lab ID:	B12121526-002	**DateReceived:**	12/18/12
Client Sample ID	121216 P.D.023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	12/18/12 18:12 / rjb
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	12/19/12 12:02 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	12/28/12
Project:	Area A Discharge	**Collection Date:**	12/17/12 13:00
Lab ID:	B12121526-001	**DateReceived:**	12/18/12
Client Sample ID	121217 P.D.023	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Solids, Total Dissolved TDS @ 180 C	2760	mg/L		10		A2540 C	12/19/12 12:52 / rjo
METALS, TOTAL							
Boron	0.50	mg/L		0.05		E200.8	12/20/12 12:58 / mas
Iron	0.09	mg/L		0.03		E200.7	12/20/12 17:36 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	12/27/12 16:55 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	05/01/13
Project:	20130424 P.D. 026	**Collection Date:**	04/23/13 16:03
Lab ID:	B13041781-001	**DateReceived:**	04/24/13
Client Sample ID	20130423 P.D. 026	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	04/24/13 17:16 / pjw
Conductivity @ 25 C	2440	umhos/cm		5		A2510 B	04/24/13 17:16 / pjw
Solids, Total Suspended TSS @ 105 C	14	mg/L		10		A2540 D	04/25/13 09:59 / pdg
Solids, Total Dissolved TDS @ 180 C	2220	mg/L		10		A2540 C	04/25/13 10:34 / hmb
INORGANICS							
Chloride	8	mg/L	D	2		E300.0	04/25/13 16:40 / jrs
Sulfate	1420	mg/L	D	10		E300.0	04/25/13 16:40 / jrs
Sodium Adsorption Ratio (SAR)	0.92	unitless		0.01		Calculation	04/26/13 14:37 / jrs
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.06	mg/L		0.01		E353.2	04/26/13 09:04 / bls
METALS, DISSOLVED							
Aluminum	0.08	mg/L		0.03		E200.7	04/25/13 15:01 / rlh
Calcium	221	mg/L		1		E200.7	04/25/13 15:01 / rlh
Magnesium	208	mg/L		1		E200.7	04/25/13 15:01 / rlh
Sodium	79	mg/L		1		E200.7	04/25/13 15:01 / rlh
METALS, TOTAL							
Iron	0.36	mg/L		0.03		E200.7	04/27/13 00:59 / rlh
METALS, TOTAL RECOVERABLE							
Arsenic	ND	mg/L		0.001		E200.8	04/29/13 22:40 / jjw
Boron	0.47	mg/L		0.05		E200.7	04/27/13 00:59 / rlh
Cadmium	ND	mg/L		0.001		E200.8	04/29/13 22:40 / jjw
Chromium	ND	mg/L		0.005		E200.8	04/29/13 22:40 / jjw
Copper	ND	mg/L		0.005		E200.8	04/29/13 22:40 / jjw
Lead	ND	mg/L		0.001		E200.8	04/29/13 22:40 / jjw
Mercury	ND	mg/L		0.0001		E245.1	04/25/13 16:49 / ser
Nickel	0.005	mg/L		0.005		E200.8	04/29/13 22:40 / jjw
Selenium	ND	mg/L		0.001		E200.8	04/29/13 22:40 / jjw
Silver	ND	mg/L		0.001		E200.8	04/29/13 22:40 / jjw
Zinc	ND	mg/L		0.01		E200.7	04/27/13 00:59 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	04/30/13 14:23 / eli-g

Report Definitions:
- RL - Analyte reporting limit.
- QCL - Quality control limit.
- D - RL increased due to sample matrix.
- MCL - Maximum contaminant level.
- ND - Not detected at the reporting limit.
- H - Analysis performed past recommended holding time.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	05/01/13
Project:	20130424 P.D. 026	**Collection Date:**	04/24/13 10:00
Lab ID:	B13041781-002	**DateReceived:**	04/24/13
Client Sample ID	20130424 P.D. 026	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	04/24/13 17:24 / pjw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	04/25/13 09:59 / pdg

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130425 P.D. 026
Lab ID: B13041934-001
Client Sample ID 20130425 P.D. 026

Report Date: 04/30/13
Collection Date: 04/25/13 08:05
DateReceived: 04/26/13
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	04/26/13 15:32 / pjw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	04/29/13 14:41 / pdg

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	03/19/13
Project:	20130312 P.D. 026	**Collection Date:**	03/11/13 13:45
Lab ID:	B13030858-001	**DateReceived:**	03/12/13
Client Sample ID	20130311 P.D. 026	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.9	s.u.	H	0.1		A4500-H B	03/12/13 16:39 / hmb
Conductivity @ 25 C	2840	umhos/cm		5		A2510 B	03/12/13 16:39 / hmb
Solids, Total Suspended TSS @ 105 C	18	mg/L		10		A2540 D	03/13/13 13:52 / pdg
Solids, Total Dissolved TDS @ 180 C	2700	mg/L		10		A2540 C	03/13/13 15:24 / hmb
INORGANICS							
Chloride	9	mg/L	D	2		E300.0	03/13/13 17:11 / klc
Sulfate	1810	mg/L	D	10		E300.0	03/13/13 17:11 / klc
Sodium Adsorption Ratio (SAR)	1.09	unitless		0.01		Calculation	03/15/13 11:10 / meh
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.11	mg/L		0.01		E353.2	03/13/13 09:31 / bls
METALS, DISSOLVED							
Aluminum	0.14	mg/L		0.03		E200.7	03/13/13 16:21 / rlh
Calcium	261	mg/L		1		E200.7	03/13/13 16:21 / rlh
Magnesium	279	mg/L		1		E200.7	03/13/13 16:21 / rlh
Sodium	107	mg/L		1		E200.7	03/13/13 16:21 / rlh
METALS, TOTAL RECOVERABLE							
Arsenic	ND	mg/L		0.001		E200.8	03/14/13 14:14 / mas
Boron	0.71	mg/L		0.05		E200.8	03/14/13 14:14 / mas
Cadmium	ND	mg/L		0.001		E200.8	03/14/13 14:14 / mas
Chromium	ND	mg/L		0.005		E200.8	03/14/13 14:14 / mas
Copper	ND	mg/L		0.005		E200.8	03/14/13 14:14 / mas
Lead	ND	mg/L		0.001		E200.8	03/14/13 14:14 / mas
Mercury	ND	mg/L		0.0001		E245.1	03/13/13 17:59 / ser
Nickel	ND	mg/L		0.005		E200.8	03/16/13 15:07 / jjw
Selenium	ND	mg/L		0.001		E200.8	03/18/13 17:00 / mas
Silver	ND	mg/L		0.001		E200.8	03/14/13 14:14 / mas
Zinc	ND	mg/L		0.01		E200.8	03/14/13 14:14 / mas
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	03/14/13 16:10 / ell-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
H - Analysis performed past recommended holding time.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	03/14/13
Project:	20130312 P.D. 026	**Collection Date:**	03/12/13 08:15
Lab ID:	B13030860-001	**DateReceived:**	03/12/13
Client Sample ID	20130312 P.D. 026	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	03/12/13 16:59 / hmb
Solids, Total Suspended TSS @ 105 C	21	mg/L		10		A2540 D	03/13/13 13:52 / pdg

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	03/28/13
Project:	20130318 P.D. 026	**Collection Date:**	03/13/13 13:00
Lab ID:	B13031280-001	**DateReceived:**	03/18/13
Client Sample ID	20130313 P.D. 026	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.9	s.u.	H	0.1		A4500-H B	03/18/13 16:55 / pjw
Solids, Total Suspended TSS @ 105 C	17	mg/L		10		A2540 D	03/19/13 14:29 / pdg

Report Definitions:

RL - Analyte reporting limit.

QCL - Quality control limit.

H - Analysis performed past recommended holding time.

MCL - Maximum contaminant level.

ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130318 P.D. 026
Lab ID: B13031280-002
Client Sample ID 20130314 P.D. 026

Report Date: 03/28/13
Collection Date: 03/14/13 09:00
DateReceived: 03/18/13
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.9	s.u.	H	0.1		A4500-H B	03/18/13 17:08 / pjw
Solids, Total Suspended TSS @ 105 C	13	mg/L		10		A2540 D	03/19/13 14:29 / pdg

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	03/28/13
Project:	20130318 P.D. 026	**Collection Date:**	03/15/13 11:15
Lab ID:	B13031280-003	**DateReceived:**	03/18/13
Client Sample ID	20130315 P.D. 026	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.9	s.u.	H	0.1		A4500-H B	03/18/13 17:15 / pjw
Solids, Total Suspended TSS @ 105 C	12	mg/L		10		A2540 D	03/19/13 14:29 / pdg

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	03/28/13
Project:	20130318 P.D. 026	**Collection Date:**	03/16/13 11:00
Lab ID:	B13031280-004	**DateReceived:**	03/18/13
Client Sample ID	20130316 P.D. 026	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.9	s.u.	H	0.1		A4500-H B	03/18/13 17:18 / pjw
Solids, Total Suspended TSS @ 105 C	19	mg/L		10		A2540 D	03/19/13 14:29 / pdg

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	03/28/13
Project:	20130318 P.D. 026	**Collection Date:**	03/17/13 14:45
Lab ID:	B13031280-005	**DateReceived:**	03/18/13
Client Sample ID	20130317 P.D. 026	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	03/18/13 17:21 / pjw
Solids, Total Suspended TSS @ 105 C	27	mg/L		10		A2540 D	03/19/13 14:29 / pdg

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130318 P.D. 026
Lab ID: B13031280-006
Client Sample ID 20130318 P.D. 026

Report Date: 03/28/13
Collection Date: 03/18/13 08:15
DateReceived: 03/18/13
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	03/18/13 17:24 / pjw
Solids, Total Suspended TSS @ 105 C	19	mg/L		10		A2540 D	03/19/13 14:29 / pdg
Solids, Total Dissolved TDS @ 180 C	2430	mg/L		10		A2540 C	03/21/13 11:37 / hmb
METALS, TOTAL							
Iron	0.74	mg/L		0.03		E200.7	03/20/13 22:29 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	03/27/13 12:27 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	03/26/13
Project:	20130321 PD 026	**Collection Date:**	03/19/13 09:45
Lab ID:	B13031701-001	**DateReceived:**	03/22/13
Client Sample ID	20130319 PD 026	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	03/22/13 18:55 / pjw
Solids, Total Suspended TSS @ 105 C	12	mg/L		10		A2540 D	03/22/13 14:52 / pdg

Report Definitions:

RL - Analyte reporting limit.

QCL - Quality control limit.

H - Analysis performed past recommended holding time.

MCL - Maximum contaminant level.

ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	03/26/13
Project:	20130321 PD 026	**Collection Date:**	03/20/13 11:15
Lab ID:	B13031701-002	**DateReceived:**	03/22/13
Client Sample ID	20130320 PD 026	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	03/22/13 18:58 / pjw
Solids, Total Suspended TSS @ 105 C	10	mg/L		10		A2540 D	03/25/13 14:11 / pdg

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	03/26/13
Project:	20130321 PD 026	**Collection Date:**	03/21/13 08:15
Lab ID:	B13031701-003	**DateReceived:**	03/22/13
Client Sample ID	20130321 PD 026	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	03/22/13 19:01 / pjw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	03/25/13 14:11 / pdg
METALS, TOTAL RECOVERABLE							
Boron	0.59	mg/L		0.05		E200.7	03/26/13 13:51 / rlh

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130325 P.D. 026
Lab ID: B13031887-001
Client Sample ID 20130322 P.D. 026

Report Date: 03/28/13
Collection Date: 03/22/13 10:40
DateReceived: 03/26/13
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	03/26/13 17:37 / pjw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	03/27/13 11:51 / pdg

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/24/13
Project:	20130612 P.D.	**Collection Date:**	06/12/13 09:30
Lab ID:	B13061047-005	**DateReceived:**	06/12/13
Client Sample ID	20130612 P.D. 032	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.6	s.u.	H	0.1		A4500-H B	06/13/13 10:01 / bas
Conductivity @ 25 C	916	umhos/cm		5		A2510 B	06/13/13 10:01 / bas
Solids, Total Suspended TSS @ 105 C	12	mg/L		10		A2540 D	06/15/13 10:29 / qej
Solids, Total Dissolved TDS @ 180 C	679	mg/L		10		A2540 C	06/14/13 10:20 / qej
INORGANICS							
Chloride	5	mg/L		1		E300.0	06/13/13 23:33 / jrs
Sulfate	397	mg/L	D	5		E300.0	06/14/13 13:41 / jrs
Sodium Adsorption Ratio (SAR)	0.71	unitless		0.01		Calculation	06/17/13 12:48 / jrs
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.14	mg/L		0.01		E353.2	06/14/13 09:16 / bls
METALS, DISSOLVED							
Aluminum	0.03	mg/L		0.03		E200.7	06/14/13 22:01 / rlh
Calcium	99	mg/L		1		E200.7	06/14/13 22:01 / rlh
Magnesium	45	mg/L		1		E200.7	06/14/13 22:01 / rlh
Sodium	34	mg/L		1		E200.7	06/14/13 22:01 / rlh
METALS, TOTAL							
Iron	0.48	mg/L		0.03		E200.7	06/15/13 04:02 / rlh
METALS, TOTAL RECOVERABLE							
Arsenic	0.001	mg/L		0.001		E200.8	06/14/13 15:23 / mas
Boron	0.16	mg/L		0.05		E200.7	06/15/13 04:06 / rlh
Cadmium	ND	mg/L		0.001		E200.8	06/14/13 15:23 / mas
Chromium	ND	mg/L		0.005		E200.8	06/14/13 15:23 / mas
Copper	ND	mg/L		0.005		E200.8	06/14/13 15:23 / mas
Lead	ND	mg/L		0.001		E200.8	06/14/13 15:23 / mas
Mercury	ND	mg/L		0.0001		E245.1	06/13/13 12:18 / ser
Nickel	ND	mg/L		0.005		E200.8	06/14/13 15:23 / mas
Selenium	ND	mg/L		0.001		E200.8	06/14/13 15:23 / mas
Silver	ND	mg/L		0.001		E200.8	06/14/13 15:23 / mas
Zinc	ND	mg/L		0.01		E200.8	06/14/13 15:23 / mas
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	4	mg/L		1		E1664A	06/21/13 07:37 / ell-g

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
H - Analysis performed past recommended holding time.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130617 P.D.
Lab ID: B13061468-013
Client Sample ID 20130613 P.D. 032

Report Date: 06/28/13
Collection Date: 06/13/13 10:31
DateReceived: 06/17/13
Matrix: Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.6	s.u.	H	0.1		A4500-H B	06/18/13 14:46 / bas
Solids, Total Suspended TSS @ 105 C	35	mg/L		10		A2540 D	06/18/13 09:50 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/28/13
Project:	20130617 P.D.	**Collection Date:**	06/14/13 14:42
Lab ID:	B13061468-012	**DateReceived:**	06/17/13
Client Sample ID	20130614 P.D. 032	**Matrix:**	Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.4	s.u.	H	0.1		A4500-H B	06/18/13 14:44 / bas
Solids, Total Suspended TSS @ 105 C	39	mg/L		10		A2540 D	06/18/13 11:17 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/28/13
Project:	20130617 P.D.	**Collection Date:**	06/15/13 20:57
Lab ID:	B13061468-009	**DateReceived:**	06/17/13
Client Sample ID	20130615 P.D. 032	**Matrix:**	Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.8	s.u.	H	0.1		A4500-H B	06/18/13 14:34 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/18/13 11:17 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	06/28/13
Project:	20130617 P.D.		**Collection Date:**	06/16/13 15:30
Lab ID:	B13061468-006		**DateReceived:**	06/17/13
Client Sample ID	20130616 P.D. 032		**Matrix:**	Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.7	s.u.	H	0.1		A4500-H B	06/18/13 14:20 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/18/13 11:17 / pjw

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/28/13
Project:	20130617 P.D.	**Collection Date:**	06/17/13 12:01
Lab ID:	B13061468-001	**DateReceived:**	06/17/13
Client Sample ID	20130617 P.D. 032	**Matrix:**	Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.8	s.u.	H	0.1		A4500-H B	06/18/13 14:08 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/18/13 09:51 / pjw
Solids, Total Dissolved TDS @ 180 C	726	mg/L		10		A2540 C	06/20/13 09:35 / pjw
METALS, TOTAL							
Iron	0.12	mg/L		0.03		E200.7	06/20/13 22:29 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	06/27/13 14:39 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/25/13
Project:	20130619 P.D.	**Collection Date:**	06/18/13 10:47
Lab ID:	B13061802-003	**DateReceived:**	06/20/13
Client Sample ID	20130618 P.D. 032	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.8	s.u.	H	0.1		A4500-H B	06/21/13 16:00 / bas
Solids, Total Suspended TSS @ 105 C	18	mg/L		10		A2540 D	06/22/13 14:59 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/25/13
Project:	20130619 P.D.	**Collection Date:**	06/19/13 10:21
Lab ID:	B13061802-005	**DateReceived:**	06/20/13
Client Sample ID	20130619 P.D. 032	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.8	s.u.	H	0.1		A4500-H B	06/21/13 16:17 / bas
Solids, Total Suspended TSS @ 105 C	17	mg/L		10		A2540 D	06/22/13 14:59 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/09/13
Project:	20130625 P.D.	**Collection Date:**	06/20/13 10:45
Lab ID:	B13062211-003	**DateReceived:**	06/25/13
Client Sample ID	20130620 P.D. 032	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.6	s.u.	H	0.1		A4500-H B	06/26/13 12:03 / llj
Solids, Total Suspended TSS @ 105 C	18	mg/L		10		A2540 D	06/26/13 12:36 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/09/13
Project:	20130625 P.D.	**Collection Date:**	06/21/13 20:30
Lab ID:	B13062211-004	**DateReceived:**	06/25/13
Client Sample ID	20130621 P.D. 032	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.7	s.u.	H	0.1		A4500-H B	06/26/13 12:05 / tlj
Solids, Total Suspended TSS @ 105 C	13	mg/L		10		A2540 D	06/26/13 12:36 / qcl

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/09/13
Project:	20130625 P.D.	**Collection Date:**	06/22/13 15:00
Lab ID:	B13062211-007	**DateReceived:**	06/25/13
Client Sample ID	20130622 P.D. 032	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.5	s.u.	H	0.1		A4500-H B	06/26/13 13:46 / llj
Solids, Total Suspended TSS @ 105 C	28	mg/L		10		A2540 D	06/26/13 12:36 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

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LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/09/13
Project:	20130625 P.D.	**Collection Date:**	06/23/13 21:46
Lab ID:	B13062211-012	**DateReceived:**	06/25/13
Client Sample ID	20130623 P.D. 032	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.6	s.u.	H	0.1		A4500-H B	06/26/13 14:12 / llj
Solids, Total Suspended TSS @ 105 C	29	mg/L		10		A2540 D	06/26/13 12:37 / qel

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co.	**Report Date:**	07/09/13
Project:	20130625 P.D.	**Collection Date:**	06/24/13 12:06
Lab ID:	B13062211-013	**DateReceived:**	06/25/13
Client Sample ID	20130624 P.D. 032	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.6	s.u.	H	0.1		A4500-H B	06/26/13 14:14 / llj
Solids, Total Suspended TSS @ 105 C	18	mg/L		10		A2540 D	06/26/13 12:37 / qej
Solids, Total Dissolved TDS @ 180 C	893	mg/L		10		A2540 C	06/27/13 10:14 / qej
METALS, TOTAL							
Iron	0.64	mg/L		0.03		E200.8	06/27/13 10:54 / mas
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	2	mg/L		1		E1664A	07/08/13 15:52 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/02/13
Project:	20130627 P.D.	**Collection Date:**	06/25/13 10:06
Lab ID:	B13062487-004	**DateReceived:**	06/27/13
Client Sample ID	20130625 P.D. 032	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.3	s.u.	H	0.1		A4500-H B	06/29/13 14:42 / bas
Solids, Total Suspended TSS @ 105 C	19	mg/L		10		A2540 D	06/28/13 10:50 / qoj

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/28/13
Project:	20130816 P.D.	**Collection Date:**	08/15/13 12:33
Lab ID:	B13081526-002	**DateReceived:**	08/16/13
Client Sample ID	20130815 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.8	s.u.	H	0.1		A4500-H B	08/16/13 16:54 / bas
Conductivity @ 25 C	1380	umhos/cm		5		A2510 B	08/16/13 16:54 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/20/13 11:06 / pjw
Solids, Total Dissolved TDS @ 180 C	1070	mg/L		10		A2540 C	08/17/13 12:19 / qej
INORGANICS							
Chloride	6	mg/L		1		E300.0	08/21/13 01:48 / jrs
Sulfate	774	mg/L	D	2		E300.0	08/19/13 18:35 / jrs
Sodium Adsorption Ratio (SAR)	0.51	unitless		0.01		Calculation	08/23/13 10:18 / jrs
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	ND	mg/L		0.01		E353.2	08/26/13 13:02 / bls
METALS, DISSOLVED							
Aluminum	0.04	mg/L		0.03		E200.8	08/22/13 18:38 / jjw
Calcium	125	mg/L		1		E200.7	08/20/13 11:52 / mas
Magnesium	97	mg/L		1		E200.7	08/20/13 11:52 / mas
Sodium	32	mg/L		1		E200.7	08/20/13 11:52 / mas
METALS, TOTAL							
Iron	ND	mg/L		0.03		E200.7	08/22/13 09:36 / mas
METALS, TOTAL RECOVERABLE							
Arsenic	0.002	mg/L		0.001		E200.8	08/20/13 00:49 / jjw
Boron	0.16	mg/L		0.05		E200.8	08/20/13 18:09 / mas
Cadmium	ND	mg/L		0.001		E200.8	08/20/13 00:49 / jjw
Chromium	ND	mg/L		0.005		E200.8	08/20/13 00:49 / jjw
Copper	ND	mg/L		0.005		E200.8	08/20/13 00:49 / jjw
Lead	ND	mg/L		0.001		E200.8	08/20/13 00:49 / jjw
Mercury	ND	mg/L		0.0001		E245.1	08/19/13 14:37 / ser
Nickel	ND	mg/L		0.005		E200.8	08/20/13 00:49 / jjw
Selenium	0.001	mg/L		0.001		E200.8	08/20/13 00:49 / jjw
Silver	ND	mg/L		0.001		E200.8	08/20/13 18:09 / mas
Zinc	ND	mg/L		0.01		E200.8	08/20/13 00:49 / jjw
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	3	mg/L		1		E1664A	08/20/13 15:13 / ell-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
H - Analysis performed past recommended holding time.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/28/13
Project:	20130816 P.D.	**Collection Date:**	08/16/13 07:58
Lab ID:	B13081526-004	**DateReceived:**	08/16/13
Client Sample ID	20130815 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.8	s.u.	H	0.1		A4500-H B	08/16/13 17:00 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/20/13 11:06 / pjw

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/28/13
Project:	20130820 PD	**Collection Date:**	08/17/13 14:38
Lab ID:	B13081676-001	**DateReceived:**	08/20/13
Client Sample ID	20130817 PD 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.8	s.u.	H	0.1		A4500-H B	08/20/13 13:03 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/20/13 15:08 / pjw

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/28/13
Project:	20130820 PD	**Collection Date:**	08/18/13 13:38
Lab ID:	B13081676-003	**DateReceived:**	08/20/13
Client Sample ID	20130818 PD 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.8	s.u.	H	0.1		A4500-H B	08/20/13 13:09 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/20/13 15:08 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/28/13
Project:	20130820 PD	**Collection Date:**	08/19/13 09:48
Lab ID:	B13081676-005	**DateReceived:**	08/20/13
Client Sample ID	20130819 PD 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.7	s.u.	H	0.1		A4500-H B	08/20/13 13:27 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/20/13 15:08 / pjw
Solids, Total Dissolved TDS @ 180 C	1120	mg/L		10		A2540 C	08/21/13 09:14 / pjw
METALS, TOTAL							
Iron	0.04	mg/L		0.03		E200.7	08/22/13 10:26 / mas
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	08/27/13 20:46 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/28/13
Project:	20130820 PD	**Collection Date:**	08/20/13 08:00
Lab ID:	B13081676-006	**DateReceived:**	08/20/13
Client Sample ID	20130820 PD 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.6	s.u.	H	0.1		A4500-H B	08/20/13 14:21 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/21/13 10:38 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	09/05/13
Project:	20130823 PD	**Collection Date:**	08/21/13 10:50
Lab ID:	B13082115-001	**DateReceived:**	08/23/13
Client Sample ID	20130821 PD 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.8	s.u.	H	0.1		A4500-H B	08/23/13 15:37 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/24/13 13:50 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	09/05/13
Project:	20130823 PD	**Collection Date:**	08/22/13 07:46
Lab ID:	B13082115-002	**DateReceived:**	08/23/13
Client Sample ID	20130822 PD 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.8	s.u.	H	0.1		A4500-H B	08/23/13 15:40 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/24/13 13:50 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	09/05/13
Project:	20130823 PD	**Collection Date:**	08/23/13 08:10
Lab ID:	B13082115-004	**DateReceived:**	08/23/13
Client Sample ID	20130823 PD 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.7	s.u.	H	0.1		A4500-H B	08/23/13 15:48 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/24/13 13:50 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/28/13
Project:	20130827 PD JS	**Collection Date:**	08/24/13 06:05
Lab ID:	B13082306-001	**DateReceived:**	08/27/13
Client Sample ID	20130824 PD 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.8	s.u.	H	0.1		A4500-H B	08/27/13 14:40 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/27/13 14:31 / pjw

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	08/28/13
Project:	20130827 PD JS		**Collection Date:**	08/25/13 18:15
Lab ID:	B13082306-003		**DateReceived:**	08/27/13
Client Sample ID	20130825 PD 046		**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.8	s.u.	H	0.1		A4500-H B	08/27/13 14:47 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/27/13 14:31 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	09/09/13
Project:	20130827 PD WS	**Collection Date:**	08/26/13 09:42
Lab ID:	B13082307-001	**DateReceived:**	08/27/13
Client Sample ID	20130826 PD 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.5	s.u.	H	0.1		A4500-H B	08/27/13 14:58 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/27/13 14:31 / pjw
Solids, Total Dissolved TDS @ 180 C	1160	mg/L		10		A2540 C	08/27/13 15:41 / pjw
METALS, TOTAL							
Iron	0.22	mg/L		0.03		E200.7	08/28/13 16:35 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	09/06/13 15:51 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	09/09/13
Project:	20130827 PD WS	**Collection Date:**	08/27/13 08:37
Lab ID:	B13082307-003	**DateReceived:**	08/27/13
Client Sample ID	20130827 PD 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	08/27/13 15:06 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/27/13 14:31 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/16/13
Project:	20130701 P.D. 046	**Collection Date:**	07/01/13 09:33
Lab ID:	B13070068-001	**DateReceived:**	07/01/13
Client Sample ID	20130701 P. D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	07/02/13 12:23 / bas
Conductivity @ 25 C	1200	umhos/cm		5		A2510 B	07/02/13 12:23 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/03/13 15:17 / qej
Solids, Total Dissolved TDS @ 180 C	921	mg/L		10		A2540 C	07/05/13 10:48 / pjw
INORGANICS							
Chloride	5	mg/L		1		E300.0	07/06/13 22:22 / jrs
Sulfate	558	mg/L	D	10		E300.0	07/09/13 20:18 / jrs
Sodium Adsorption Ratio (SAR)	0.45	unitless		0.01		Calculation	07/05/13 12:35 / jrs
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.25	mg/L		0.01		E353.2	07/08/13 09:56 / bls
METALS, DISSOLVED							
Aluminum	ND	mg/L		0.03		E200.7	07/03/13 15:30 / rlh
Calcium	124	mg/L		1		E200.7	07/03/13 15:30 / rlh
Magnesium	82	mg/L		1		E200.7	07/03/13 15:30 / rlh
Sodium	27	mg/L		1		E200.7	07/03/13 15:30 / rlh
METALS, TOTAL							
Iron	0.08	mg/L		0.03		E200.7	07/03/13 01:08 / rlh
METALS, TOTAL RECOVERABLE							
Arsenic	0.001	mg/L		0.001		E200.8	07/02/13 18:59 / mas
Boron	0.15	mg/L		0.05		E200.7	07/03/13 01:08 / rlh
Cadmium	ND	mg/L		0.001		E200.8	07/02/13 18:59 / mas
Chromium	ND	mg/L		0.005		E200.8	07/02/13 18:59 / mas
Copper	ND	mg/L		0.005		E200.8	07/02/13 18:59 / mas
Lead	ND	mg/L		0.001		E200.8	07/02/13 18:59 / mas
Mercury	ND	mg/L		0.0001		E245.1	07/03/13 11:01 / ser
Nickel	ND	mg/L		0.005		E200.8	07/02/13 18:59 / mas
Selenium	0.002	mg/L		0.001		E200.8	07/02/13 18:59 / mas
Silver	ND	mg/L		0.001		E200.8	07/02/13 18:59 / mas
Zinc	ND	mg/L		0.01		E200.7	07/03/13 01:08 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	07/15/13 16:06 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
H - Analysis performed past recommended holding time.

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LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/18/13
Project:	20130708 P.D.	**Collection Date:**	07/02/13 11:30
Lab ID:	B13070499-001	**DateReceived:**	07/08/13
Client Sample ID	20130702 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	07/08/13 17:01 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/09/13 10:24 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/18/13
Project:	20130708 P.D.	**Collection Date:**	07/03/13 11:30
Lab ID:	B13070499-003	**DateReceived:**	07/08/13
Client Sample ID	20130703 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	07/08/13 17:08 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/09/13 10:24 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/18/13
Project:	20130708 P.D.	**Collection Date:**	07/08/13 11:22
Lab ID:	B13070499-005	**DateReceived:**	07/08/13
Client Sample ID	20130708 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	07/08/13 17:15 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/09/13 10:25 / pjw
Solids, Total Dissolved TDS @ 180 C	988	mg/L		10		A2540 C	07/09/13 13:05 / pjw
METALS, TOTAL							
Iron	0.06	mg/L		0.03		E200.7	07/10/13 22:02 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	07/18/13 11:43 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/16/13
Project:	20130712 P.D.	**Collection Date:**	07/09/13 16:18
Lab ID:	B13071118-002	**DateReceived:**	07/12/13
Client Sample ID	20130709 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	07/15/13 10:52 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/13/13 15:31 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	07/16/13
Project:	20130712 P.D.		**Collection Date:**	07/10/13 09:20
Lab ID:	B13071118-004		**DateReceived:**	07/12/13
Client Sample ID	20130710 P.D. 046		**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	07/15/13 11:00 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/13/13 15:31 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/16/13
Project:	20130712 P.D.	**Collection Date:**	07/11/13 08:17
Lab ID:	B13071118-006	**DateReceived:**	07/12/13
Client Sample ID	20130711 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	07/15/13 11:04 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/13/13 15:31 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/16/13
Project:	20130712 P.D.	**Collection Date:**	07/12/13 08:37
Lab ID:	B13071118-008	**DateReceived:**	07/12/13
Client Sample ID	20130712 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	07/15/13 11:10 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/13/13 15:31 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/30/13
Project:	20130715 P.D.	**Collection Date:**	07/13/13 11:49
Lab ID:	B13071347-002	**DateReceived:**	07/16/13
Client Sample ID	20130713 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.4	s.u.	H	0.1		A4500-H B	07/17/13 08:53 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/17/13 09:43 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/30/13
Project:	20130715 P.D.	**Collection Date:**	07/14/13 11:47
Lab ID:	B13071347-005	**DateReceived:**	07/16/13
Client Sample ID	20130714 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.4	s.u.	H	0.1		A4500-H B	07/17/13 09:01 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/17/13 09:43 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/30/13
Project:	20130715 P.D.	**Collection Date:**	07/15/13 08:29
Lab ID:	B13071347-007	**DateReceived:**	07/16/13
Client Sample ID	20130715 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.4	s.u.	H	0.1		A4500-H B	07/17/13 09:08 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/17/13 09:43 / qej
Solids, Total Dissolved TDS @ 180 C	1020	mg/L		10		A2540 C	07/17/13 09:29 / pjw
METALS, TOTAL							
Iron	0.04	mg/L		0.03		E200.7	07/18/13 18:50 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	07/29/13 15:44 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	07/30/13
Project:	20130715 P.D.		**Collection Date:**	07/16/13 06:22
Lab ID:	B13071347-010		**DateReceived:**	07/16/13
Client Sample ID	20130716 P.D. 046		**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.5	s.u.	H	0.1		A4500-H B	07/17/13 09:17 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/17/13 09:47 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/24/13
Project:	20130722 P.D. 046	**Collection Date:**	07/17/13 15:23
Lab ID:	B13071878-001	**DateReceived:**	07/22/13
Client Sample ID	20130717 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.7	s.u.	H	0.1		A4500-H B	07/22/13 18:20 / tlj
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/23/13 10:09 / pjw

Report Definitions:	RL - Analyte reporting limit.	MCL - Maximum contaminant level.
	QCL - Quality control limit.	ND - Not detected at the reporting limit.
	H - Analysis performed past recommended holding time.	

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/24/13
Project:	20130722 P.D. 046	**Collection Date:**	07/18/13 14:00
Lab ID:	B13071878-002	**DateReceived:**	07/22/13
Client Sample ID	20130718 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.6	s.u.	H	0.1		A4500-H B	07/22/13 18:22 / tlj
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/23/13 10:09 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/24/13
Project:	20130612 P.D.	**Collection Date:**	06/11/13 14:01
Lab ID:	B13061047-002	**DateReceived:**	06/12/13
Client Sample ID	20130611 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	06/13/13 09:53 / bas
Conductivity @ 25 C	1390	umhos/cm		5		A2510 B	06/13/13 09:53 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/15/13 10:29 / qej
Solids, Total Dissolved TDS @ 180 C	1120	mg/L		10		A2540 C	06/14/13 10:19 / qej
INORGANICS							
Chloride	7	mg/L		1		E300.0	06/13/13 23:18 / jrs
Sulfate	705	mg/L	D	10		E300.0	06/14/13 13:26 / jrs
Sodium Adsorption Ratio (SAR)	0.60	unitless		0.01		Calculation	06/17/13 12:48 / jrs
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.25	mg/L		0.01		E353.2	06/14/13 09:07 / bls
METALS, DISSOLVED							
Aluminum	ND	mg/L		0.03		E200.7	06/14/13 21:57 / rlh
Calcium	118	mg/L		1		E200.7	06/14/13 21:57 / rlh
Magnesium	116	mg/L		1		E200.7	06/14/13 21:57 / rlh
Sodium	38	mg/L		1		E200.7	06/14/13 21:57 / rlh
METALS, TOTAL							
Iron	0.08	mg/L		0.03		E200.7	06/15/13 03:55 / rlh
METALS, TOTAL RECOVERABLE							
Arsenic	0.001	mg/L		0.001		E200.8	06/14/13 15:20 / mas
Boron	0.19	mg/L		0.05		E200.7	06/15/13 03:59 / rlh
Cadmium	ND	mg/L		0.001		E200.8	06/14/13 15:20 / mas
Chromium	ND	mg/L		0.005		E200.8	06/14/13 15:20 / mas
Copper	ND	mg/L		0.005		E200.8	06/14/13 15:20 / mas
Lead	ND	mg/L		0.001		E200.8	06/14/13 15:20 / mas
Mercury	ND	mg/L		0.0001		E245.1	06/13/13 12:16 / ser
Nickel	ND	mg/L		0.005		E200.8	06/14/13 15:20 / mas
Selenium	0.001	mg/L		0.001		E200.8	06/14/13 15:20 / mas
Silver	ND	mg/L		0.001		E200.8	06/14/13 15:20 / mas
Zinc	ND	mg/L		0.01		E200.8	06/14/13 15:20 / mas
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	06/21/13 07:46 / eli-g

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
H - Analysis performed past recommended holding time.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/24/13
Project:	20130612 P.D.	**Collection Date:**	06/12/13 09:18
Lab ID:	B13061047-004	**DateReceived:**	06/12/13
Client Sample ID	20130612 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	06/13/13 09:59 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/15/13 10:29 / qcj

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/28/13
Project:	20130617 P.D.	**Collection Date:**	06/13/13 11:00
Lab ID:	B13061468-014	**DateReceived:**	06/17/13
Client Sample ID	20130613 P.D. 046	**Matrix:**	Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	06/18/13 14:49 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/18/13 09:51 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/28/13
Project:	20130617 P.D.	**Collection Date:**	06/14/13 14:21
Lab ID:	B13061468-011	**DateReceived:**	06/17/13
Client Sample ID	20130614 P.D. 046	**Matrix:**	Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	06/18/13 14:41 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/18/13 11:17 / pjw

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/28/13
Project:	20130617 P.D.	**Collection Date:**	06/15/13 20:36
Lab ID:	B13061468-007	**DateReceived:**	06/17/13
Client Sample ID	20130615 P.D. 046	**Matrix:**	Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	06/21/13 07:25 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/18/13 11:17 / pjw

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130617 P.D.
Lab ID: B13061468-004
Client Sample ID 20130616 P.D. 046

Report Date: 06/28/13
Collection Date: 06/16/13 14:48
DateReceived: 06/17/13
Matrix: Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	06/18/13 14:15 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/18/13 09:51 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/28/13
Project:	20130617 P.D.	**Collection Date:**	06/17/13 12:25
Lab ID:	B13061468-002	**DateReceived:**	06/17/13
Client Sample ID	20130617 P.D. 046	**Matrix:**	Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	06/18/13 14:11 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/18/13 09:51 / pjw
Solids, Total Dissolved TDS @ 180 C	1050	mg/L		10		A2540 C	06/20/13 09:35 / pjw
METALS, TOTAL							
Iron	0.07	mg/L		0.03		E200.7	06/20/13 22:48 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	06/27/13 14:41 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	06/25/13
Project:	20130619 P.D.		**Collection Date:**	06/18/13 10:11
Lab ID:	B13061802-002		**DateReceived:**	06/20/13
Client Sample ID	20130618 P.D. 046		**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	06/21/13 15:57 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/21/13 13:36 / goj

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co.	**Report Date:**	06/25/13
Project:	20130619 P.D.	**Collection Date:**	06/19/13 09:46
Lab ID:	B13061802-004	**DateReceived:**	06/20/13
Client Sample ID	20130619 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	06/21/13 16:12 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/22/13 14:59 / qej

Report Definitions:
- RL - Analyte reporting limit.
- QCL - Quality control limit.
- H - Analysis performed past recommended holding time.
- MCL - Maximum contaminant level.
- ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/09/13
Project:	20130625 P.D.	**Collection Date:**	06/20/13 10:05
Lab ID:	B13062211-002	**DateReceived:**	06/25/13
Client Sample ID	20130620 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	06/26/13 12:00 / tlj
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/26/13 12:35 / qcj

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/09/13
Project:	20130625 P.D.	**Collection Date:**	06/21/13 20:51
Lab ID:	B13062211-005	**DateReceived:**	06/25/13
Client Sample ID	20130621 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	06/26/13 12:11 / tlj
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/26/13 12:36 / gej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co.	**Report Date:**	07/09/13
Project:	20130625 P.D.	**Collection Date:**	06/22/13 15:40
Lab ID:	B13062211-009	**DateReceived:**	06/25/13
Client Sample ID	20130622 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	06/26/13 13:52 / llj
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/26/13 12:36 / qoj

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	07/09/13
Project:	20130625 P.D.		**Collection Date:**	06/23/13 21:16
Lab ID:	B13062211-010		**DateReceived:**	06/25/13
Client Sample ID	20130623 P.D. 046		**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	06/26/13 14:03 / tlj
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/26/13 12:37 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/09/13
Project:	20130625 P.D.	**Collection Date:**	06/24/13 13:07
Lab ID:	B13062211-014	**DateReceived:**	06/25/13
Client Sample ID	20130624 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	06/26/13 14:17 / tlj
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/26/13 12:37 / qej
Solids, Total Dissolved TDS @ 180 C	980	mg/L		10		A2540 C	06/27/13 10:14 / qej
METALS, TOTAL							
Iron	0.05	mg/L		0.03		E200.7	06/27/13 21:41 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	07/08/13 15:49 / eli-g

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/02/13
Project:	20130627 P.D.	**Collection Date:**	06/25/13 10:35
Lab ID:	B13062487-003	**DateReceived:**	06/27/13
Client Sample ID	20130625 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	06/29/13 14:38 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/28/13 10:50 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/02/13
Project:	20130627 P.D.	**Collection Date:**	06/26/13 09:25
Lab ID:	B13062487-002	**DateReceived:**	06/27/13
Client Sample ID	20130626 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	06/29/13 14:36 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/28/13 10:50 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

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LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/11/13
Project:	20130701 P.D. 046	**Collection Date:**	06/27/13 08:51
Lab ID:	B13070070-001	**DateReceived:**	07/01/13
Client Sample ID	20130627 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	07/02/13 12:25 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/03/13 15:17 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/11/13
Project:	20130701 P.D. 046	**Collection Date:**	06/28/13 10:00
Lab ID:	B13070070-003	**DateReceived:**	07/01/13
Client Sample ID	20130628 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	07/02/13 12:28 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/03/13 15:17 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/11/13
Project:	20130701 P.D. 046	**Collection Date:**	06/29/13 08:16
Lab ID:	B13070070-005	**DateReceived:**	07/01/13
Client Sample ID	20130629 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	07/02/13 12:30 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/03/13 15:17 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/11/13
Project:	20130701 P.D. 046	**Collection Date:**	06/30/13 19:27
Lab ID:	B13070070-006	**DateReceived:**	07/01/13
Client Sample ID	20130630 P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	07/02/13 12:33 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/03/13 15:17 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/13/13
Project:	20130801 P.D.	**Collection Date:**	08/01/13 09:00
Lab ID:	B13080216-001	**DateReceived:**	08/02/13
Client Sample ID	20130801P.D.052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	08/05/13 11:02 / jlw
Conductivity @ 25 C	2450	umhos/cm		5		A2510 B	08/05/13 11:02 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/03/13 10:19 / qej
Solids, Total Dissolved TDS @ 180 C	2370	mg/L		10		A2540 C	08/06/13 09:55 / pjw
INORGANICS							
Chloride	9	mg/L	D	2		E300.0	08/05/13 19:07 / jpv
Sulfate	1630	mg/L	D	10		E300.0	08/05/13 19:07 / jpv
Sodium Adsorption Ratio (SAR)	1.16	unitless		0.01		Calculation	08/07/13 09:53 / jrs
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.35	mg/L		0.01		E353.2	08/06/13 10:05 / bls
METALS, DISSOLVED							
Aluminum	0.03	mg/L		0.03		E200.7	08/05/13 12:59 / rlh
Calcium	233	mg/L		1		E200.7	08/05/13 12:59 / rlh
Magnesium	205	mg/L		1		E200.7	08/05/13 12:59 / rlh
Sodium	101	mg/L		1		E200.7	08/05/13 12:59 / rlh
METALS, TOTAL							
Iron	0.16	mg/L		0.03		E200.7	08/06/13 14:24 / rlh
METALS, TOTAL RECOVERABLE							
Arsenic	0.002	mg/L		0.001		E200.8	08/07/13 18:10 / jjw
Boron	0.54	mg/L		0.05		E200.7	08/06/13 14:51 / rlh
Cadmium	ND	mg/L		0.001		E200.8	08/06/13 15:12 / AMM
Chromium	ND	mg/L		0.005		E200.8	08/06/13 15:12 / AMM
Copper	0.007	mg/L		0.005		E200.8	08/06/13 15:12 / AMM
Lead	ND	mg/L		0.001		E200.8	08/06/13 15:12 / AMM
Mercury	ND	mg/L		0.0001		E245.1	08/05/13 16:38 / ser
Nickel	0.008	mg/L		0.005		E200.8	08/06/13 15:12 / AMM
Selenium	0.005	mg/L	D	0.002		E200.8	08/06/13 15:12 / AMM
Silver	ND	mg/L		0.001		E200.8	08/06/13 15:12 / AMM
Zinc	ND	mg/L		0.01		E200.7	08/06/13 14:51 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	08/12/13 15:37 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
H - Analysis performed past recommended holding time.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/14/13
Project:	20130805 P.D. 052	**Collection Date:**	08/05/13 12:25
Lab ID:	B13080330-001	**DateReceived:**	08/06/13
Client Sample ID	20130805 P.D. 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.4	s.u.	H	0.1		A4500-H B	08/06/13 10:52 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/07/13 09:42 / qej
Solids, Total Dissolved TDS @ 180 C	2370	mg/L		10		A2540 C	08/06/13 10:00 / pjw
METALS, TOTAL							
Iron	0.16	mg/L		0.03		E200.7	08/07/13 17:20 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	08/13/13 14:15 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130808PD052
Lab ID: B13081095-001
Client Sample ID 20130808PD052

Report Date: 08/22/13
Collection Date: 08/08/13 14:49
DateReceived: 08/13/13
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	08/14/13 10:59 / bas
Solids, Total Suspended TSS @ 105 C	38	mg/L		10		A2540 D	08/14/13 09:52 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/22/13
Project:	20130808PD052	**Collection Date:**	08/09/13 09:00
Lab ID:	B13081095-002	**DateReceived:**	08/13/13
Client Sample ID	20130809PD052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	08/14/13 11:01 / bas
Solids, Total Suspended TSS @ 105 C	18	mg/L		10		A2540 D	08/14/13 09:52 / pjw

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130808PD052
Lab ID: B13081095-003
Client Sample ID 20130810PD052

Report Date: 08/22/13
Collection Date: 08/10/13 16:08
DateReceived: 08/13/13
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.6	s.u.	H	0.1		A4500-H B	08/14/13 11:04 / bas
Solids, Total Suspended TSS @ 105 C	14	mg/L		10		A2540 D	08/14/13 09:52 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/22/13
Project:	20130808PD052	**Collection Date:**	08/11/13 13:10
Lab ID:	B13081095-004	**DateReceived:**	08/13/13
Client Sample ID	20130811PD052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	08/14/13 11:07 / bas
Solids, Total Suspended TSS @ 105 C	24	mg/L		10		A2540 D	08/14/13 09:52 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/22/13
Project:	20130808PD052	**Collection Date:**	08/12/13 10:05
Lab ID:	B13081095-005	**DateReceived:**	08/13/13
Client Sample ID	20130812PD052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	08/14/13 11:11 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/14/13 09:52 / pjw
Solids, Total Dissolved TDS @ 180 C	2890	mg/L		10		A2540 C	08/14/13 14:42 / pjw
METALS, TOTAL							
Iron	0.11	mg/L		0.03		E200.7	08/20/13 19:11 / mas
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	08/19/13 14:15 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/22/13
Project:	20130808PD052	**Collection Date:**	08/13/13 09:57
Lab ID:	B13081095-006	**DateReceived:**	08/13/13
Client Sample ID	20130813PD052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	08/14/13 11:13 / bas
Solids, Total Suspended TSS @ 105 C	21	mg/L		10		A2540 D	08/14/13 09:52 / pjw

Report Definitions:

RL - Analyte reporting limit.

QCL - Quality control limit.

H - Analysis performed past recommended holding time.

MCL - Maximum contaminant level.

ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/28/13
Project:	20130816 P.D.	**Collection Date:**	08/15/13 12:12
Lab ID:	B13081526-001	**DateReceived:**	08/16/13
Client Sample ID	20130815 P.D. 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	08/16/13 16:48 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/20/13 11:06 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/28/13
Project:	20130816 P.D.	**Collection Date:**	08/16/13 07:45
Lab ID:	B13081526-003	**DateReceived:**	08/16/13
Client Sample ID	20130815 P.D. 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	08/16/13 16:57 / bas
Solids, Total Suspended TSS @ 105 C	24	mg/L		10		A2540 D	08/20/13 11:06 / pjw

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/28/13
Project:	20130820 PD	**Collection Date:**	08/17/13 14:50
Lab ID:	B13081676-002	**DateReceived:**	08/20/13
Client Sample ID	20130817 PD 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	08/20/13 13:06 / bas
Solids, Total Suspended TSS @ 105 C	27	mg/L		10		A2540 D	08/20/13 15:08 / pjw

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/28/13
Project:	20130820 PD	**Collection Date:**	08/18/13 13:47
Lab ID:	B13081676-004	**DateReceived:**	08/20/13
Client Sample ID	20130818 PD 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	08/20/13 13:15 / bas
Solids, Total Suspended TSS @ 105 C	14	mg/L		10		A2540 D	08/20/13 15:08 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	09/05/13
Project:	20130823 PD		**Collection Date:**	08/22/13 14:04
Lab ID:	B13082115-003		**DateReceived:**	08/23/13
Client Sample ID	20130822 PD 052		**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	08/23/13 15:44 / jlw
Solids, Total Suspended TSS @ 105 C	12	mg/L		10		A2540 D	08/24/13 13:50 / qej
Solids, Total Dissolved TDS @ 180 C	3130	mg/L		10		A2540 C	08/24/13 13:01 / qej
METALS, TOTAL							
Iron	0.38	mg/L		0.03		E200.7	08/29/13 20:47 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	09/04/13 14:18 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	09/05/13
Project:	20130823 PD	**Collection Date:**	08/23/13 08:20
Lab ID:	B13082115-005	**DateReceived:**	08/23/13
Client Sample ID	20130823 PD 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	08/23/13 15:51 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/24/13 13:50 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

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LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/28/13
Project:	20130827 PD JS	**Collection Date:**	08/24/13 06:15
Lab ID:	B13082306-002	**DateReceived:**	08/27/13
Client Sample ID	20130824 PD 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	08/27/13 14:44 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/27/13 14:31 / pjw

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130827 PD JS
Lab ID: B13082306-004
Client Sample ID 20130825 PD 052

Report Date: 08/28/13
Collection Date: 08/25/13 18:00
DateReceived: 08/27/13
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	08/27/13 14:51 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/27/13 14:31 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	09/09/13
Project:	20130827 PD WS	**Collection Date:**	08/26/13 10:01
Lab ID:	B13082307-002	**DateReceived:**	08/27/13
Client Sample ID	20130826 PD 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	08/27/13 15:02 / jlw
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/27/13 14:31 / pjw
Solids, Total Dissolved TDS @ 180 C	3310	mg/L		10		A2540 C	08/27/13 15:42 / pjw
METALS, TOTAL							
Iron	0.24	mg/L		0.03		E200.7	08/28/13 16:38 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	09/06/13 16:03 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/26/13
Project:	20130712 P.D.	**Collection Date:**	07/12/13 08:20
Lab ID:	B13071112-001	**DateReceived:**	07/12/13
Client Sample ID	20130712 P.D. 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	07/15/13 10:47 / bas
Conductivity @ 25 C	580	umhos/cm		5		A2510 B	07/15/13 10:47 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/13/13 15:31 / qcj
Solids, Total Dissolved TDS @ 180 C	383	mg/L		10		A2540 C	07/12/13 16:00 / pjw
INORGANICS							
Chloride	1	mg/L		1		E300.0	07/16/13 19:41 / jrs
Sulfate	224	mg/L		1		E300.0	07/16/13 19:41 / jrs
Sodium Adsorption Ratio (SAR)	0.16	unitless		0.01		Calculation	07/22/13 12:05 / jrs
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.05	mg/L		0.01		E353.2	07/15/13 09:54 / bls
METALS, DISSOLVED							
Aluminum	ND	mg/L		0.03		E200.7	07/19/13 15:58 / rlh
Calcium	72	mg/L		1		E200.7	07/19/13 15:58 / rlh
Magnesium	28	mg/L		1		E200.7	07/19/13 15:58 / rlh
Sodium	6	mg/L		1		E200.7	07/19/13 15:58 / rlh
METALS, TOTAL							
Iron	0.12	mg/L		0.03		E200.7	07/16/13 16:07 / rlh
METALS, TOTAL RECOVERABLE							
Arsenic	ND	mg/L		0.001		E200.8	07/15/13 23:23 / mas
Boron	0.05	mg/L		0.05		E200.7	07/16/13 16:11 / rlh
Cadmium	ND	mg/L		0.001		E200.8	07/15/13 23:23 / mas
Chromium	ND	mg/L		0.005		E200.8	07/15/13 23:23 / mas
Copper	ND	mg/L		0.005		E200.8	07/15/13 23:23 / mas
Lead	ND	mg/L		0.001		E200.8	07/15/13 23:23 / mas
Mercury	ND	mg/L		0.0001		E245.1	07/15/13 15:04 / ser
Nickel	ND	mg/L		0.005		E200.8	07/15/13 23:23 / mas
Selenium	ND	mg/L		0.001		E200.8	07/15/13 23:23 / mas
Silver	ND	mg/L		0.001		E200.8	07/15/13 23:23 / mas
Zinc	ND	mg/L		0.01		E200.8	07/15/13 23:23 / mas
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	07/25/13 15:25 / eli-g

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/30/13
Project:	20130715 P.D.	**Collection Date:**	07/13/13 12:00
Lab ID:	B13071347-003	**DateReceived:**	07/16/13
Client Sample ID	20130713 P.D. 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.4	s.u.	H	0.1		A4500-H B	07/17/13 08:55 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/17/13 09:43 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	07/30/13
Project:	20130715 P.D.		**Collection Date:**	07/14/13 12:01
Lab ID:	B13071347-006		**DateReceived:**	07/16/13
Client Sample ID	20130714 P.D. 052		**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.4	s.u.	H	0.1		A4500-H B	07/17/13 09:05 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/17/13 09:43 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/30/13
Project:	20130715 P.D.	**Collection Date:**	07/15/13 08:50
Lab ID:	B13071347-008	**DateReceived:**	07/16/13
Client Sample ID	20130715 P.D. 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	07/17/13 09:11 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/17/13 09:47 / qej
Solids, Total Dissolved TDS @ 180 C	408	mg/L		10		A2540 C	07/17/13 09:31 / pjw
METALS, TOTAL							
Iron	0.28	mg/L		0.03		E200.7	07/18/13 18:54 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	07/29/13 15:34 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/30/13
Project:	20130715 P.D.	**Collection Date:**	07/16/13 06:33
Lab ID:	B13071347-012	**DateReceived:**	07/16/13
Client Sample ID	20130716 P.D. 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	07/17/13 09:34 / bas
Solids, Total Suspended TSS @ 105 C	17	mg/L		10		A2540 D	07/17/13 09:47 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	08/08/13
Project:	20130726 P.D.		**Collection Date:**	07/26/13 11:11
Lab ID:	B13072404-001		**DateReceived:**	07/26/13
Client Sample ID	20130726 P.D. 052A		**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	07/29/13 11:06 / bas
Solids, Total Suspended TSS @ 105 C	10	mg/L		10		A2540 D	07/27/13 13:51 / qej
Solids, Total Dissolved TDS @ 180 C	2220	mg/L		10		A2540 C	07/29/13 10:25 / pjw
METALS, TOTAL							
Iron	0.14	mg/L		0.03		E200.7	07/30/13 20:01 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	08/07/13 13:50 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/09/13
Project:	20130730 P.D.	**Collection Date:**	07/30/13 09:00
Lab ID:	B13072691-001	**DateReceived:**	07/31/13
Client Sample ID	20130730 P.D. 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	08/02/13 14:52 / tlj
Conductivity @ 25 C	2510	umhos/cm		5		A2510 B	08/02/13 14:52 / tlj
Solids, Total Suspended TSS @ 105 C	10	mg/L		10		A2540 D	08/01/13 10:21 / qej
Solids, Total Dissolved TDS @ 180 C	2370	mg/L		10		A2540 C	08/01/13 10:56 / pjw
INORGANICS							
Chloride	13	mg/L	D	2		E300.0	08/02/13 11:22 / jrs
Sulfate	1700	mg/L	D	10		E300.0	08/02/13 11:22 / jrs
Sodium Adsorption Ratio (SAR)	1.12	unitless		0.01		Calculation	08/07/13 09:53 / jrs
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.40	mg/L		0.01		E353.2	08/02/13 13:05 / bls
METALS, DISSOLVED							
Aluminum	0.10	mg/L		0.03		E200.7	08/02/13 13:42 / rlh
Calcium	220	mg/L		1		E200.7	08/02/13 13:42 / rlh
Magnesium	191	mg/L		1		E200.7	08/02/13 13:42 / rlh
Sodium	94	mg/L		1		E200.7	08/02/13 13:42 / rlh
METALS, TOTAL							
Iron	0.14	mg/L		0.03		E200.7	08/02/13 21:19 / rlh
METALS, TOTAL RECOVERABLE							
Arsenic	ND	mg/L		0.001		E200.8	08/03/13 07:17 / mas
Boron	0.30	mg/L		0.05		E200.7	08/02/13 21:23 / rlh
Cadmium	ND	mg/L		0.001		E200.8	08/03/13 07:17 / mas
Chromium	ND	mg/L		0.005		E200.8	08/03/13 07:17 / mas
Copper	ND	mg/L		0.005		E200.8	08/07/13 16:59 / jjw
Lead	ND	mg/L		0.001		E200.8	08/03/13 07:17 / mas
Mercury	ND	mg/L		0.0001		E245.1	08/01/13 16:39 / ser
Nickel	ND	mg/L		0.005		E200.8	08/05/13 12:32 / mas
Selenium	0.003	mg/L		0.001		E200.8	08/08/13 13:20 / AMM
Silver	ND	mg/L		0.001		E200.8	08/03/13 07:17 / mas
Zinc	ND	mg/L		0.01		E200.8	08/03/13 07:17 / mas
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	08/07/13 13:42 / oil-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
H - Analysis performed past recommended holding time.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	08/05/13
Project:	20130731 P.D.	**Collection Date:**	07/31/13 14:07
Lab ID:	B13072693-001	**DateReceived:**	07/31/13
Client Sample ID	20130731 P.D. 052	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	08/02/13 14:57 / tlj
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	08/01/13 10:21 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/16/13
Project:	20130701 P.D. 101	**Collection Date:**	07/01/13 08:15
Lab ID:	B13070073-001	**DateReceived:**	07/01/13
Client Sample ID	20130701 P.D. 101	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	07/02/13 12:36 / bas
Conductivity @ 25 C	1710	umhos/cm		5		A2510 B	07/02/13 12:36 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/03/13 15:17 / qej
Solids, Total Dissolved TDS @ 180 C	1370	mg/L		10		A2540 C	07/05/13 10:49 / pjw
INORGANICS							
Chloride	4	mg/L	D	2		E300.0	07/06/13 23:08 / jrs
Sulfate	930	mg/L	D	10		E300.0	07/06/13 23:08 / jrs
Sodium Adsorption Ratio (SAR)	1.46	unitless		0.01		Calculation	07/05/13 12:35 / jrs
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.80	mg/L		0.01		E353.2	07/08/13 09:59 / bls
METALS, DISSOLVED							
Aluminum	ND	mg/L		0.03		E200.7	07/03/13 16:01 / rlh
Calcium	141	mg/L		1		E200.7	07/03/13 16:01 / rlh
Magnesium	110	mg/L		1		E200.7	07/03/13 16:01 / rlh
Sodium	96	mg/L		1		E200.7	07/03/13 16:01 / rlh
METALS, TOTAL							
Iron	0.06	mg/L		0.03		E200.7	07/03/13 01:12 / rlh
METALS, TOTAL RECOVERABLE							
Arsenic	ND	mg/L		0.001		E200.8	07/02/13 19:05 / mas
Boron	0.22	mg/L		0.05		E200.7	07/03/13 01:12 / rlh
Cadmium	ND	mg/L		0.001		E200.8	07/02/13 19:05 / mas
Chromium	ND	mg/L		0.005		E200.8	07/02/13 19:05 / mas
Copper	ND	mg/L		0.005		E200.8	07/02/13 19:05 / mas
Lead	ND	mg/L		0.001		E200.8	07/02/13 19:05 / mas
Mercury	ND	mg/L		0.0001		E245.1	07/03/13 11:05 / ser
Nickel	ND	mg/L		0.005		E200.8	07/02/13 19:05 / mas
Selenium	0.004	mg/L		0.001		E200.8	07/02/13 19:05 / mas
Silver	ND	mg/L		0.001		E200.8	07/02/13 19:05 / mas
Zinc	ND	mg/L		0.01		E200.7	07/03/13 01:12 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	07/15/13 16:18 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
H - Analysis performed past recommended holding time.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/18/13
Project:	20130708 P.D.	**Collection Date:**	07/02/13 11:10
Lab ID:	B13070499-002	**DateReceived:**	07/08/13
Client Sample ID	20130702 P.D. 101	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	07/08/13 17:05 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/09/13 10:24 / pjw

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/18/13
Project:	20130708 P.D.	**Collection Date:**	07/03/13 11:05
Lab ID:	B13070499-004	**DateReceived:**	07/08/13
Client Sample ID	20130703 P.D. 101	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.4	s.u.	H	0.1		A4500-H B	07/08/13 17:12 / bas
Solids, Total Suspended TSS @ 105 C	10	mg/L		10		A2540 D	07/09/13 10:25 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/18/13
Project:	20130708 P.D.	**Collection Date:**	07/08/13 10:45
Lab ID:	B13070499-006	**DateReceived:**	07/08/13
Client Sample ID	20130708 P.D. 101	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.4	s.u.	H	0.1		A4500-H B	07/08/13 17:19 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/09/13 10:25 / pjw
Solids, Total Dissolved TDS @ 180 C	1430	mg/L		10		A2540 C	07/09/13 13:05 / pjw
METALS, TOTAL							
Iron	0.16	mg/L		0.03		E200.7	07/10/13 22:06 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	07/18/13 13:14 / oli-g

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	07/16/13
Project:	20130712 P.D.		**Collection Date:**	07/09/13 09:00
Lab ID:	B13071118-001		**DateReceived:**	07/12/13
Client Sample ID	20130709 P.D. 101		**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	07/15/13 10:49 / bas
Solids, Total Suspended TSS @ 105 C	20	mg/L		10		A2540 D	07/13/13 15:31 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/16/13
Project:	20130712 P.D.	**Collection Date:**	07/10/13 09:00
Lab ID:	B13071118-003	**DateReceived:**	07/12/13
Client Sample ID	20130710 P.D. 101	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	07/15/13 10:54 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/13/13 15:31 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

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LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/16/13
Project:	20130712 P.D.	**Collection Date:**	07/11/13 08:00
Lab ID:	B13071118-005	**DateReceived:**	07/12/13
Client Sample ID	20130711 P.D. 101	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	07/15/13 11:02 / bas
Solids, Total Suspended TSS @ 105 C	27	mg/L		10		A2540 D	07/13/13 15:31 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/16/13
Project:	20130712 P.D.	**Collection Date:**	07/12/13 08:01
Lab ID:	B13071118-007	**DateReceived:**	07/12/13
Client Sample ID	20130712 P.D. 101	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	07/15/13 11:07 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	07/13/13 15:31 / qoj

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/30/13
Project:	20130715 P.D.	**Collection Date:**	07/13/13 11:20
Lab ID:	B13071347-001	**DateReceived:**	07/16/13
Client Sample ID	20130713 P.D. 101	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.4	s.u.	H	0.1		A4500-H B	07/17/13 08:46 / bas
Solids, Total Suspended TSS @ 105 C	12	mg/L		10		A2540 D	07/17/13 09:43 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/30/13
Project:	20130715 P.D.	**Collection Date:**	07/14/13 11:07
Lab ID:	B13071347-004	**DateReceived:**	07/16/13
Client Sample ID	20130714 P.D. 101	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.4	s.u.	H	0.1		A4500-H B	07/17/13 08:58 / bas
Solids, Total Suspended TSS @ 105 C	11	mg/L		10		A2540 D	07/17/13 09:43 / qej

Report Definitions:
- RL - Analyte reporting limit.
- QCL - Quality control limit.
- H - Analysis performed past recommended holding time.
- MCL - Maximum contaminant level.
- ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	07/30/13
Project:	20130715 P.D.		**Collection Date:**	07/15/13 09:25
Lab ID:	B13071347-009		**DateReceived:**	07/16/13
Client Sample ID	20130715 P.D. 101		**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	07/17/13 09:14 / bas
Solids, Total Suspended TSS @ 105 C	21	mg/L		10		A2540 D	07/17/13 09:47 / qej
Solids, Total Dissolved TDS @ 180 C	1490	mg/L		10		A2540 C	07/17/13 09:31 / pjw
METALS, TOTAL							
Iron	0.46	mg/L		0.03		E200.7	07/18/13 19:47 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	07/29/13 15:42 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/30/13
Project:	20130715 P.D.	**Collection Date:**	07/16/13 05:57
Lab ID:	B13071347-011	**DateReceived:**	07/16/13
Client Sample ID	20130716 P.D. 101	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	07/17/13 09:29 / bas
Solids, Total Suspended TSS @ 105 C	15	mg/L		10		A2540 D	07/17/13 09:47 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/24/13
Project:	20130612 P.D.	**Collection Date:**	06/11/13 13:20
Lab ID:	B13061047-001	**DateReceived:**	06/12/13
Client Sample ID	20130611 P.D. 139	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.9	s.u.	H	0.1		A4500-H B	06/13/13 09:51 / bas
Conductivity @ 25 C	2120	umhos/cm		5		A2510 B	06/13/13 09:51 / bas
Solids, Total Suspended TSS @ 105 C	14	mg/L		10		A2540 D	06/15/13 10:29 / qej
Solids, Total Dissolved TDS @ 180 C	1900	mg/L		10		A2540 C	06/13/13 10:48 / pjw
INORGANICS							
Chloride	4	mg/L	D	2		E300.0	06/13/13 23:03 / jrs
Sulfate	1330	mg/L	D	10		E300.0	06/13/13 23:03 / jrs
Sodium Adsorption Ratio (SAR)	0.46	unitless		0.01		Calculation	06/17/13 12:48 / jrs
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.34	mg/L		0.01		E353.2	06/14/13 09:06 / bls
METALS, DISSOLVED							
Aluminum	0.10	mg/L		0.03		E200.7	06/14/13 21:12 / rlh
Calcium	269	mg/L		1		E200.7	06/14/13 21:12 / rlh
Magnesium	143	mg/L		1		E200.7	06/14/13 21:12 / rlh
Sodium	38	mg/L		1		E200.7	06/14/13 21:12 / rlh
METALS, TOTAL							
Iron	0.37	mg/L		0.03		E200.7	06/15/13 03:47 / rlh
METALS, TOTAL RECOVERABLE							
Arsenic	ND	mg/L		0.001		E200.8	06/14/13 15:18 / mas
Boron	0.46	mg/L		0.05		E200.7	06/15/13 03:51 / rlh
Cadmium	ND	mg/L		0.001		E200.8	06/14/13 15:18 / mas
Chromium	ND	mg/L		0.005		E200.8	06/14/13 15:18 / mas
Copper	ND	mg/L		0.005		E200.8	06/14/13 15:18 / mas
Lead	ND	mg/L		0.001		E200.8	06/14/13 15:18 / mas
Mercury	ND	mg/L		0.0001		E245.1	06/13/13 12:14 / ser
Nickel	0.016	mg/L		0.005		E200.8	06/14/13 15:18 / mas
Selenium	0.002	mg/L		0.001		E200.8	06/14/13 15:18 / mas
Silver	ND	mg/L		0.001		E200.8	06/14/13 15:18 / mas
Zinc	ND	mg/L		0.01		E200.8	06/14/13 15:18 / mas
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	06/21/13 07:42 / eli-g

Report Definitions:
- RL - Analyte reporting limit.
- QCL - Quality control limit.
- D - RL increased due to sample matrix.
- MCL - Maximum contaminant level.
- ND - Not detected at the reporting limit.
- H - Analysis performed past recommended holding time.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/24/13
Project:	20130612 P.D.	**Collection Date:**	06/12/13 09:00
Lab ID:	B13061047-003	**DateReceived:**	06/12/13
Client Sample ID	20130612 P.D. 139	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.9	s.u.	H	0.1		A4500-H B	06/13/13 09:56 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/15/13 10:29 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/28/13
Project:	20130617 P.D.	**Collection Date:**	06/13/13 12:11
Lab ID:	B13061468-015	**DateReceived:**	06/17/13
Client Sample ID	20130613 P.D. 139	**Matrix:**	Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	06/18/13 14:55 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/18/13 09:51 / pjw

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130617 P.D.
Lab ID: B13061468-010
Client Sample ID 20130614 P.D. 139

Report Date: 06/28/13
Collection Date: 06/14/13 14:00
DateReceived: 06/17/13
Matrix: Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	06/21/13 07:27 / bas
Solids, Total Suspended TSS @ 105 C	10	mg/L		10		A2540 D	06/18/13 11:17 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/28/13
Project:	20130617 P.D.	**Collection Date:**	06/15/13 20:50
Lab ID:	B13061468-008	**DateReceived:**	06/17/13
Client Sample ID	20130615 P.D. 139	**Matrix:**	Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.9	s.u.	H	0.1		A4500-H B	06/18/13 14:31 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/18/13 11:17 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130617 P.D.
Lab ID: B13061468-005
Client Sample ID 20130616 P.D. 139

Report Date: 06/28/13
Collection Date: 06/16/13 15:11
DateReceived: 06/17/13
Matrix: Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.9	s.u.	H	0.1		A4500-H B	06/18/13 14:18 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/18/13 11:16 / pjw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	06/28/13
Project:	20130617 P.D.		**Collection Date:**	06/17/13 12:51
Lab ID:	B13061468-003		**DateReceived:**	06/17/13
Client Sample ID	20130617 P.D. 139		**Matrix:**	Waste Water

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	06/18/13 14:13 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/18/13 09:51 / pjw
Solids, Total Dissolved TDS @ 180 C	1810	mg/L		10		A2540 C	06/20/13 09:36 / pjw
METALS, TOTAL							
Iron	0.12	mg/L		0.03		E200.7	06/20/13 23:26 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	06/27/13 14:43 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/25/13
Project:	20130619 P.D.	**Collection Date:**	06/18/13 10:01
Lab ID:	B13061802-001	**DateReceived:**	06/20/13
Client Sample ID	20130618 P.D. 139	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.0	s.u.	H	0.1		A4500-H B	06/21/13 15:54 / bas
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/21/13 13:36 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/09/13
Project:	20130625 P.D.	**Collection Date:**	06/20/13 09:46
Lab ID:	B13062211-001	**DateReceived:**	06/25/13
Client Sample ID	20130620 P.D. 139	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.9	s.u.	H	0.1		A4500-H B	06/26/13 11:58 / tlj
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/26/13 12:35 / gej

Report Definitions:

RL - Analyte reporting limit.

QCL - Quality control limit.

H - Analysis performed past recommended holding time.

MCL - Maximum contaminant level.

ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/09/13
Project:	20130625 P.D.	**Collection Date:**	06/21/13 21:15
Lab ID:	B13062211-006	**DateReceived:**	06/25/13
Client Sample ID	20130621 P.D. 139	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.9	s.u.	H	0.1		A4500-H B	06/26/13 12:13 / tlj
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/26/13 12:36 / gej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130625 P.D.
Lab ID: B13062211-008
Client Sample ID 20130622 P.D. 139

Report Date: 07/09/13
Collection Date: 06/22/13 15:23
DateReceived: 06/25/13
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.8	s.u.	H	0.1		A4500-H B	06/26/13 13:49 / tlj
Solids, Total Suspended TSS @ 105 C	20	mg/L		10		A2540 D	06/26/13 12:36 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20130625 P.D.
Lab ID: B13062211-011
Client Sample ID 20130623 P.D. 139

Report Date: 07/09/13
Collection Date: 06/23/13 21:28
DateReceived: 06/25/13
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.8	s.u.	H	0.1		A4500-H B	06/26/13 14:09 / tlj
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/26/13 12:37 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co		**Report Date:**	07/09/13
Project:	20130625 P.D.		**Collection Date:**	06/25/13 08:07
Lab ID:	B13062211-015		**DateReceived:**	06/25/13
Client Sample ID	20130625 P.D. 139		**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	7.8	s.u.	H	0.1		A4500-H B	06/26/13 14:22 / llj
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	06/26/13 12:37 / qej
Solids, Total Dissolved TDS @ 180 C	1920	mg/L		10		A2540 C	06/27/13 10:14 / qej
METALS, TOTAL							
Iron	0.24	mg/L		0.03		E200.7	06/27/13 22:19 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	07/08/13 15:59 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	06/27/13
Project:	20130625 139 Al	**Collection Date:**	06/25/13 11:11
Lab ID:	B13062215-001	**DateReceived:**	06/25/13
Client Sample ID	20130625 139 Al	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
METALS, DISSOLVED							
Aluminum	0.05	mg/L		0.03		E200.7	06/26/13 19:01 / rlh

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/02/13
Project:	20130627 P.D.	**Collection Date:**	06/26/13 09:44
Lab ID:	B13062487-001	**DateReceived:**	06/27/13
Client Sample ID	20130626 139 Al	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
METALS, DISSOLVED							
Aluminum	0.07	mg/L		0.03		E200.7	07/01/13 22:13 / rlh

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/11/13
Project:	20130701 P.D. 046	**Collection Date:**	06/27/13 09:12
Lab ID:	B13070070-002	**DateReceived:**	07/01/13
Client Sample ID	20130627 139 Al	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
METALS, DISSOLVED							
Aluminum	0.07	mg/L		0.03		E200.7	07/03/13 15:34 / rlh

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	07/11/13
Project:	20130701 P.D. 046	**Collection Date:**	06/28/13 10:10
Lab ID:	B13070070-004	**DateReceived:**	07/01/13
Client Sample ID	20130628 139 Al	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
METALS, DISSOLVED							
Aluminum	ND	mg/L		0.03		E200.7	07/03/13 15:38 / rlh

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	05/06/14
Project:	20140422 PD 144 and Prep 100	**Collection Date:**	04/23/14 14:00
Lab ID:	B14042103-002	**DateReceived:**	04/24/14
Client Sample ID:	PD 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	04/24/14 15:37 / cnm
Conductivity @ 25 C	1910	umhos/cm		5		A2510 B	04/24/14 15:37 / cnm
Solids, Total Suspended TSS @ 105 C	29	mg/L		10		A2540 D	05/02/14 11:30 / qej
Solids, Total Settleable	ND	mL/L		0.5		A2540 F	04/25/14 08:40 / qej
Solids, Total Dissolved TDS @ 180 C	1650	mg/L		10		A2540 C	04/25/14 08:21 / pjw
INORGANICS							
Chloride	11	mg/L		1		E300.0	04/30/14 07:20 / jpv
Sulfate	1080	mg/L	D	5		E300.0	04/30/14 07:20 / jpv
Sodium Adsorption Ratio (SAR)	0.77	unitless		0.01		Calculation	04/29/14 15:57 / sln
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	0.05	mg/L		0.01		E353.2	04/29/14 14:33 / klc
METALS, DISSOLVED							
Aluminum	0.060	mg/L		0.009		E200.8	04/25/14 23:56 / mas
Calcium	174	mg/L		1		E200.7	04/25/14 16:34 / rlh
Magnesium	165	mg/L		1		E200.7	04/25/14 16:34 / rlh
Sodium	59	mg/L		1		E200.7	04/25/14 16:34 / rlh
METALS, TOTAL RECOVERABLE							
Arsenic	0.003	mg/L		0.001		E200.8	04/25/14 21:03 / amm
Boron	0.27	mg/L		0.05		E200.7	04/26/14 00:35 / rlh
Cadmium	0.00003	mg/L		0.00003		E200.8	04/25/14 21:03 / amm
Chromium	ND	mg/L		0.005		E200.8	04/25/14 21:03 / amm
Copper	0.004	mg/L		0.002		E200.8	04/25/14 21:03 / amm
Iron	1.41	mg/L		0.02		E200.7	04/26/14 00:35 / rlh
Lead	0.0012	mg/L		0.0003		E200.8	04/25/14 21:03 / amm
Mercury	ND	mg/L		5E-06		E245.1	04/28/14 15:06 / ser
Nickel	0.003	mg/L		0.002		E200.8	04/25/14 21:03 / amm
Selenium	ND	mg/L		0.001		E200.8	04/28/14 17:51 / amm
Silver	ND	mg/L		0.0002		E200.8	04/25/14 21:03 / amm
Zinc	ND	mg/L		0.008		E200.7	04/26/14 00:35 / rlh
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	2	mg/L		1		E1664A	05/05/14 09:29 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
H - Analysis performed past recommended holding time.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	05/05/14
Project:	20140429 P.D. 144 & 046	**Collection Date:**	04/24/14 13:00
Lab ID:	B14042555-002	**DateReceived:**	04/30/14
Client Sample ID:	P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	04/30/14 14:14 / cnm
Solids, Total Suspended TSS @ 105 C	35	mg/L		10		A2540 D	04/30/14 11:06 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co.	**Report Date:**	05/05/14
Project:	20140429 P.D. 144 & 046	**Collection Date:**	04/25/14 11:09
Lab ID:	B14042555-004	**DateReceived:**	04/30/14
Client Sample ID:	P.D. 046	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	04/30/14 14:19 / cnm
Solids, Total Suspended TSS @ 105 C	23	mg/L		10		A2540 D	04/30/14 11:06 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Western Energy Co
Project: 20140422 P.D. 144 & Prep 100
Lab ID: B14041944-001
Client Sample ID: PD 144

Revised Date: 05/07/14
Report Date: 04/30/14
Collection Date: 04/22/14 13:05
DateReceived: 04/23/14
Matrix: Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	04/23/14 13:38 / bas
Conductivity @ 25 C	322	umhos/cm		5		A2510 B	04/23/14 13:38 / bas
Solids, Total Suspended TSS @ 105 C	13	mg/L		10		A2540 D	05/02/14 11:29 / qej
Solids, Total Settleable	ND	mL/L		0.5		A2540 F	04/23/14 10:00 / pjw
Solids, Total Dissolved TDS @ 180 C	214	mg/L		10		A2540 C	04/23/14 14:47 / qej
INORGANICS							
Chloride	1	mg/L		1		E300.0	04/25/14 16:27 / jpv
Sulfate	50	mg/L		1		E300.0	04/25/14 16:27 / jpv
Sodium Adsorption Ratio (SAR)	0.06	unitless		0.01		Calculation	04/25/14 14:50 / sln
NUTRIENTS							
Nitrogen, Nitrate+Nitrite as N	ND	mg/L		0.01		E353.2	04/23/14 14:59 / klc
METALS, DISSOLVED							
Aluminum	0.023	mg/L		0.009		E200.8	04/24/14 17:15 / amm
Calcium	48	mg/L		1		E200.7	04/24/14 11:58 / mas
Magnesium	13	mg/L		1		E200.7	04/24/14 11:58 / mas
Sodium	2	mg/L		1		E200.7	04/24/14 11:58 / mas
METALS, TOTAL RECOVERABLE							
Arsenic	0.001	mg/L		0.001		E200.8	04/25/14 00:14 / jjw
Boron	ND	mg/L		0.1		E200.7	04/24/14 23:52 / mas
Cadmium	ND	mg/L		0.00003		E200.8	04/25/14 00:14 / jjw
Chromium	ND	mg/L		0.01		E200.7	04/24/14 23:52 / mas
Copper	0.002	mg/L		0.002		E200.8	04/25/14 00:14 / jjw
Iron	0.63	mg/L		0.02		E200.7	04/24/14 23:52 / mas
Lead	0.0006	mg/L		0.0003		E200.8	04/25/14 00:14 / jjw
Nickel	0.002	mg/L		0.002		E200.8	04/25/14 00:14 / jjw
Selenium	ND	mg/L		0.001		E200.8	04/25/14 00:14 / jjw
Silver	ND	mg/L		0.0002		E200.8	04/26/14 03:18 / amm
Zinc	ND	mg/L		0.008		E200.7	04/24/14 23:52 / mas
METALS, TOTAL							
Mercury	ND	mg/L		5E-06		E245.1	04/23/14 14:30 / ser
ORGANIC CHARACTERISTICS							
Oil & Grease (HEM)	ND	mg/L		1		E1664A	04/29/14 08:42 / eli-g

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	05/06/14
Project:	20140422 PD 144 and Prep 100	**Collection Date:**	04/23/14 08:50
Lab ID:	B14042103-001	**DateReceived:**	04/24/14
Client Sample ID:	PD 144	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.2	s.u.	H	0.1		A4500-H B	04/24/14 15:16 / cnm
Solids, Total Suspended TSS @ 105 C	11	mg/L		10		A2540 D	04/24/14 14:06 / qej

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.

MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	05/05/14
Project:	20140429 P.D. 144 & 046	**Collection Date:**	04/24/14 09:20
Lab ID:	B14042555-001	**DateReceived:**	04/30/14
Client Sample ID:	P.D. 144	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.1	s.u.	H	0.1		A4500-H B	04/30/14 14:11 / cnm
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	04/30/14 11:06 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Western Energy Co	**Report Date:**	05/05/14
Project:	20140429 P.D. 144 & 046	**Collection Date:**	04/25/14 12:00
Lab ID:	B14042555-003	**DateReceived:**	04/30/14
Client Sample ID:	P.D. 144	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
pH	8.3	s.u.	H	0.1		A4500-H B	04/30/14 14:16 / cnm
Solids, Total Suspended TSS @ 105 C	ND	mg/L		10		A2540 D	04/30/14 11:06 / qej

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

Exhibit A

Exhibit B

Attachment A

PERMIT NO.: MT0023965 – Modification 1
Major Industrial

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY

AUTHORIZATION TO DISCHARGE UNDER THE
MONTANA POLLUTANT DISCHARGE ELIMINATION SYSTEM (MPDES)

In compliance with Montana Water Quality Act, Title 75, Chapter 5, Montana Code Annotated (MCA) and the Federal Water Pollution Control Act (the "Clean Water Act"), 33 U.S.C. § 1251 et seq.,

WESTERN ENERGY COMPANY (the Permittee)

is authorized to discharge from its **ROSEBUD MINE**

located at **CASTLE ROCK ROAD, COLSTRIP, MT, 59323**

to receiving waters named **EAST FORK ARMELLS CREEK, STOCKER CREEK, LEE COULEE, WEST FORK ARMELLS CREEK, BLACK HANK CREEK, DONLEY CREEK, COW CREEK, SPRING CREEK, AND PONY CREEK**

in accordance with discharge point(s), effluent limitations, monitoring requirements and other conditions set forth herein. Authorization for discharge is limited to those outfalls specifically listed in the permit.

This permit shall become effective: November 1, 2012

This permit and the authorization to discharge shall expire at midnight, October 31, 2017.

FOR THE MONTANA DEPARTMENT OF
ENVIRONMENTAL QUALITY

Jon Kenning, Chief
Water Protection Bureau
Permitting & Compliance Division

Modified Date: September 8, 2014

TABLE OF CONTENTS

TABLE OF FIGURES

I. EFFLUENT LIMITATIONS AND MONITORING & REPORTING REQUIREMENTS

A. Description of Discharge Point(s) and Mixing Zone(s)

The authorization to discharge provided under this permit is limited to those outfalls specially designated below as discharge locations. Discharges at any location not authorized under an MPDES permit is a violation of the Montana Water Quality Act and could subject the person(s) responsible for such discharge to penalties under the Act. Knowingly discharging from an unauthorized location or failing to report an unauthorized discharge within a reasonable time from first learning of an unauthorized discharge could subject such person to criminal penalties as provided under Montana Water Quality Act, Section 75-5-632.

Table 1 below provides a description of the discharge points and mixing zones for each outfall. Treatment consists of the use of sediment ponds or traps, with a 10-year, 24-hour design capacity, to remove suspended solids from commingled storm water and pit water or coal plant wash down water.

Table 1. Description of Discharge Points and Mixing Zones

Outfall	Mine Area	Latitude	Longitude	Receiving Water/ Mixing Zone[1]
08D	A	45°55'07.54"N	106°35'25.86"W	East Fork Armells Creek
009	A	45°52'32.07"N	106°37'43.04"W	East Fork Armells Creek
09A	A	45°52'20.24"N	106°37'54.51"W	East Fork Armells Creek
13A	A	45°52'07.74"N	106°38'18.66"W	East Fork Armells Creek
014	A	45°51'57.46"N	106°38'46.04"W	East Fork Armells Creek
016	A	45°51'51.96"N	106°38'58.45"W	East Fork Armells Creek
16A	A	45°51'41.63"N	106°39'26.47"W	East Fork Armells Creek
023	A	45°51'38.54"N	106°40'22.36"W	East Fork Armells Creek
024	A	45°51'36.25"N	106°40'49.67"W	East Fork Armells Creek
069	A	45°52'52.27"N	106°42'08.78"W	Stocker Creek
070	A	45°53'06.14"N	106°41'57.75"W	Stocker Creek
071	A	45°53'21.63"N	106°41'15.25"W	Stocker Creek
71C	A	45°53'30.68"N	106°40'51.29"W	Stocker Creek
072	A	45°53'44.52"N	106°40'05.27"W	Stocker Creek
073	A	45°53'42.82"N	106°39'47.94"W	Stocker Creek
73A	A	45°53'41.42"N	106°39'44.54"W	Stocker Creek
074	A	45°53'40.81"N	106°39'28.20"W	Stocker Creek
075	A	45°53'32.77"N	106°39'04.81"W	East Fork Armells Creek (via Castle Rock Lake)
10C	B-East	45°52'0.79"N	106°36'33.27"W	East Fork Armells Creek
011	B-East	45°52'05.58"N	106°37'41.89"W	East Fork Armells Creek
012	B-East	45°52'01.49"N	106°38'02.54"W	East Fork Armells Creek
015	B-East	45°51'50.96"N	106°38'35.06"W	East Fork Armells Creek
018	B-East	45°51'35.98"N	106°39'12.49"W	East Fork Armells Creek
019	B-East	45°51'42.01"N	106°39'06.64"W	East Fork Armells Creek

Outfall	Mine Area	Latitude	Longitude	Receiving Water/ Mixing Zone[1]
020	B-East	45°51'29.58"N	106°39'44.17"W	East Fork Armells Creek
021	B-East	45°51'30.22"N	106°39'54.40"W	East Fork Armells Creek
022	B-East	45°51'30.98"N	106°39'56.35"W	East Fork Armells Creek
025	B-East	45°51'15.98"N	106°41'10.74"W	East Fork Armells Creek
026	B-West	45°51'07.26"N	106°41'36.91"W	East Fork Armells Creek
048	B-West	45°51'01.15"N	106°42'20.53"W	East Fork Armells Creek
056	B-West	45°50'42.13"N	106°44'04.97"W	East Fork Armells Creek
061	B-West	45°50'35.05"N	106°45'10.86"W	East Fork Armells Creek
127	B-West	45°50'38.66"N	106°46'49.00"W	East Fork Armells Creek
128	B-West	45°50'31.87"N	106°45'32.31"W	East Fork Armells Creek
128A	B-West	45°50'34.08"N	106°45'38.26"W	East Fork Armells Creek
128B	B-West	45°50'34.81"N	106°45'46.23"W	East Fork Armells Creek
128C	B-West	45°50'38.81"N	106°45'54.30"W	East Fork Armells Creek
128D	B-West	45°50'47.96"N	106°46'22.90"W	East Fork Armells Creek
129	B-West	45°50'38.45"N	106°44'26.24"W	East Fork Armells Creek
133	B-West	45°50'36.76"N	106°43'50.01"W	East Fork Armells Creek
136	B-West	45°50'38.29"N	106°43'31.85"W	East Fork Armells Creek
137	B-West	45°50'52.10"N	106°42'52.53"W	East Fork Armells Creek
139	B-West	45°50'59.84"N	106°42'07.16"W	East Fork Armells Creek
130	B-West	45°49'55.94"N	106°45'06.47"W	Lee Coulee
130A	B-West	45°49'55.93"N	106°44'31.72"W	Lee Coulee
130B	B-West	45°49'55.83"N	106°44'26.12"W	Lee Coulee
131	B-West	45°49'55.88"N	106°44'02.06"W	Lee Coulee
131A	B-West	45°49'55.95"N	106°43'54.32"W	Lee Coulee
132	B-West	45°49'56.11"N	106°43'42.38"W	Lee Coulee
134	B-West	45°49'56.10"N	106°43'05.84"W	Lee Coulee
030	C-East	45°52'36.96"N	106°46'06.14"W	Stocker Creek
032	C-East	45°52'19.00"N	106°45'47.23"W	Stocker Creek
033	C-East	45°52'31.74"N	106°45'14.89"W	Stocker Creek
034	C-East	45°52'31.68"N	106°45'08.32"W	Stocker Creek
035	C-East	45°52'20.96"N	106°44'06.26"W	Stocker Creek
036	C-East	45°52'30.83"N	106°43'26.38"W	Stocker Creek
037	C-East	45°52'32.24"N	106°43'09.49"W	Stocker Creek
038	C-East	45°52'31.49"N	106°42'51.82"W	Stocker Creek
039	C-East	45°52'29.39"N	106°42'20.73"W	Stocker Creek
040	C-East	45°52'25.06"N	106°42'12.23"W	Stocker Creek
041	C-East	45°52'20.67"N	106°42'07.31"W	Stocker Creek
042	C-East	45°51'53.75"N	106°41'30.62"W	East Fork Armells Creek
043	C-East	45°51'24.42"N	106°41'24.81"W	East Fork Armells Creek
044	C-East	45°51'15.98"N	106°41'39.21"W	East Fork Armells Creek
046	C-East	45°51'26.75"N	106°42'11.71"W	East Fork Armells Creek

Outfall	Mine Area	Latitude	Longitude	Receiving Water/ Mixing Zone[1]
049	C-East	45°51'10.96"N	106°42'54.96"W	East Fork Armells Creek
051	C-East	45°51'06.15"N	106°43'17.06"W	East Fork Armells Creek
052	C-East	45°50'57.26"N	106°43'41.63"W	East Fork Armells Creek
054	C-East	45°50'52.05"N	106°43'47.21"W	East Fork Armells Creek
058	C-East	45°50'50.79"N	106°44'24.22"W	East Fork Armells Creek
059	C-East	45°50'48.65"N	106°44'47.60"W	East Fork Armells Creek
59A	C-East	45°50'40.95"N	106°45'16.11"W	East Fork Armells Creek
060	C-East	45°50'39.79"N	106°45'44.60"W	East Fork Armells Creek
063	C-East	45°50'46.26"N	106°46'05.19"W	East Fork Armells Creek
064	C-East	45°50'58.75"N	106°46'33.31"W	East Fork Armells Creek
116	C-North	45°53'35.82"N	106°46'34.19"W	Stocker Creek
116A	C-North	45°53'31.76"N	106°46'19.29"W	Stocker Creek
119	C-North	45°53'08.08"N	106°45'48.84"W	Stocker Creek
121	C-North	45°52'44.18"N	106°46'08.98"W	Stocker Creek
121A	C-North	45°52'53.13"N	106°46'02.02"W	Stocker Creek
109	C-North	45°52'27.56"N	106°48'51.92"W	West Fork Armells Creek
112	C-North	45°53'23.54"N	106°48'15.03"W	West Fork Armells Creek
112A	C-North	45°53'24.12"N	106°47'24.00"W	West Fork Armells Creek
112B	C-North	45°53'30.74"N	106°47'08.03"W	West Fork Armells Creek
113	C-North	45°53'25.58"N	106°47'30.84"W	West Fork Armells Creek
096	C-West	45°53'16.74"N	106°52'30.57"W	Black Hank Creek
098	C-West	45°53'29.64"N	106°51'55.76"W	Donley Creek
095	C-West	45°53'13.99"N	106°51'30.80"W	West Fork Armells Creek
95A	C-West	45°53'20.03"N	106°51'35.24"W	West Fork Armells Creek
100	C-West	45°53'03.80"N	106°51'15.05"W	West Fork Armells Creek
101	C-West	45°52'55.77"N	106°50'57.26"W	West Fork Armells Creek
103	C-West	45°52'49.42"N	106°50'41.34"W	West Fork Armells Creek
104	C-West	45°52'45.78"N	106°50'30.14"W	West Fork Armells Creek
104A	C-West	45°52'41.11"N	106°47'39.94"W	West Fork Armells Creek
105	C-West	45°52'31.32"N	106°49'56.43"W	West Fork Armells Creek
106	C-West	45°52'33.21"N	106°49'42.00"W	West Fork Armells Creek
107	C-West	45°52'30.39"N	106°49'35.37"W	West Fork Armells Creek
108	C-West	45°52'33.16"N	106°49'26.97"W	West Fork Armells Creek
006	D	45°53'48.32"N	106°35'10.13"W	Cow Creek
007	D	45°54'14.87"N	106°36'48.10"W	East Fork Armells Creek
077	D	45°55'06.57"N	106°36'35.71"W	East Fork Armells Creek
079	D	45°55'13.15"N	106°36'08.19"W	East Fork Armells Creek
080	D	45°55'18.56"N	106°35'36.78"W	Spring Creek
082	D	45°55'21.56"N	106°35'07.92"W	Spring Creek
083	D	45°55'17.69"N	106°34'51.79"W	Spring Creek
090	D	45°53'52.24"N	106°34'00.13"W	Cow Creek

Outfall	Mine Area	Latitude	Longitude	Receiving Water/ Mixing Zone[1]
091	D	45°53'50.76"N	106°34'25.62"W	Cow Creek
092	D	45°53'50.38"N	106°34'37.70"W	Cow Creek
093	D	45°53'28.95"N	106°35'05.66"W	Cow Creek
141	D	45°54'53.18"N	106°36'51.03"W	East Fork Armells Creek
142	D	45°54'41.31"N	106°36'42.86"W	East Fork Armells Creek
143	D	45°54'32.92"N	106°36'46.36"W	East Fork Armells Creek
144	D	45°54'02.64"N	106°36'45.56"W	East Fork Armells Creek
151	D	45°52'56.29"N	106°35'31.64"W	Cow Creek
152	D	45°52'56.29"N	106°35'31.64"W	Cow Creek
153	D	45°53'07.09"N	106°35'22.24"W	Cow Creek
154	D	45°53'13.55"N	106°35'13.54"W	Cow Creek
155	D	45°53'23.19"N	106°35'11.24"W	Cow Creek
194	D	45°53'04.86"N	106°36'28.22"W	East Fork Armells Creek
195	D	45°53'04.57"N	106°36'13.69"W	East Fork Armells Creek
173	D-East	45°53'57.75"N	106°32'00.13"W	Cow Creek
175	D-East	45°53'50.23"N	106°32'35.82"W	Cow Creek
176	D-East	45°53'54.21"N	106°33'04.49"W	Cow Creek
177	D-East	45°53'52.02"N	106°35'18.38"W	Cow Creek
178	D-East	45°53'49.59"N	106°33'30.32"W	Cow Creek
179	D-East	45°53'50.86"N	106°33'52.65"W	Cow Creek
165	D-East	45°54'44.68"N	106°32'59.42"W	Pony Creek
166	D-East	45°54'44.69"N	106°33'04.25"W	Pony Creek
167	D-East	45°54'44.90"N	106°33'08.88"W	Pony Creek
168	D-East	45°54'44.71"N	106°33'19.72"W	Pony Creek
169	D-East	45°54'36.85"N	106°33'25.23"W	Pony Creek
169A	D-East	45°54'30.32"N	106°33'24.93"W	Pony Creek
170	D-East	45°54'19.05"N	106°33'06.14"W	Pony Creek
171	D-East	45°54'14.03"N	106°32'58.49"W	Pony Creek
172	D-East	45°54'13.94"N	106°32'39.80"W	Pony Creek
084	D-East	45°54'13.94"N	106°32'39.80"W	Spring Creek
085	D-East	45°55'02.18"N	106°34'11.91"W	Spring Creek
086	D-East	45°55'07.26"N	106°34'00.12"W	Spring Creek
160A	D-East	45°55'07.65"N	106°33'42.39"W	Spring Creek
160B	D-East	45°55'07.50"N	106°33'48.45"W	Spring Creek
161	D-East	45°55'07.08"N	106°33'29.29"W	Spring Creek
161A	D-East	45°55'07.62"N	106°33'34.39"W	Spring Creek
162	D-East	45°55'07.73"N	106°33'25.15"W	Spring Creek
163	D-East	45°55'07.04"N	106°33'01.10"W	Spring Creek
164	D-East	45°55'02.77"N	106°32'56.35"W	Spring Creek
010	E	45°52'12.48"N	106°37'05.52"W	East Fork Armells Creek
10A	E	45°52'30.01"N	106°36'42.14"W	East Fork Armells Creek

Outfall	Mine Area	Latitude	Longitude	Receiving Water/ Mixing Zone[1]
003	E	45°51'20.85"N	106°34'00.17"W	Cow Creek
004	E	45°52'10.22"N	106°34'54.76"W	Cow Creek
005	E	45°52'35.11"N	106°35'24.77"W	Cow Creek
027	E	45°51'56.32"N	106°34'28.47"W	Cow Creek

Footnotes:
1. There are no acute, chronic, or human health mixing zones allowed for any outfall.

B. Final Effluent Limitations and Monitoring Requirements

Effective immediately and lasting through the term of the permit, the quality of effluent discharged at each outfall shall, as a minimum, meet the limitations set forth in Tables 2 through 8, below. All monitoring shall be conducted at the overflow structure where effluent discharges as overflow from the sediment control structure, or at the end of the discharge pipe when pumped or drained, and prior to contact with the receiving water. Monitoring must be conducted at a minimum monitoring frequency and sampling type specified in Tables 2 through 8. Samples must achieve the listed required reporting value (RRV) or minimum level (ML).

Table 2. Final Numeric Effluent Limitations and Monitoring Requirements – Discharges to East Fork Armells Creek[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
Total Suspended Solids (TSS)	mg/L	35	70	1/Day	Grab	10
pH	s.u.	Between 6.0 and 9.0		1/Day	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Month	Grab	9
Iron, Total	mg/L	3.5	7.0	1/Week	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Month	Grab	1
Oil and Grease	mg/L	--	10	1/Week	Grab	1
Total Dissolved Solids (TDS)	mg/L	3000	4500	1/Week	Grab	10
Sulfate	mg/L	2050	3075	1/Month	Grab	10
Boron	mg/L	0.70	1.1	1/Month	Grab	0.01
Flow	gpd	Report Only		1/Day	Continuous	--
Chloride	µg/L	Report Only		1/Month	Grab	--
Electrical Conductivity (EC)	µS/cm	Report Only		1/Month	Grab	10
Sodium Adsorption Ratio (SAR)	Unitless	Report Only		1/Month	Calculated	0.1
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Month	Grab	0.02
Metals, Total Recoverable[3]	µg/L	Report Only		1/Year	Grab	--[3]
Whole Effluent Toxicity, Acute[4]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the East Fork Armells Creek drainage are Outfalls 08D, 009, 09A, 13A, 014, 016, 16A, 023, 024, 075, 10C, 011, 012, 015, 018, 019, 020, 021, 022, 025, 026, 048, 056, 061, 127, 128, 128A, 128B, 128C, 128D, 129, 133, 136, 137, 139, 042, 043, 044, 046, 049, 051, 052, 054, 058, 059, 59A, 060, 063, 064, 079, 141, 142, 194, 010, and 10A
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0. 3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
4. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

Table 3. Final Numeric Effluent Limitations and Monitoring Requirements – Discharges to West Fork Armells, Black Hank, and Donley Creeks[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
TSS	mg/L	35	70	1/Day	Grab	10
pH	s.u.	Between 6.0 and 9.0		1/Day	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Month	Grab	9
Iron, Total	mg/L	3.5	7.0	1/Week	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Month	Grab	1
Oil and Grease	mg/L	--	10	1/Week	Grab	1
TDS	mg/L	2600	3900	1/Week	Grab	10
Sulfate	mg/L	1500	2250	1/Month	Grab	10
Boron	mg/L	0.40	0.60	1/Month	Grab	0.01
Flow	gpd	Report Only		1/Day	Continuous	--
Chloride	µg/L	Report Only		1/Month	Grab	--
EC	µS/cm	Report Only		1/Month	Grab	10
SAR	Unitless	Report Only		1/Month	Calculated	0.1
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Month	Grab	0.02
Metals, Total Recoverable[3]	µg/L	Report Only		1/Year	Grab	--[3]
Whole Effluent Toxicity, Acute[4]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the West Fork Armells Creek drainage are Outfalls 109, 095, 95A, 100, 101, 103, 104, 104A, 105, 106, 107, and 108. The Outfall that is in the Black Hank Creek drainage is Outfall 096. The Outfall that is in the Donley Creek drainage is Outfall 098.
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
4. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

Table 4. Final Numeric Effluent Limitations and Monitoring Requirements – Discharges to Stocker Creek[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
TSS	mg/L	35	70	1/Day	Grab	10
pH	s.u.	Between 6.0 and 9.0		1/Day	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Month	Grab	9
Iron, Total	mg/L	3.5	7.0	1/Week	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Month	Grab	1
Oil and Grease	mg/L	--	10	1/Week	Grab	1
TDS	mg/L	3950	5925	1/Week	Grab	10
Sulfate	mg/L	2400	3600	1/Month	Grab	10
Boron	mg/L	1.0	1.5	1/Month	Grab	0.01
Flow	gpd	Report Only		1/Day	Continuous	--
Chloride	µg/L	Report Only		1/Month	Grab	--
EC	µS/cm	Report Only		1/Month	Grab	10
SAR	Unitless	Report Only		1/Month	Calculated	0.1
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Month	Grab	0.02
Metals, Total Recoverable[3]	µg/L	Report Only		1/Year	Grab	--[3]
Whole Effluent Toxicity, Acute[4]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the Stocker Creek drainage are Outfalls 069, 070, 071, 71C, 072, 073, 73A, 074, 030, 032, 033, 034, 035, 036, 037, 038, 039, 040, 041, 116, 116A, 119, 121, and 121A
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
4. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

Table 5. Final Numeric Effluent Limitations and Monitoring Requirements – Discharges to Lee Coulee[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
TSS	mg/L	35	70	1/Day	Grab	10
pH	s.u.	Between 6.0 and 9.0		1/Day	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Month	Grab	9
Iron, Total	mg/L	3.5	7.0	1/Week	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Month	Grab	1
Oil and Grease	mg/L	--	10	1/Week	Grab	1
EC	µS/cm	500	500	1/Month	Grab	10
SAR	Unitless	Report Only		1/Month	Calculated	0.1
Sulfate	mg/L	1500	2250	1/Month	Grab	10

Boron	mg/L	0.40	0.60	1/Month	Grab	0.01
Flow	gpd	Report Only		1/Day	Continuous	--
Chloride	µg/L	Report Only		1/Month	Grab	--
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Month	Grab	0.02
Metals, Total Recoverable[3]	µg/L	Report Only		1/Year	Grab	--[3]
Whole Effluent Toxicity, Acute[4]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the Lee Coulee drainage are Outfalls 130, 130A, 130B, 131, 131A, 132, and 134
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
4. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

Table 6. Final Numeric Effluent Limitations and Monitoring Requirements – Discharges to Pony Creek[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
TSS	mg/L	35	70	1/Day	Grab	10
pH	s.u.	Between 6.0 and 9.0		1/Day	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Month	Grab	9
Iron, Total	mg/L	3.5	7.0	1/Week	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Month	Grab	1
Oil and Grease	mg/L	--	10	1/Week	Grab	1
EC	µS/cm	500	500	1/Month	Grab	10
SAR	Unitless	Report Only		1/Month	Calculated	0.1
Sulfate	mg/L	1550	2325	1/Month	Grab	10
Boron	mg/L	1.2	1.8	1/Month	Grab	0.01
Flow	gpd	Report Only		1/Day	Continuous	--
Chloride	µg/L	Report Only		1/Month	Grab	--
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Month	Grab	0.02
Metals, Total Recoverable[3]	µg/L	Report Only		1/Year	Grab	--[3]
Whole Effluent Toxicity, Acute[4]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the Pony Creek drainage are Outfalls 165, 166, 167, 168, 169, 169A, 170, 171, and 172
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.

4. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

Table 7. Final Numeric Effluent Limitations and Monitoring Requirements – Discharges to Cow Creek[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
TSS	mg/L	35	70	1/Day	Grab	10
pH	s.u.	Between 6.0 and 9.0		1/Day	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Month	Grab	9
Iron, Total	mg/L	3.5	7.0	1/Week	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Month	Grab	1
Oil and Grease	mg/L	--	10	1/Week	Grab	1
EC	µS/cm	500	500	1/Month	Grab	10
SAR	Unitless	Report Only		1/Month	Calculated	0.1
Sulfate	mg/L	2300	3450	1/Month	Grab	10
Boron	mg/L	1.6	2.4	1/Month	Grab	0.01
Flow	gpd	Report Only		1/Day	Continuous	--
Chloride	µg/L	Report Only		1/Month	Grab	--
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Month	Grab	0.02
Metals, Total Recoverable[3]	µg/L	Report Only		1/Year	Grab	--[3]
Whole Effluent Toxicity, Acute[4]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the Cow Creek drainage are Outfalls 090, 091, 092, 152, 153, 154, 155, 173, 175, 176, 177, 178, 179, 003, 004, 005, and 027
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
4. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

Table 8. Final Numeric Effluent Limitations and Monitoring Requirements – Discharges to Spring Creek[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
TSS	mg/L	35	70	1/Day	Grab	10
pH	s.u.	Between 6.0 and 9.0		1/Day	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Month	Grab	9
Iron, Total	mg/L	3.5	7.0	1/Week	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Month	Grab	1
Oil and Grease	mg/L	--	10	1/Week	Grab	1

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
EC	µS/cm	500	500	1/Month	Grab	10
SAR	Unitless	Report Only		1/Month	Calculated	0.1
Sulfate	mg/L	1300	1950	1/Month	Grab	10
Boron	mg/L	1.1	1.7	1/Month	Grab	0.01
Flow	gpd	Report Only		1/Day	Continuous	--
Chloride	µg/L	Report Only		1/Month	Grab	--
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Month	Grab	0.02
Metals, Total Recoverable[3]	µg/L	Report Only		1/Year	Grab	--[3]
Whole Effluent Toxicity, Acute[4]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the Spring Creek drainage are Outfalls 080, 085, 086, 160A, 160B, 161, 161A, 162, 163, and 164
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
4. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

a. Narrative Effluent Limitations: All Outfalls

Effective immediately and lasting through the term of this permit, discharges from all outfalls shall be free from substances that will:

i. settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines;
ii. create floating debris, scum, a visible oil film, or globule of grease or other floating materials;
iii. produce odors, colors, or other conditions that create a nuisance or render undesirable tastes to fish flesh or make fish inedible;
iv. create conditions that produce undesirable aquatic life; or
v. create concentrations or combinations of materials which are toxic or harmful to human, animal, plant, or aquatic life.

b. Monitoring Locations:

The Permittee shall establish monitoring locations at each outfall to demonstrate compliance with the effluent limitations and other requirements in section I of this Permit. Appropriate monitoring locations include: at the overflow structure where the effluent discharges as overflow from the sediment control structure, or at the end of the discharge pipe when pumped or drained, and prior to contact with the receiving water.

The Permittee shall monitor effluent at the specific monitoring location during discharge. The location of each outfall regulated by this permit shall be permanently identified in the field.

1. **Alternate Numeric Effluent Limitations and Monitoring Requirements –** Alternate effluent limitations and monitoring requirements will be applied to discharges driven by precipitation events and/or snowmelt. Effluent limitations and monitoring requirements presented in Tables 9 through 15 will be applied alternately to the otherwise applicable effluent limitations and monitoring requirements presented in Tables 2 through 8.

Table 9. Alternate Numeric Effluent Limitations and Monitoring Requirements – Precipitation Events – Discharges to East Fork Armells Creek[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
Settleable Solids[3]	ml/L	--	0.5	1/Discharge	Grab	0.5
pH	s.u.	Between 6.0 and 9.0		1/Discharge	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Discharge	Grab	9
Iron, Total	mg/L	Report Only		1/Discharge	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Discharge	Grab	1
Oil and Grease	mg/L	--	10	1/Discharge	Grab	1
TDS	mg/L	--	4500	1/Discharge	Grab	10
Sulfate	mg/L	--	3075	1/Discharge	Grab	10
Boron	mg/L	--	1.1	1/Discharge	Grab	0.01
Flow	gpd	Report Only		1/Discharge	Continuous	--
Chloride	µg/L	Report Only		1/Discharge	Grab	--
EC	µS/cm	Report Only		1/Discharge	Grab	10
SAR	Unitless	Report Only		1/Discharge	Calculated	0.1
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Discharge	Grab	0.02
Metals, Total Recoverable[4]	µg/L	Report Only		1/Year	Grab	--[4]
Whole Effluent Toxicity, Acute[5]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the East Fork Armells Creek drainage are Outfalls 08D, 009, 09A, 13A, 014, 016, 16A, 023, 024, 075, 10C, 011, 012, 015, 018, 019, 020, 021, 022, 025, 026, 048, 056, 061, 127, 128, 128A, 128B, 128C, 128D, 129, 133, 136, 137, 139, 042, 043, 044, 046, 049, 051, 052, 054, 058, 059, 59A, 060, 063, 064, 079, 141, 142, 194, 010, and 10A
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Applicable to discharges or increases in the volume of discharges caused by precipitation within any 24 hour period less than or equal to the 10-yr, 24-hr precipitation event (or snowmelt of equivalent volume)
4. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
5. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

Table 10. Alternate Numeric Effluent Limitations and Monitoring Requirements – Precipitation Events – Discharges to West Fork Armells, Black Hank, and Donley Creeks[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
Settleable Solids[3]	ml/L	--	0.5	1/Discharge	Grab	0.5
pH	s.u.	Between 6.0 and 9.0		1/Discharge	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Discharge	Grab	9
Iron, Total	mg/L	Report Only		1/Discharge	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Discharge	Grab	1
Oil and Grease	mg/L	--	10	1/Discharge	Grab	1
TDS	mg/L	--	3900	1/Discharge	Grab	10
Sulfate	mg/L	--	2250	1/Discharge	Grab	10
Boron	mg/L	--	0.60	1/Discharge	Grab	0.01
Flow	gpd	Report Only		1/Discharge	Continuous	--
Chloride	µg/L	Report Only		1/Discharge	Grab	--
EC	µS/cm	Report Only		1/Discharge	Grab	10
SAR	Unitless	Report Only		1/Discharge	Calculated	0.1
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Discharge	Grab	0.02
Metals, Total Recoverable[4]	µg/L	Report Only		1/Year	Grab	--[4]
Whole Effluent Toxicity, Acute[5]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the West Fork Armells Creek drainage are Outfalls 109, 095, 95A, 100, 101, 103, 104, 104A, 105, 106, 107, and 108. The Outfall that is in the Black Hank Creek drainage is Outfall 096. The Outfall that is in the Donley Creek drainage is Outfall 098.
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Applicable to discharges or increases in the volume of discharges caused by precipitation within any 24 hour period less than or equal to the 10-yr, 24-hr precipitation event (or snowmelt of equivalent volume)
4. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
5. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

Table 11. Alternate Numeric Effluent Limitations and Monitoring Requirements – Precipitation Events – Discharges to Stocker Creek[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
Settleable Solids[3]	ml/L	--	0.5	1/Discharge	Grab	0.5
pH	s.u.	Between 6.0 and 9.0		1/Discharge	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Discharge	Grab	9
Iron, Total	mg/L	Report Only		1/Discharge	Grab	0.02

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
Selenium, Total	µg/L	Report Only		1/Discharge	Grab	1
Oil and Grease	mg/L	--	10	1/Discharge	Grab	1
TDS	mg/L	--	5925	1/Discharge	Grab	10
Sulfate	mg/L	--	3600	1/Discharge	Grab	10
Boron	mg/L	--	1.5	1/Discharge	Grab	0.01
Flow	gpd	Report Only		1/Discharge	Continuous	--
Chloride	µg/L	Report Only		1/Discharge	Grab	--
EC	µS/cm	Report Only		1/Discharge	Grab	10
SAR	Unitless	Report Only		1/Discharge	Calculated	0.1
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Discharge	Grab	0.02
Metals, Total Recoverable[4]	µg/L	Report Only		1/Year	Grab	--[4]
Whole Effluent Toxicity, Acute[5]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the Stocker Creek drainage are Outfalls 069, 070, 071, 71C, 072, 073, 73A, 074, 030, 032, 033, 034, 035, 036, 037, 038, 039, 040, 041, 116, 116A, 119, 121, and 121A
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Applicable to discharges or increases in the volume of discharges caused by precipitation within any 24 hour period less than or equal to the 10-yr, 24-hr precipitation event (or snowmelt of equivalent volume)
4. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury 0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
5. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

Table 12. Alternate Numeric Effluent Limitations and Monitoring Requirements – Precipitation Events – Discharges to Lee Coulee[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
Settleable Solids[3]	ml/L	--	0.5	1/Discharge	Grab	0.5
pH	s.u.	Between 6.0 and 9.0		1/Discharge	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Discharge	Grab	9
Iron, Total	mg/L	Report Only		1/Discharge	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Discharge	Grab	1
Oil and Grease	mg/L	--	10	1/Discharge	Grab	1
EC	µS/cm	--	500	1/Discharge	Grab	10
SAR	Unitless	Report Only		1/Discharge	Calculated	0.1
Sulfate	mg/L	--	2250	1/Discharge	Grab	10
Boron	mg/L	--	0.60	1/Discharge	Grab	0.01
Flow	gpd	Report Only		1/Discharge	Continuous	--
Chloride	µg/L	Report Only		1/Discharge	Grab	--

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Discharge	Grab	0.02
Metals, Total Recoverable[4]	µg/L	Report Only		1/Year	Grab	--[4]
Whole Effluent Toxicity, Acute[5]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the Lee Coulee drainage are Outfalls 130, 130A, 130B, 131, 131A, 132, and 134
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Applicable to discharges or increases in the volume of discharges caused by precipitation within any 24 hour period less than or equal to the 10-yr, 24-hr precipitation event (or snowmelt of equivalent volume)
4. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
5. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

Table 13. Alternate Numeric Effluent Limitations and Monitoring Requirements – Precipitation Events – Discharges to Pony Creek[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
Settleable Solids[3]	ml/L	--	0.5	1/Discharge	Grab	0.5
pH	s.u.	Between 6.0 and 9.0		1/Discharge	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Discharge	Grab	9
Iron, Total	mg/L	Report Only		1/Discharge	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Discharge	Grab	1
Oil and Grease	mg/L	--	10	1/Discharge	Grab	1
EC	µS/cm	--	500	1/Discharge	Grab	10
SAR	Unitless	Report Only		1/Discharge	Calculated	0.1
Sulfate	mg/L	--	2325	1/Discharge	Grab	10
Boron	mg/L	--	1.8	1/Discharge	Grab	0.01
Flow	gpd	Report Only		1/Discharge	Continuous	--
Chloride	µg/L	Report Only		1/Discharge	Grab	--
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Discharge	Grab	0.02
Metals, Total Recoverable[4]	µg/L	Report Only		1/Year	Grab	--[4]
Whole Effluent Toxicity, Acute[5]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the Pony Creek drainage are Outfalls 165, 166, 167, 168, 169, 169A, 170, 171, and 172
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.

3. Applicable to discharges or increases in the volume of discharges caused by precipitation within any 24 hour period less than or equal to the 10-yr, 24-hr precipitation event (or snowmelt of equivalent volume)
4. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
5. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

Table 14. Alternate Numeric Effluent Limitations and Monitoring Requirements – Precipitation Events – Discharges to Cow Creek[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
Settleable Solids[3]	ml/L	--	0.5	1/Discharge	Grab	0.5
pH	s.u.	Between 6.0 and 9.0		1/Discharge	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Discharge	Grab	9
Iron, Total	mg/L	Report Only		1/Discharge	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Discharge	Grab	1
Oil and Grease	mg/L	--	10	1/Discharge	Grab	1
EC	µS/cm	--	500	1/Discharge	Grab	10
SAR	Unitless	Report Only		1/Discharge	Calculated	0.1
Sulfate	mg/L	--	3450	1/Discharge	Grab	10
Boron	mg/L	--	2.4	1/Discharge	Grab	0.01
Flow	gpd	Report Only		1/Discharge	Continuous	--
Chloride	µg/L	Report Only		1/Discharge	Grab	--
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Discharge	Grab	0.02
Metals, Total Recoverable[4]	µg/L	Report Only		1/Year	Grab	--[4]
Whole Effluent Toxicity, Acute[5]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the Cow Creek drainage are Outfalls 090, 091, 092, 152, 153, 154, 155, 173, 175, 176, 177, 178, 179, 003, 004, 005, and 027
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Applicable to discharges or increases in the volume of discharges caused by precipitation within any 24 hour period less than or equal to the 10-yr, 24-hr precipitation event (or snowmelt of equivalent volume)
4. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
5. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details).

Table 15. Alternate Numeric Effluent Limitations and Monitoring Requirements – Precipitation Events – Discharges to Spring Creek[1]

Parameter	Units	Average Monthly Limitation	Maximum Daily Limitation	Minimum Monitoring Frequency	Sample Type	RRV or ML[2]
Settleable Solids[3]	ml/L	--	0.5	1/Discharge	Grab	0.5
pH	s.u.	Between 6.0 and 9.0		1/Discharge	Grab	0.1
Aluminum, Dissolved	µg/L	Report Only		1/Discharge	Grab	9
Iron, Total	mg/L	Report Only		1/Discharge	Grab	0.02
Selenium, Total	µg/L	Report Only		1/Discharge	Grab	1
Oil and Grease	mg/L	--	10	1/Discharge	Grab	1
EC	µS/cm	--	500	1/Discharge	Grab	10
SAR	Unitless	Report Only		1/Discharge	Calculated	0.1
Sulfate	mg/L	--	1950	1/Discharge	Grab	10
Boron	mg/L	--	1.7	1/Discharge	Grab	0.01
Flow	gpd	Report Only		1/Discharge	Continuous	--
Chloride	µg/L	Report Only		1/Discharge	Grab	--
Nitrate + Nitrite (as N)	mg/L	Report Only		1/Discharge	Grab	0.02
Metals, Total Recoverable[4]	µg/L	Report Only		1/Year	Grab	--[4]
Whole Effluent Toxicity, Acute[5]	% Effluent	Report Only		1/Year	Grab	--

Footnotes:

1. The Outfalls that are in the Spring Creek drainage are Outfalls 080, 085, 086, 160A, 160B, 161, 161A, 162, 163, and 164
2. Required reporting values (RRV) for parameters listed in *Circular DEQ-7 Montana Numeric Water Quality Standards* are current as of the October 2012 edition.
3. Applicable to discharges or increases in the volume of discharges caused by precipitation within any 24 hour period less than or equal to the 10-yr, 24-hr precipitation event (or snowmelt of equivalent volume)
4. Metals include those metals with aquatic life numeric standards contained in the Montana *Circular DEQ-7 Montana Numeric Water Quality Standard*: arsenic (1), cadmium (0.03), chromium (10), copper (2), lead (0.3), mercury (0.005), nickel (2), silver (0.2), and zinc (8) as total recoverable. Corresponding RRV's (µg/L) are in parentheses behind each parameter.
5. Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas", and "coal plant water circuit", as determined in 40 CFR 434.11 are conducted or are located (see permit Section I.C.3 for details)

a. **Monitoring Locations:**

Due to the number of outfalls at the facility and inaccessibility of remote outfalls, representative monitoring will be allowed only for discharges resulting from precipitation events. Discharges consisting of stormwater runoff from areas classified as "Alkaline Mine Drainage" and "Coal Preparation Plants and Coal Preparation Plant Associated Areas" (40 CFR 434 Subparts B and D) may be sampled at the representative outfalls listed in Table 16, corresponding to 20% of total outfalls.

Sampling equipment must be installed at representative monitoring locations to ensure flow measurement and automatic sample collection regardless of weather and/or site conditions.

Table 16. Summary of Representative Monitoring Outfalls – Precipitation-Driven Discharges

Outfall	40 CFR 434 Subpart	Mine Area	Receiving Water
009	B	A	E. Fork Armells Creek
09A	B	A	E. Fork Armells Creek
16A	B	A	E. Fork Armells Creek
075	D	A	Stocker Creek
10C	D	B-East	E. Fork Armells Creek
011	D	B-East	E. Fork Armells Creek
021	B	B-East	E. Fork Armells Creek
128	D	B-West	E. Fork Armells Creek
133	D	B-West	E. Fork Armells Creek
139	D	B-West	E. Fork Armells Creek
035	D	C-East	Stocker Creek
043	B	C-East	E. Fork Armells Creek
046	D	C-East	E. Fork Armells Creek
058	D	C-East	E. Fork Armells Creek
095	D	C-West	W. Fork Armells Creek
096	D	C-West	Black Hank Creek
105	D	C-West	W. Fork Armells Creek
109	D	C-Central	W. Fork Armells Creek
083	D	D	Spring Creek
194	B	D	E. Fork Armells Creek

b. Sample Methods

The permittee shall collect a grab sample within the first thirty minutes of discharge from any permitted outfall for any discharges which results from a precipitation related events, at minimum. As an alternative to a single grab sample, the permittee may take a flow-weighted composite of either the entire discharge or for the first three hours of the discharge. For a flow-weighted composite, only one analysis of the composited aliquots is required. Flow-weighted composite samples are not allowed for pH, total phenols, and oil and grease.

2. Effluent Limitations and Monitoring Requirements – Western Alkaline Coal Mining

During the period beginning on the effective date of this permit and lasting through the date of expiration, the permittee is authorized to discharge runoff from those outfalls listed in Table 17 to their corresponding receiving waters. <u>Effluent sampling and flow measurement are not required, and numeric effluent limitations do not apply to discharges from those outfalls listed in Table 17.</u> Such discharges shall be limited and monitored by the permittee as specified below. The permittee has submitted a site-specific Sediment Control Plan (SCP) that identifies Best Management Practices (BMPs), including design specifications, construction specifications, maintenance schedules, criteria for inspection, and expected performance and longevity of the BMPs. The SCP has also demonstrated using watershed models that implementation of the SCP will result in average annual sediment yields that will not be greater than the sediment yield levels from pre-mined, undisturbed conditions. The watershed model is the same model that was used to acquire the permittee's SMCRA permit.

Table 17. Outfalls Subject to Western Alkaline Coal Mining Standards

Outfall	Mine Area	Receiving Water
073	A	Stocker Creek
073A	A	Stocker Creek
074	A	Stocker Creek
036	C-East	Stocker Creek
037	C-East	Stocker Creek
038	C-East	Stocker Creek
039	C-East	East Fork Armells Creek
040	C-East	East Fork Armells Creek
041	C-East	East Fork Armells Creek
042	C-East	East Fork Armells Creek
112	C-North	West Fork Armells Creek
112A	C-North	West Fork Armells Creek
112B	C-North	West Fork Armells Creek
113	C-North	West Fork Armells Creek
116	C-North	Stocker Creek
116A	C-North	Stocker Creek
119	C-North	Stocker Creek
121	C-North	Stocker Creek
121A	C-North	Stocker Creek
006	D	Cow Creek
007	D	East Fork Armells Creek
077	D	East Fork Armells Creek
079	D	East Fork Armells Creek
082	D	Spring Creek
083	D	Spring Creek
090	D	Cow Creek
091	D	Cow Creek
092	D	Cow Creek
093	D	Cow Creek
141	D	East Fork Armells Creek
142	D	East Fork Armells Creek

Outfall	Mine Area	Receiving Water
143	D	East Fork Armells Creek
144	D	East Fork Armells Creek
151	D	Cow Creek
152	D	Cow Creek
153	D	Cow Creek
154	D	Cow Creek
155	D	Cow Creek
195	D	East Fork Armells Creek
084	D-East	Spring Creek
085	D-East	Spring Creek
086	D-East	Spring Creek
160A	D-East	Spring Creek
160B	D-East	Spring Creek
161A	D-East	Spring Creek
161	D-East	Spring Creek
162	D-East	Spring Creek
163	D-East	Spring Creek
164	D-East	Spring Creek
165	D-East	Pony Creek
166	D-East	Pony Creek
167	D-East	Pony Creek
168	D-East	Pony Creek
169	D-East	Pony Creek
169A	D-East	Pony Creek
173	D-East	Cow Creek
175	D-East	Cow Creek
176	D-East	Cow Creek
177	D-East	Cow Creek
178	D-East	Cow Creek
179	D-East	Cow Creek
170	D-East	Pony Creek
171	D-East	Pony Creek
172	D-East	Pony Creek
010	E	East Fork Armells Creek
003	E	Cow Creek

Outfall	Mine Area	Receiving Water
004	E	Cow Creek
005	E	Cow Creek
027	E	Cow Creek

Sediment Control Plan

The permittee shall during the term of this permit operate the facility in accordance with the SCP. Department approval of the SCP is based upon a demonstration that the Best Management Practices (BMP) given in the Plan will result in an average annual sediment yield that is less than the pre-mine undisturbed condition for the outfalls and watersheds specified in Table 17, above. The approved SCP applies to, and is limited to, reclamation areas, brushing and grubbing areas, topsoil stockpiling areas, and regraded areas, and is applicable until the facility receives final bond release.

a. Managerial Best Management Practices

Managerial sediment control BMPs include project design and planning methods used to protect water quality and minimize erosion and sedimentation (US EPA, 2001). Managerial BMPs are employed prior to, during, and following reclamation of a site.

i. *Proposed Design of Area*

The Permittee will minimize to the greatest extent possible the areas necessary to accomplish mining and conduct concurrent reclamation on disturbed areas. Erosion control will be accomplished as close as practicable to the source and must receive approval from state SMCRA permitting agencies. Post-mine topography, erosion control, and sediment control practices will be implemented to control overland flow, trap sediment in runoff or protect the disturbed land surface from erosion. Designs will be developed to meet the intent of the Western Alkaline Coal Mining subcategory to prevent increases in sediment transport above pre-mining levels. The Permittee commits to reclaim all mining-related land disturbances to a use equal to or better than what existed prior to mining.

The Western Energy Reclamation Plan within the Surface Mining Permit 86003A (WECO, 2007) addresses procedures that will be used at Rosebud Mine during reclamation activities. The following discussions from the Reclamation Plan are incorporated into the SCP.

ii. *Erosion Control*

Reclamation Planning. The relationship between topography, substrate and vegetation will be incorporated into reclamation design to promote successful vegetation re-establishment. Revegetation is divided into reclamation types; each type represents a particular plant or community type. Revegetation will be based on existing communities present prior to mining disturbances.

Re-contouring. After mining, overburden spoil piles will be re-graded to a topography meeting the SMCRA requirement of approximate original contour to facilitate erosion control, revegetation and the post-mining land use. Post-mining topography must be approved by the state regulatory agency and must meet the final land use requirements. Re-contouring of reclaimed areas will consider the following:

- planning post-mining topography using modeling to mimic approximate original contour or pre-mining natural, background erosion and sedimentation yields;
- designing and implementing a BMP plan that will approximate natural drainage as closely as possible;
- choosing sediment control structures according to review of existing topography, flow direction and volume, outlet location, and feasibility of construction;
- backfilling and grading to approximate original topography or other acceptable slope gradients and configurations;
- blending disturbed areas into the surrounding terrain;
- eliminating unstable areas to the greatest extent possible;
- with the exception of agricultural areas, re-graded landscapes are left in a roughened condition to minimize compaction; and
- coarse-textured substrates, including soils with high coarse-fragment content are used, particularly on sites with increased erosion potential, or where establishment of woody species is desired.

Soil Redistribution. Soil salvaged prior to mining disturbance is redistributed on appropriate regraded areas to meet a specific reclamation type. Soil laydown depths; specific to the type of reclamation will be of a thickness consistent with the soil resource and will promote its successful end use. The soil type, depth and redistribution must be approved by the Industrial Energy and Minerals Bureau (IEMB) to promote revegetation establishment, similar to the pre-mining conditions.

Soil Preparation on the Contour. Spoil scarification, soil placement, soil preparation and seeding are done on the contour provided the safety of equipment operators is not compromised. After soil lay down, soils are deep ripped to reduce subsurface compaction. The site will then be chisel plowed to breakup surface compaction and prepare an appropriate seedbed. Surface conditions will remain rough to aid in infiltration and mulch adherence (if applied).

Establishment of Vegetation. The Permittee has prepared an extensive revegetation plan for re-establishing vegetative communities on reclaimed areas. Approved vegetation plans require not only specific acreages but, specific vegetative communities to be reintroduced. Vegetation communities include lowland grasslands, shrub and complex shrub grasslands, and deciduous tree/shrub reclamation types. Upland communities include: grasslands, shrub/sagebrush/skunkbush sumac and complex shrub grasslands, deciduous tree/shrub, and conifer/shrub vegetation complexes.

Seedbed preparation techniques are specific to the vegetative communities and include: re-contouring and conditioning of spoils, topsoil type and depth, and seedbed preparation. Seed mixes for each community have been approved by the state SMCRA authority and require specific application rates and subsequent live plantings if required by the vegetation type.

Normal seeding periods include September through November (fall) and March through May (spring). Sufficient soil moisture and temperatures conditions may extend these periods. The Permittee has the option to mulch reclaimed areas should erosion potential exist; however, they are required to mulch areas with slopes greater than 3:1. The Permittee may use hydro-mulching instead of straw on slopes greater than 3:1 at a rate of 500 lbs/acre.

Permanent vegetation cover appropriate for the site typically is established by the end of the third growing season following initial seeding, although the reclaimed plant community will continue to develop. From a hydrologic perspective the objective is 75 percent cover, including litter, which defines "good" hydrologic condition for runoff and sediment modeling purposes.

iii. *Sediment Control*

At points of concentrated runoff flows, sediment control BMPs will be proposed to slow down runoff or capture sediment contained in the runoff. Site-specific BMPs include silt fence, straw waddles, straw or hay bales, matting/mulch, rip-rap etc. Exhibits 7 through 10 of the SCP contain Standard Notes for the construction of typical BMPs used on site. The Standard Notes contain information pertaining to design guidelines and maintenance/inspection criteria. Additional sediment control structures are described below.

Roadways Transecting Reclamation. Permanent or semi-permanent roadways crossing applicable reclaimed areas shall be constructed with conveyance structures (borrow ditches) capable of passing the runoff from a 10-year, 24-hour storm event. Energy dissipation (site-specific BMPs) structures will be used to reduce velocities of runoff to prevent sediment mobilization. Ditch transitions and intersections will be constructed to minimize erosion and sedimentation transport.

Road Crossings. Where drainage conveyance or watercourses are diverted beneath a roadway, culverts will be sized to convey a 10-year, 24-hour storm event. Inlet and outlet protection (rip-rap or matting) will be considered at high-risk locations to prevent sediment mobilization.

Small Depressions. During reclamation, sediment traps and ponds will be converted to small depressions designed for vegetation diversity and wildlife habitat enhancement in addition to short-term sediment capture. Small depressions may also be established on an opportunistic basis within the reclaimed area for vegetation diversity and wildlife habitat enhancement in addition to short-term sediment control. Small depressions will meet the following criteria:

- each depression on the interior of the reclaimed area will be one acre-foot or less in capacity;
- each depression at the margin of the reclaimed area will be two acre feet or less in capacity;
- no depression will be deeper than three feet;
- depressions will be soiled and revegetated;
- maximum slopes will be 5:1 on the uphill (inflow) side and 3:1 on the lateral and downhill (outflow) sides; and
- site-specific sediment control (silt fence, straw waddles, etc.) may be used at the outlet to further the effectiveness of the structure.

Sediment Traps. In smaller watersheds, which range from less than 10 to approximately 160 acres, ditching to convey and sediment traps to contain at a minimum the 2-year, 24-hour storm event plus appropriate sediment storage will be established prior to clearing, grubbing and soil salvage. Sediment traps or other appropriate BMPs will be used where drainage flows from disturbed to undisturbed or reclaimed areas. Other site-specific BMPs may be used to increase effectiveness of the trap.

Sediment Ponds. Sediment ponds or traps located at final discharge points are designed to detain runoff from a 10-year 24-hour storm event during active mining operations. Ponds or traps may be reduced in size to 2-year, 24-hour capacity during the reclamation phase, or they may be eliminated, with IEMB approval, when the contributing watershed is fully reclaimed and revegetated. Sediment traps may be reclaimed as small depressions for topographic, vegetative and wildlife habitat diversity per plans approved by IEMB.

iv. *Planning*

The Permittee will evaluate erosion and sedimentation control capabilities, site-specific environmental conditions, and sedimentation predictions to fulfill the intent of the Western Alkaline subcategory. After coal extraction is complete, disturbed areas are reclaimed as rapidly as is practicable and rehabilitated for the designated post-mining land use. The facility has an approved reclamation schedule (Section 17.24.313(1)(b), Reclamation Plan) which lays out the timetable for reclaiming disturbed lands within the permitted site.

v. *Construction*
The Permittee will backfill, re-contour, replace soils and re-vegetate areas as timely as practicable based on the reclamation timetable and current mining plan needs. The IEMB must approve all reclamation plans prior to construction.

b. Inspection and Maintenance
The Permittee will perform routine inspections of erosion and sediment control structures as required by state and federal regulations. Federal regulations (40 CFR 434.82(a)) require "sediment control plans to identify best management practices (BMPs) and also must describe design specification, construction specifications, maintenance schedules, criteria for inspections, as well as expected performance and longevity of the best management practices." Exhibits 7 through 10 of the SCP contain Standard Notes for BMPs currently used to control erosion and sediment transport on the mine site. The Standard Notes contain the design and installation specifications, inspection and maintenance criteria as required by the above-mentioned rule. Additional maintenance activities specific to Rosebud Mine are described below.

Maintenance of Conveyance Structures. Ditches and culverts are inspected periodically for blockages and erosion. Erosion and/or sedimentation that compromises the ability of the ditch to convey its design flow are addressed by reconstructing the ditch to its design geometry. Where ditch erosion occurs, more frequent trap maintenance to maintain design capacity may be required. Sediment accumulations in culverts will be removed as necessary to maintain design flow capacities.

Maintenance of Sediment Traps. Sediment accumulations in sediment traps and ponds will be cleaned when sediment accumulation may interfere with detention of the 2-year or 10-year, 24-hour event, as appropriate.

Maintenance of Sediment Control BMP's. Sediment traps and site-specific BMPs (e.g., ponds, traps, and erosion control products) are maintained in effective operating condition during the active mining phase. Control measures for site-specific sediment control (e.g., straw dikes, rip rap) are removed during reclamation.

Reclamation of Rills and Gullies. Rills and gullies developed post-reclamation are remediated on a site-specific basis if they adversely impact the establishment of vegetation, or disrupt post-mine land use (ARM 17.24.721).

Maintenance of Vegetation. Revegetated areas are inspected periodically and maintained throughout the post-mine phase. Maintenance of revegetated areas utilizes DEQ approved husbandry practices for use on coal mines (see Appendix A of the SCP). Interseeding, supplemental plantings or mulching may be used to enhance revegetation on a site-specific basis. Mechanical practices (e.g., cutting, mowing and raking, etc.), pest control, grazing and prescribed burns may be used to control weeds, undesirable litter buildup, or stimulate growth. A comprehensive noxious weed control plan will be submitted to the Rosebud County Weed Board for approval prior to pest and weed control.

Maintenance of Water Resources. Water resources developed for approved post-mining land uses are maintained (cleaned, repaired, upgraded, stabilized, and revegetated) and protected (fencing/animal exclusion) according to approved husbandry practices (see Appendix A of the SCP).

The approved SCP contains the criteria and reporting requirements for inspections conducted on site. Comprehensive inspections are required annually for all areas covered under the SCP. Visual inspections will be conducted annually or after significant storm events (>0.5 inches in 24 hours) on areas where vegetation has been established for less than two years. Based on the outcomes of these inspections, maintenance will be scheduled. Maintenance activities will be documented (date, type and location of activity, supervisor or contractor), and records will be retained for a minimum of three years. Appendix B of the SCP contains the Visual Inspection Form for Sediment Control BMPs.

c. Reporting

For discharges that are regulated under the Western Alkaline Coal Mining Effluent Limitation Guidelines (ELGs), Comprehensive Site Inspections must be conducted and an annual Compliance Evaluation Report must be submitted to evaluate the BMPs performance as identified in the Plan

i. Comprehensive Site Inspection

Comprehensive site inspections must be performed annually. Comprehensive site inspections must assess the following:

- Whether the description of area covered by the Plan is accurate as required under the discharge permit;
- Whether the site map has been updated or otherwise modified to reflect current conditions;
- Whether the BMPs to control sediment as identified in the Plan are being effectively implemented; and
- Whether any Plan revisions such as additional BMPs are necessary.

Based on the results of the Comprehensive Site Inspection, the description of potential pollutant sources and BMPs identified in the SCP must be revised as appropriate and submitted to the DEQ within 14 days of such inspection for review. All changes to the SCP must be reviewed and approved by the DEQ prior to implementation.

ii. Compliance Evaluation Report

A compliance evaluation report must be submitted to the DEQ addressing the site inspections performed during each calendar year.

- The report must identify personnel making the inspection and the date(s) of the inspection.

- The report must summarize observations made based on the items stated in Section 6.1.
- The report must summarize actions taken in accordance with Section 6.1.
- The report must be retained with the Plan.
- The permittee shall submit a copy of the report to the DEQ by January 28th of each year for the preceding calendar year's inspection.
- The report must identify any incidents of noncompliance. Where a report does not identify any incidents of noncompliance, the report must contain a certification that the facility is in compliance with the Plan and this permit.
- The report must be signed in accordance with the signatory requirements stated in Part IV. G, of the MPDES Permit.

iii. *Record Retention*

Records of the Comprehensive Site Inspection, the Compliance Evaluation Report, and any related follow-up actions must be maintained by the permittee for a minimum of three years.

A tracking or follow-up procedure, including a schedule for implementation, must be used and identified in the annual Compliance Evaluation Report which ensures adequate response and corrective actions have been taken in response to the Comprehensive Site Inspection and/or noncompliance. The Visual Inspection Form for Sediment Control BMPs provides a method of tracking maintenance activities following visual inspections (See SCP Appendix B).

d. Prohibition Against Comingling

Outfalls regulated by Western Alkaline Coal Mining ELGs (40 CFR 434 Subpart H) are prohibited from receiving or discharging water from any outfall regulated by another set of ELGs. Therefore, water associated with outfalls regulated by Coal Preparation Plants and Associated Areas ELGs (40 CFR 434 Subpart B) or Alkaline Mine Drainage ELGs (40 CFR 434 Subpart D) may not be routed to any Western Alkaline Coal Mining outfall listed in Table 17.

e. Transfer of Additional Outfalls

As outfalls defined in this permit are reclaimed, the approved Sediment Control Plan may be updated to incorporate the newly reclaimed outfalls. A revised Sediment Control Plan and revised watershed model must be submitted to and approved by DEQ before it becomes effective. Revisions to the Sediment Control Plan must meet all requirements contained at 40 CFR Part 434.82, and 100% of the drainage area to an outfall must meet the definition of "western alkaline reclamation, brushing and grubbing, topsoil stockpiling, and regraded areas" (as defined at 40 CFR 434.80) to be considered for coverage. DEQ's approval of an updated Sediment Control Plan and reclassification of an existing outfall to a reclaimed area will be considered a minor modification to the permit.

3. **Toxicity Limitations**

   a. **Acute Whole Effluent Toxicity Limitations – Not Applicable**

   b. **Chronic Whole Effluent Toxicity Limitations – Not Applicable**

4. **Interim Effluent Limitations – Not Applicable**

5. **Other Monitoring Requirements**

   a. Precipitation Monitoring. Precipitation shall be monitored and recorded in each of the drainage basins where regulated outfalls are located (East Fork Armells, Stocker Creek, West Fork Armells, Black Hank Creek, Donley Creek, Cow Creek, Lee Coulee, Spring Creek, and Pony Creek) using a precipitation gauge which meets the standards provided in National Weather Services Instructional Bulletin 10-1302 (October 4, 2005), *Instrument Requirements and Standards for the NWS Surface Observing Programs (Land)*, and provided below.

Precipitation Gauge Performance Standard			
Parameter	Accuracy	Range	Resolution
Liquid Precipitation Accumulated Amount	±0.02 inches or 4 percent of hourly amount (whichever is greater)	0-10"/Hour	0.01 inches
Snow Depth	0 to 5 inches- ±0.5 inches >5 to 99 inches - ±1.0 inch	0 to 99 inches (auto)	1 inch
Freezing Precipitation	Detection occurs whenever 0.01" accumulates	0 to 40 inches	0.01 inches
Frozen Precipitation (water equivalent)	±0.04 inches or 1% of total accumulation	0 to 40 inches	0.01 inches

   b. Flow Monitoring and Sampling Units. The Permit requires the Permittee to install and use flow monitoring and sampling equipment at each representative outfall listed in Table 16, above. A crest gauge or equivalent equipment can measure flow at the crest, with the establishment of a ratings curve that shows the relationship between peak flow and gauge height. Remote sampling units can sample a representative sample of the discharged effluent when discharge occurs. The discharge point and monitoring location shall be permanently marked and identified at the overflow.

C. General Monitoring and Reporting Requirements

Samples or measurements shall be representative of the volume and nature of the monitored discharge as specified. If no discharge occurs during the entire reporting period, it shall be stated on the Discharge Monitoring Report Form (EPA No. 3320-1) that no discharge occurred. The reporting period for discharges is monthly. If multiple discharge events occur during the monthly reporting period the permittee must report the highest calculated or measured values that conform to the numeric effluent in the permit.

Data collected on site, copies of Discharge Monitoring Reports, and a copy of this MPDES permit must be maintained on site during the duration of activity at the permitted location.

1. **Monitoring Locations**
   The Permittee shall establish monitoring locations at each outfall to demonstrate compliance with the effluent limitations and other requirements in section I of this Permit. Appropriate monitoring locations include: at the overflow structure where the effluent discharges as overflow from the sediment control structure, or at the end of the discharge pipe when pumped or drained, and prior to contact with the receiving water.

   The Permittee shall monitor effluent at the specific monitoring location during discharge. The location of each outfall regulated by this permit shall be permanently identified in the field.

2. **Mass Loading Calculations**
   Where Section I.B.1 above includes effluent limitations expressed in terms of mass or requires reporting mass loading for a particular parameter, the Permittee shall calculate the mass loading must be calculated using the following equations:

$$\text{Daily Mass Load (lb/day)} = \text{Daily Discharge Concentration (mg/L)} \times \text{Daily Effluent Flow Rate (MGD)} \times 8.34$$

   The permittee shall calculate the Average Monthly Mass Load (lb/day) for a calendar month by determining the arithmetic mean of all daily mass loads calculated for that calendar month.

3. **Whole Effluent Toxicity Testing**
   a. **Acute Whole Effluent Toxicity Testing**
      Whole effluent toxicity testing is required for any outfall where activities that meet the definition of "coal preparation plant", "coal preparation plant associated areas" and "coal plant water circuit", as defined in 40 CFR 434.11 are conducted or are located. As defined by the Permittee's application, this includes Outfalls 009, 09A, 16A, 021, 043, and 194.

      i. **Sampling and Dilution Series Requirements**. Beginning in the calendar year in which this Permit becomes effective, the Permittee shall conduct annual acute static replacement toxicity tests on grab samples of the effluent. Testing will employ two species per test and will consist of 6 effluent concentrations (100, 50, 25, 12.5, 6.25 percent effluent) and a control. Dilution water and the control shall consist of grab samples of the receiving water. If a sample of the receiving water is unavailable, because of its ephemeral nature, standard synthetic water may be used. If a discharge does not occur for a specified monitoring location during the calendar year, this fact shall be reported in the annual report.

ii. **Methods**. Acute WET tests shall be conducted in general accordance with the procedures set out in *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*, Fifth Edition, EPA-821-R-02-012 <http://www.epa.gov/waterscience/WET/disk2/atx.pdf> (or a subsequent edition) and the "Region VIII USEPA NPDES Acute Test Conditions—Static Renewal Whole Effluent Toxicity Test" contained in the *Region VIII NPDES Whole Effluent Toxics Control Program, August 1997.* The Permittee must conduct a 48-hour static renewal acute toxicity test using *Ceriodaphnia dubia* (USEPA Method 2002.0) and a 96-hour static renewal acute toxicity test using *Pimephales promelas* (fathead minnow) (USEPA Method 2000.0). Acute toxicity is measured by determining the LC_{50} (i.e., the percent of effluent that is lethal to 50 percent of the exposed test organisms) for each type of test.

iii. **Test Validity**. If more than 10 percent control mortality occurs, the test is considered invalid and shall be repeated until satisfactory control survival is achieved, unless a specific individual exception is granted by the Department. This exception may be granted if less than 10 percent mortality was observed at the dilutions containing high effluent concentrations.

iv. **Accelerated Testing**. If acute toxicity occurs in a routine test, an additional test shall be conducted within 14 days of the date of the initial sample. Should acute toxicity occur in the second test, testing shall occur once a month until further notified by the Department. In all cases, the results of all toxicity tests must be submitted to the Department in accordance with Section III.A of this Permit.

v. **Reduced Monitoring Frequency – Not Applicable**

4. **Monitoring Periods and Reporting Schedule**
Monitoring periods and reporting for all required monitoring shall be completed according to the schedule in Table 17, below.

When the minimum monitoring frequency is 1/Week or less (e.g, 1/Month), monitoring must take place on a weekday (Monday through Friday).

Table 17. Monitoring Periods and Reporting Schedule

Required Monitoring Frequency	Monitoring Period Begins On:	Monitoring Period	Reporting Due Date
1/Day	NOVEMBER 1, 2012	Midnight through 11:59 PM or any 24-hour period that reasonably represents a calendar day for purposes of monitoring.	Due date for next DMR submittal
1/Month	NOVEMBER 1, 2012	1st day of calendar month through last day of calendar month	Due date for next DMR submittal
Annually	JANUARY 1, 2013	January 1 through December 31	28 days from the end of the monitoring period
1 / Discharge	NOVEMBER 1, 2012	Duration of discharge event	Due date for next DMR submittal

5. **Discharge Monitoring Reports**
All monitoring results obtained during the previous month(s) shall be summarized and reported on a monthly Discharge Monitoring Report Form (EPA No. 3320-1) postmarked no later than the 28th day of the month following the completed reporting period. Whole effluent toxicity (biomonitoring) results must be reported with copies of the laboratory analysis report on forms from the most recent version of USEPA Region VIII's *Guidance for Whole Effluent Reporting.*

If no discharge occurs during the monitoring period, "No Discharge" shall be reported on the report form.

Legible copies of these, and all other reports required herein, shall be signed and certified in accordance with the "Signatory Requirements" (see Section III.C.7. of this permit), and submitted to DEQ and to the USEPA as follows:

To DEQ by depositing in the United States Mail to:

Montana Department of Environmental Quality
Water Protection Bureau
PO Box 200901
Helena, Montana 59620-0901
Phone: (406) 444-3080

To the USEPA: when DEQ enters the discharge monitoring data into the Integrated Compliance Information System.

Whole Effluent Toxicity (WET) results from the laboratory shall be reported along with the next DMR form submitted. The format for the laboratory report shall be consistent with the latest revision of *Region VIII Guidance for Acute Whole Effluent Reporting and Chronic Whole Effluent Reporting*, and shall include all chemical and physical data as specified.

II. SPECIAL CONDITIONS

A. Additional Monitoring and Special Studies

1. Ambient Monitoring - Not Applicable.

2. Supplemental Monitoring and Studies - Not Applicable.

3. Toxicity Identification Evaluation (TIE)/Toxicity Reduction Evaluation (TRE)
The Permittee shall submit to the Department and initiate implementation of a TIE/TRE plan within 45 days of detecting acute toxicity during any accelerated testing required under section I.C.3. The TIE/TRE shall describe steps to be undertaken by the Permittee to establish the cause of the toxicity, locate the source(s) of the toxicity, and develop control or treatment for the toxicity.

If implementation of the TIE/TRE establishes that the toxicity cannot be eliminated, the Permittee shall submit a proposed compliance plan to the Department. The compliance plan shall include the proposed approach to control toxicity and a proposed compliance schedule for achieving control. If the approach and schedule are acceptable to the Department, this permit may be reopened and modified.

If the TIE/TRE shows that the toxicity is caused by a toxicant(s) that may be controlled with parameter-specific numeric limitations, the Permittee may:

a. Submit an alternative control program for compliance with the parameter-specific numeric effluent limitations,
b. If necessary, provide a modified whole effluent testing protocol, which compensates for the pollutant(s) being controlled with parameter-specific numeric effluent limitations.

Based on the results of WET testing and a TIE/TRE conducted by the Permittee, the Department may reopen and modify this Permit in accordance with the provisions in section II.D to incorporate any additional WET or parameter-specific numeric limitations, a modified compliance schedule if judged necessary by the Department, and/or a modified whole effluent toxicity protocol.

B. Best Management Practices and Pollution Prevention – Not Applicable

C. Compliance Schedules

The Permittee will be granted a one-year compliance schedule from the date of permit issuance to facilitate procurement, installation, and commissioning of flow monitoring and effluent sampling devices at representative monitoring outfalls. Until such equipment is installed, the Permittee must continue to monitor and sample effluent using non-automated methods.

D. Reopener Provisions

This permit shall be reopened and modified (following proper administrative procedures) to include the appropriate effluent limitations (and compliance schedule, if necessary), or other appropriate requirements if one or more of the following events occurs:

1. **Water Quality Standards**
   The water quality standards of the receiving water(s) to which the Permittee discharges are modified in such a manner as to require different effluent limitations than contained in this permit.

2. **Water Quality Standards are Exceeded**
   If it is found that water quality standards or Trigger Values in the receiving stream are exceeded either for parameters included in the permit or others, the Department may modify the effluent limitations or the water quality management plan. Trigger Values are used to determine if a given increase in the concentration of toxic parameters is significant or non-significant as per the non-degradation rules ARM 17.30.701 et seq. and are listed in Circular DEQ-7.

3. **TMDL or Wasteload Allocation**
   TMDL requirements or a wasteload allocation is developed and approved by the Department and/or USEPA for incorporation in this permit.

4. **Water Quality Management Plan**
   A revision to the current water quality management plan is approved and adopted which calls for different effluent limitations than contained in this permit.

5. **Toxic Pollutants**
   A toxic standard or prohibition is established under Clean Water Act Section 307(a) for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit.

6. **Toxicity Limitations – Not Applicable**

III. STANDARD CONDITIONS

A. Monitoring, Recording, and Reporting

1. **Representative Sampling:** Samples and measurements taken for the purpose of monitoring must be representative of the monitored activity. [*ARM 17.30.1342(10)(a)*]

2. **Monitoring and Reporting Procedures:** Monitoring results must be reported on a Discharge Monitoring Report (DMR) form at the intervals specified in Section I of this permit. Calculations for all limitations that require averaging of measurements must use an arithmetic mean unless otherwise specified by the Department in the permit [*ARM 17.30.1342(12)(d)(i),(iii)*]. Monitoring must be conducted according to test procedures approved under Title 40 of the Code of Federal Regulations (40 CFR) Part 136, unless other test procedures have been specified in this permit. [*ARM 17.30.1342(10)(d)*]

3. **Penalties for Tampering:** The Montana Water Quality Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate, any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $25,000, or by imprisonment for not more than six months, or by both. [*MCA 75-5-633*]

4. **Compliance Schedule Reporting:** Reports of compliance or noncompliance with, or any progress reports on interim and final requirements contained in any Compliance Schedule of this permit shall be submitted no later than 14 days following each schedule date. [*ARM 17.30.1342(12)(e)*]

5. **Additional Monitoring by the Permittee:** If the permittee monitors any pollutant more frequently than required by this permit, using test procedures approved under 40 CFR Part 136 or as specified in this permit, the results of this monitoring must be included in the calculation and reporting of the data submitted in the Discharge Monitoring Report. [*ARM 17.30.1342(12)(d)(ii)*]

6. **Records Contents** [*ARM 17.30.1342(9)(c)*]: Records of monitoring information must include:
   a. the date, exact place, and time of sampling or measurements;
   b. the initials or name(s) of the individual(s) who performed the sampling or measurements;
   c. the date(s) analyses were performed;
   d. the initials or name(s) of individual(s) who performed the analyses;
   e. the analytical techniques or methods used; and
   f. the results of such analyses;

7. **Retention of Records:** The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for

this permit, for a period of at least three years from the date of the sample, measurement, report or application. [*ARM 17.30.1342(10)(b)*]

8. **Twenty-four Hour Notification** [*ARM 17.30.1342(12)(f)*]: The permittee shall report any serious incident of noncompliance as soon as possible, but no later than twenty-four (24) hours from the time the permittee first became aware of the circumstances.
   a. *Oral notification.* The report shall be made orally to the Water Protection Bureau at (406) 444-3080 or the Office of Disaster and Emergency Services at (406) 841-3911. The following examples are considered serious incidents of noncompliance:
      i. Any noncompliance which might endanger health or the environment;
      ii. Any unanticipated bypass that exceeds any effluent limitation in the permit (See Subsection III.B.7 of this permit, "Bypass of Treatment Facilities");
      iii. Any upset which exceeds any effluent limitation in the permit (See Subsection III.B.8 of this permit, "Upset Conditions") or;
      iv. Violation of a maximum daily discharge limitation for any of the pollutants listed by the Department in this permit to be reported within 24 hours.
   b. *Written notification.* A written submission shall also be provided within five days of the time that the permittee becomes aware of the circumstances. The written submission shall contain:
      i. A description of the noncompliance and its cause;
      ii. The period of noncompliance, including exact dates and times;
      iii. The estimated time noncompliance is expected to continue if it has not been corrected; and
      iv. Steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.
   c. *Waiver of written notification requirement*: The Department may waive the written report on a case-by-case basis if the oral report has been received within 24 hours by the Water Protection Bureau, by phone, (406) 444-3080. Reports shall be submitted to the addresses in Subsection I.C.5 of this permit ("Discharge Monitoring Reports").

9. **Other Noncompliance Reporting**: Instances of noncompliance not required to be reported within 24 hours shall be reported at the time that monitoring reports for Subsection I.C.5 of this permit ("Discharge Monitoring Reports") are submitted. The reports shall contain the information listed in Subsection III.A.8 of this permit ("Twenty-four Hour Notification"). [*ARM 17.30.1342(12)(g)*]

10. **Inspection and Entry** [*ARM 17.30.1342(9)*]: The permittee shall allow the head of the Department, or an authorized representative upon the presentation of credentials and other documents as may be required by law, to:
    a. Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;
    b. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;
    c. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and

d. Sample or monitor at reasonable times, for the purpose of assuring permit compliance or as otherwise authorized by the Montana Water Quality Act, any substances or parameters at any location.

B. Compliance Responsibilities

1. Duty to Comply: The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Montana Water Quality Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application. [*ARM 17.30.1342(1)*]

2. Planned Changes: The permittee shall give notice to the Department as soon as possible of any planned physical alterations or additions to the permitted facility. Notice is required only when:

- The alteration or addition to the permitted facility may meet one of the criteria for determining whether a facility is a new source under ARM 17.30.1340(2); or
- The alteration or addition could significantly change the nature or increase the quantity of pollutant discharged. This notification applies to pollutants that are subject neither to effluent limitations in the permit, nor to notification requirements under ARM 17.30.1343(1)(a).

The permittee shall give advance notice to the Department of any planned changes at the permitted facility or of an activity that could result in noncompliance with permit requirements. [*ARM 17.30.1342(12)(b)*]

3. Penalties for Violations of Permit Conditions

a. In an action initiated by the Department to collect civil penalties against a person who is found to have violated a permit condition, the person is subject to a civil penalty not to exceed $25,000. Each day of violation constitutes a separate violation. [*MCA 75-5-631*], [*ARM 17.30.1342(1)(b)*].

b. The Montana Water Quality Act provides that any person who willfully or negligently violates a prohibition or permit condition is subject, upon conviction, to criminal penalties not to exceed $25,000 per day or one year in prison, or both, for the first conviction, and $50,000 per day of violation or by imprisonment for not more than two years, or both, for subsequent convictions. [*MCA 75-5-632*], [*ARM 17.30.1342(1)(b)*].

c. MCA 75-5-611(9)(a) also provides for administrative penalties not to exceed $10,000 for each day of violation and up to a maximum not to exceed $100,000 for any related series of violations.

d. Except as provided in permit conditions on Subsection III.B.7 of this permit ("Bypass of Treatment Facilities") and Subsection III.B.8 of this permit ("Upset Conditions"), nothing in this permit shall be construed to relieve the permittee of the civil or criminal penalties for noncompliance.

4. Need to Halt or Reduce Activity Not a Defense: It may not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit. [*ARM 17.30.1342(3)*]

5. **Duty to Mitigate:** The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment. [*ARM 17.30.1342(4)*]

6. **Proper Operation and Maintenance:** The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems which are installed by a permittee only when the operation is necessary to achieve compliance with the conditions of the permit. [*ARM 17.30.1342(5)*]

7. **Bypass of Treatment Facilities** [*ARM 17.30.1342(13)*]
   a. *Bypass not exceeding limitations*. The permittee may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to assure efficient operation. These bypasses are not subject to the provisions under "Prohibition of bypass" and "Notice" (Subsections III.B.7.b and c of this permit) below.

   b. *Prohibition of bypass*. Bypass is prohibited and the Department may take enforcement action against a permittee for a bypass, unless:
      i. The bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;
      ii. There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and
      iii. The permittee submitted notices as required under "Notice" below (Subsection III.B.7.c of this permit).

   c. *Notice*:
      i. Anticipated bypass. If the permittee knows in advance of the need for a bypass, it shall submit prior notice, if possible at least ten (10) days before the date of the bypass.
      ii. Unanticipated bypass. The permittee shall submit notice of an unanticipated bypass as required under Subsection III.A.8 of this permit ("Twenty-four Hour Reporting").

   d. *Approval of bypass under certain conditions*. The Department may approve an anticipated bypass, after considering its adverse effects, if the Department determines that it will meet the three conditions listed above under "Prohibition of bypass" (Subsection III.B.7.b of this permit).

8. **Upset Conditions** [*ARM 17.30.1342(14)*]

   a. *Effect of an upset.* An upset constitutes an affirmative defense to an action brought for noncompliance with technology based permit effluent limitations if the requirements of Subsection III.B.8.2 of this permit are met. No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

   b. *Conditions necessary for a demonstration of upset.* A permittee who wishes to establish the affirmative defense of upset shall demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

      i. An upset occurred and that the permittee can identify the cause(s) of the upset;
      ii. The permitted facility was at the time being properly operated;
      iii. The permittee submitted notice of the upset as required under Subsection III.A.8 of this permit ("Twenty-four Hour Notification"); and
      iv. The permittee complied with any remedial measures required under Subsection III.B.5 of this permit, ("Duty to Mitigate").

   c. *Burden of proof.* In any enforcement proceeding, the permittee seeking to establish the occurrence of an upset has the burden of proof.

C. <u>**General Requirements**</u>

1. **Planned Changes** [*ARM 17.30.1342(12)(a)*]: The permittee shall give notice to the Department as soon as possible of any planned physical alterations or additions to the permitted facility. Notice is required only when:

   a. The alteration or addition could significantly change the nature or increase the quantity of pollutant discharged. This notification applies to pollutants that are subject neither to effluent limitations in the permit, nor to notification requirements under Subsection III.D.1 of this permit ; or

   b. The alteration or addition to the permitted facility may meet one of the criteria in ARM 17.30.1340(2) for determining whether a facility is a new source.

2. **Anticipated Noncompliance:** The permittee shall give advance notice to the Department of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements [*ARM 17.30.1342(12)(b)*].

3. **Permit Actions:** This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition. [*ARM 17.30.1342(6)*]

4. **Duty to Reapply:** If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must first apply for and obtain a new permit. [*ARM 17.30.1342(2)*] In accordance with ARM 17.30.1322(4), the application must be submitted at least 180 days before the expiration date of this permit.

5. **Duty to Provide Information:** The permittee shall furnish to the Department, within a reasonable time, any information which the Department may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit. The permittee shall also furnish to the Department, upon request, copies of records required to be kept by this permit. [*ARM 17.30.1342(8)*]

6. **Other Information:** Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or any report to the Department, it shall promptly submit such facts or information [*ARM 17.30.1342(12)(h)*].

7. **Signatory Requirements**
   a. All applications, reports or information submitted to the Department shall be signed and certified. [*ARM 17.30.1342(11)*]

   b. All permit applications must be signed as follows:
   i. *For a corporation*: By a responsible corporate officer, which means
      1) A president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation; or
      2) The manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or having gross annual sales or expenditures exceeding $25 million (in second-quarter 1980 dollars), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.
   ii. *For a partnership or sole proprietorship*: By a general partner or the proprietor, respectively.
   iii. *For a municipality, state, federal, or other public agency*: By either a principal executive officer or ranking elected official. A principal executive office of a federal agency includes:
      1) The chief executive officer of the agency; or
      2) A senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency.

   c. *Authorized representatives.* All reports required by the permit and other information requested by the Department shall be signed by a person described above in Subsection III.C.7.b of this permit or by a duly authorized representative of that person. A person is considered a duly authorized representative only if:
   i. The authorization is made in writing by a person described above in Subsection III.C.7.b and submitted to the Department; and
   ii. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, operator of a well or well field, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters. (a duly authorized representative may thus be either a named individual or an individual occupying a named position).

d. *Changes to authorization.* If an authorization under Subsection III.C.7.c of this permit is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of Subsection III.C.7.c of this permit must be submitted to the Department prior to or together with any reports, information, or applications to be signed by an authorized representative.

e. *Certification.* Any person signing a document under this section shall make the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

8. Penalties for Falsification of Reports: The Montana Water Quality Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance shall, upon conviction be punished by a fine of not more that $25,000 per violation, or by imprisonment for not more than six months per violation, or both. [*MCA 75-5-633*]

9. Property or Water Rights: The issuance of this permit does not convey any property or water rights of any sort, or any exclusive privilege. [*ARM 17.30.1342(7)*]

10. Severability: The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby. [*ARM 17.30.1302*]

11. Transfers [*ARM 17.30.1360(2)*]: This permit may be automatically transferred to a new permittee if:

a. The current permittee notifies the Department at least 30 days in advance of the proposed transfer date;

b. The notice includes a written agreement between the existing and new permittees containing a specific date for transfer of permit responsibility, coverage, and liability between them;

c. The Department does not notify the existing permittee and the proposed new permittee of an intent to revoke or modify and reissue the permit. If this notice is not received, the transfer is effective on the date specified in the agreement mentioned in Subsection III.C.11.b of this permit; and

d. Required annual and application fees have been paid.

12. **Fees** [*ARM 17.30.201(8)*]: The permittee is required to submit payment of an annual fee as set forth in ARM 17.30.201. If the permittee fails to pay the annual fee within 90 days after the due date for the payment, the Department may:
   a. Impose an additional assessment consisting of 15% of the fee plus interest on the required fee computed at the rate established under 15-31-510(3), MCA, or
   b. Suspend the processing of the application for a permit or authorization or, if the nonpayment involves an annual permit fee, suspend the permit, certificate or authorization for which the fee is required. The Department may lift suspension at any time up to one year after the suspension occurs if the holder has paid all outstanding fees, including all penalties, assessments and interest imposed under this subsection. Suspensions are limited to one year, after which the permit will be terminated.

D. <u>Notification Levels</u>

1. The permittee shall comply with effluent standards or prohibitions established under Clean Water Act Section 307(a) for toxic pollutants within the time provided in the regulations that establish those standards or prohibitions, even if the permit has not yet been modified to incorporate the requirement. [*ARM 17.30.1342(1)(a)*]

2. Notification shall be provided to the Department as soon as the permittee knows of, or has reason to believe [*ARM 17.30.1343(1)(a)*]:
   a. That any activity has occurred or will occur which would result in the discharge, on a routine or frequent basis, of any toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":
      i. One hundred micrograms per liter (100 µg/l);
      ii. Two hundred micrograms per liter (200 µg/l) for acrolein and acrylonitrile; five hundred micrograms per liter (500 µg/l) for 2,4-dinitrophenol and for 2-methyl-4, 6-dinitrophenol; and one milligram per liter (1 mg/l) for antimony;
      iii. Five (5) times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR 122.21(g)(7); or
      iv. The level established by the Department in accordance with 40 CFR 122.44(f).
   b. That any activity has occurred or will occur which would result in any discharge, on a non-routine or infrequent basis, of a toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":
      i. Five hundred micrograms per liter (500 µg/l);
      ii. One milligram per liter (1 mg/l) for antimony;
      iii. Ten (10) times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR 122.21(g)(7); or
      iv. The level established by the Department in accordance with 40 CFR 122.44(f).

IV. DEFINITIONS AND ABBREVIATIONS

"1-year, 2-year, and 10-year, 24-hour precipitation events" means the maximum 24-hour precipitation event with a probable recurrence interval of once in one, two, and ten years, respectively, as defined by the National Weather Service Technical Paper No. 40, *Rainfall Frequency Atlas of the U.S.*, May 1961, or equivalent regional or rainfall probability information developed therefrom.

"Act" means the Montana Water Quality Act, Title 75, chapter 5, MCA.

"Active mining area" means the area, on and beneath land, used or disturbed in activity related to the extraction, removal, or recovery of coal from its natural deposits. This term excludes coal preparation plants, coal preparation plant associated areas, and post-mining areas.

"Acute Toxicity" occurs when 50 percent or more mortality is observed for either species (See Subsection I.C of this permit) at any effluent concentration. Mortality in the control must simultaneously be 10 percent or less for the effluent results to be considered valid.

"Administrator" means the administrator of the United States Environmental Protection Agency.

"Alkaline mine drainage" means mine drainage which, before any treatment, has a pH equal or greater than 6.0, and total iron concentration of less than 10 mg/L.

"Arithmetic Mean" or "Arithmetic Average" for any set of related values means the summation of the individual values divided by the number of individual values.

"Average monthly limitation" means the highest allowable average of daily discharges over a calendar month, calculated as the sum of all daily discharges measured during a calendar month divided by the number of daily discharges measured during that month.

"Average weekly limitation" means the highest allowable average of daily discharges over a calendar week, calculated as the sum of all daily discharges measured during a calendar week divided by the number of daily discharges measured during that week.

"Best Management Practices" (BMPs) mean schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants to waters of the United States.

"Bond release" means the time at which the appropriate regulatory authority returns a reclamation or performance bond based upon its determination that reclamation work has been satisfactorily completed.

"Brushing and grubbing area" means the area where woody plant materials that would interfere with soil salvage operations have been removed or incorporated into the soil being salvaged.

"Bypass" means the intentional diversion of waste streams from any portion of a treatment facility.

"CFR" means the Code of Federal Regulations.

"Chronic toxicity" occurs when, during a chronic toxicity test, the 25% inhibition concentration (IC_{25}) for any tested species is less than or equal to 100% effluent (i.e., $IC_{25} \leq 100\%$ effluent).

"Clean Water Act" means the federal legislation at 33 USC 1251, et seq.

"Coal preparation plant" means a facility where coal is subjected to cleaning, concentrating, or other processing preparation in order to separate coal from its impurities and then is loaded for transit to a consuming facility.

"Coal preparation plant associated areas" means the coal preparation plant yards, immediate access roads, coal refuse piles, and coal storage piles and facilities.

"Composite samples" shall be flow proportioned. The composite sample shall, as a minimum, contain at least four (4) samples collected over the compositing period. Unless otherwise specified, the time between the collection of the first sample and the last sample shall not be less than six (6) hours nor more than 24 hours. Acceptable methods for preparation of composite samples are as follows:

a. Constant time interval between samples, sample volume proportional to flow rate at time of sampling;
b. Constant time interval between samples, sample volume proportional to total flow (volume) since last sample. For the first sample, the flow rate at the time the sample was collected may be used;
c. Constant sample volume, time interval between samples proportional to flow (i.e. sample taken every "X" gallons of flow); and,
d. Continuous collection of sample, with sample collection rate proportional to flow rate.

"Daily Discharge" means the discharge of a pollutant measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the daily discharge is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurement, the daily discharge is calculated as the average measurement of the pollutant over the day.

"Department" means the Montana Department of Environmental Quality (MDEQ). Established by 2-15-3501, MCA.

"Director" means the Director of the Montana Department of Environmental Quality.

"Discharge" means the injection, deposit, dumping, spilling, leaking, placing, or failing to remove any pollutant so that it or any constituent thereof may enter into state waters, including ground water.

"Effluent Limitations Guidelines" (ELGs) mean regulations published by the Administrator under Section 304(b) of the CWA that establishes national technology-based effluent requirements for a specific industrial category.
"EPA" or "USEPA" means the United States Environmental Protection Agency.

"GPM" means gallons per minute.

"Grab Sample" means a sample which is taken from a waste stream on a one-time basis without consideration of flow rate of the effluent or without consideration for time.

"Instantaneous Maximum Limit" means the maximum allowable concentration of a pollutant determined from the analysis of any discrete or composite sample collected, independent of the flow rate and the duration of the sampling event.

"Instantaneous Measurement", for monitoring requirements, means a single reading, observation, or measurement.

"Maximum Daily Limit" means the highest allowable discharge of a pollutant during a calendar day. Expressed as units of mass, the daily discharge is cumulative mass discharged over the course of the day. Expressed as a concentration, it is the arithmetic average of all measurements taken that day.

"mg/L" means milligrams per liter.

"Mine drainage" means any drainage, and any water pumped or siphoned, from an active mining area or a post-mining area.

"Minimum Level" (ML) of quantitation means the lowest level at which the entire analytical system gives a recognizable signal and acceptable calibration point for the analyte, as determined by the procedure set forth at 40 CFR 136. In most cases the ML is equivalent to the Required Reporting Value (RRV) unless otherwise specified in the permit. (ARM 17.30.702(22))

"Mixing zone" means a limited area of a surface water body or aquifer where initial dilution of a discharge takes place and where certain water quality standards may be exceeded.

"mL/L" means milliliters per liter.

"Nondegradation" means the prevention of a significant change in water quality that lowers the quality of high-quality water for one or more parameters. Also, the prohibition of any increase in discharge that exceeds the limits established under or determined from a permit or approval issued by the Department prior to April 29, 1993.

"Reclamation area" means the surface area of a coal mine which has been returned to required contour and on which re-vegetation (specifically, seeding or planting) work has commenced.

"Regraded area" means the surface area of a coal mine that has been returned to required contour.

"Regional Administrator" means the administrator of Region VIII of EPA, which has jurisdiction over federal water pollution control activities in the state of Montana.

"Settleable solids" means that matter measured by the volumetric method specified in 40 CFR 434.64.

"Severe property damage" means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

"SMCRA" means the Surface Mining Control and Reclamation Act.

"Storm water" means storm water runoff, snow melt runoff, and surface run-off and drainage in response to a precipitation event.

"TIE" means a toxicity identification evaluation.

"TMDL" means the total maximum daily load limitation of a parameter, representing the estimated assimilative capacity for a water body before other designated uses are adversely affected. Mathematically, it is the sum of wasteload allocations for point sources, load allocations for non-point and natural background sources, and a margin of safety.

"Topsoil stockpiling area" means the area outside the mined-out area where topsoil is temporarily stored for use in reclamation, including containment berms.

"TRE" means a toxicity reduction evaluation.

"TSS" means the pollutant parameter total suspended solids.

"Upset" means an exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

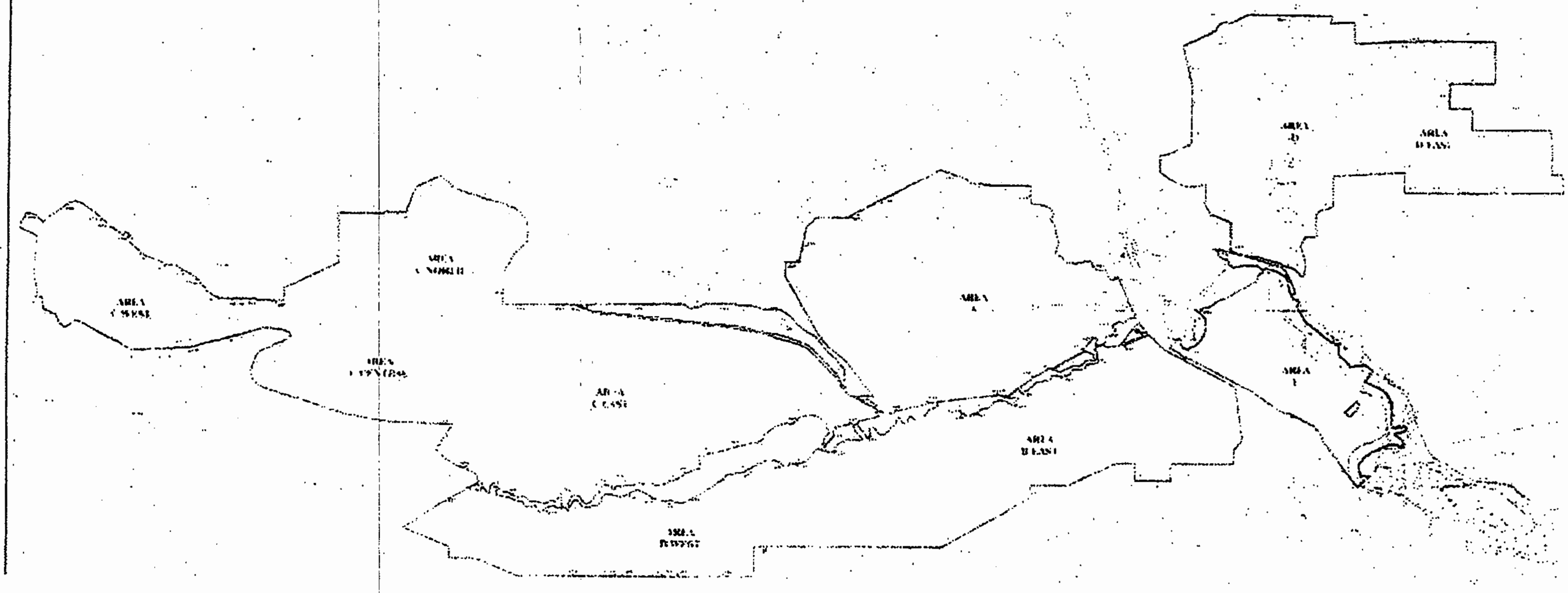
ATTACHMENT I – MAPS

ATTACHMENT II – FLOW SCHEMATIC

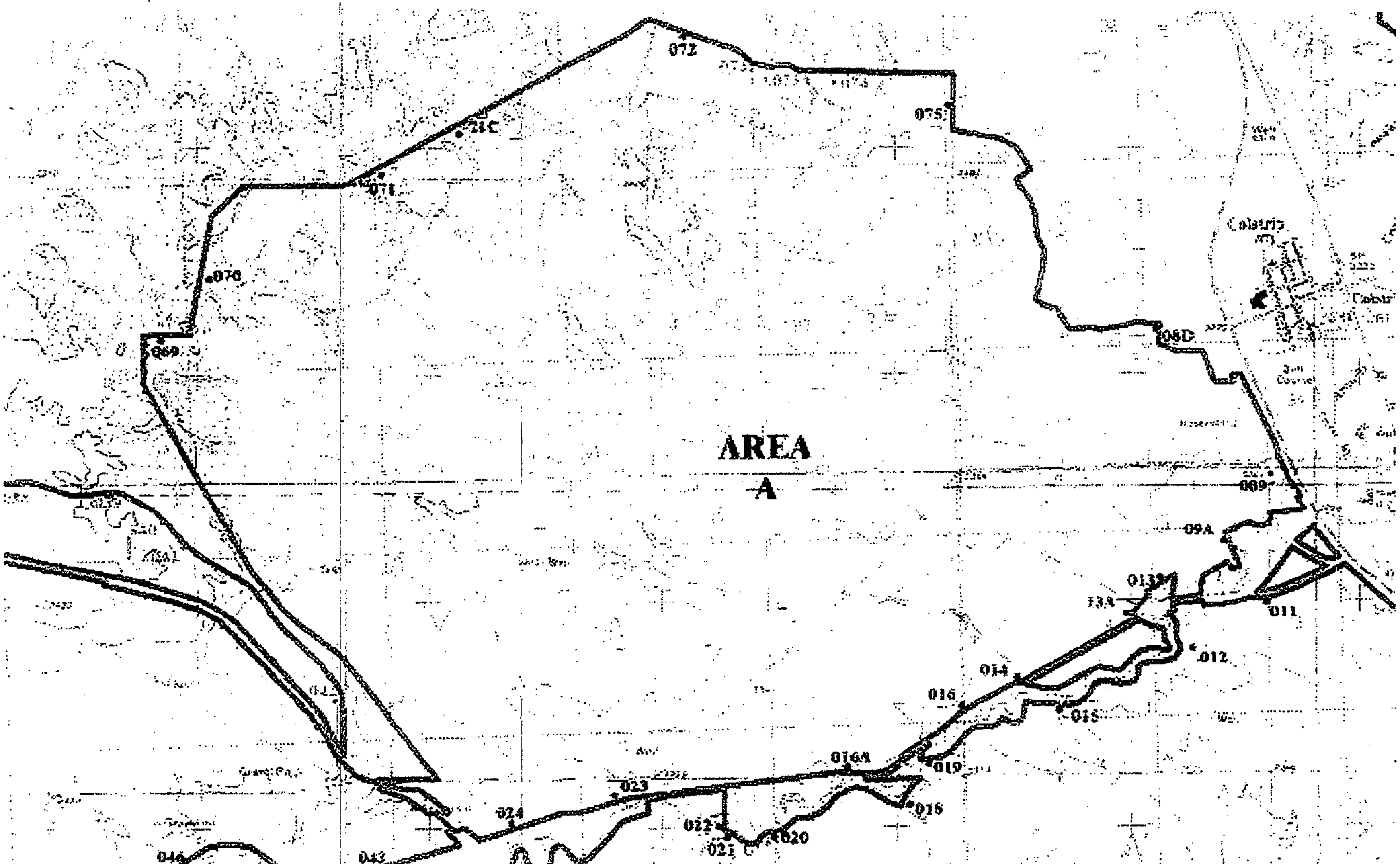
ATTACHMENT III – FACT SHEET

ATTACHMENT I - FACILITY MAPS

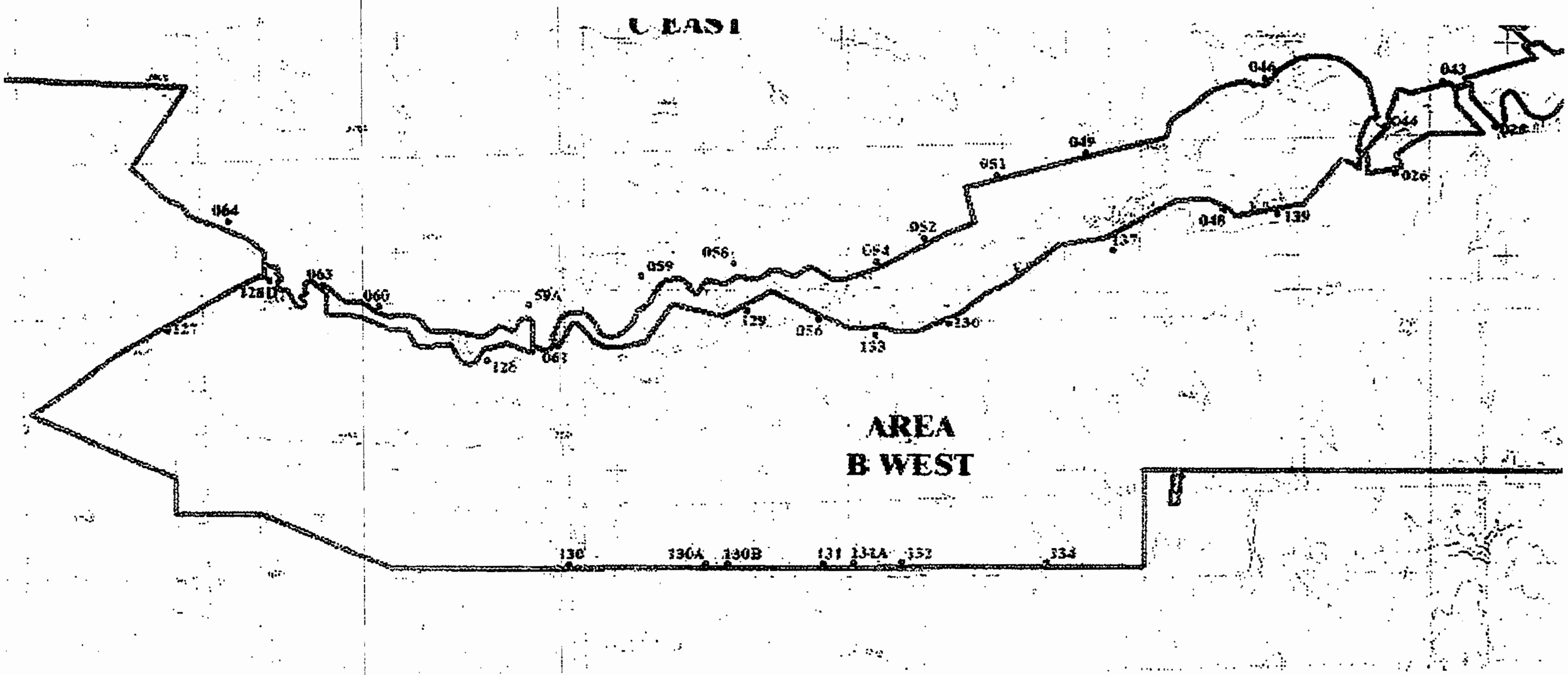
Overview Map



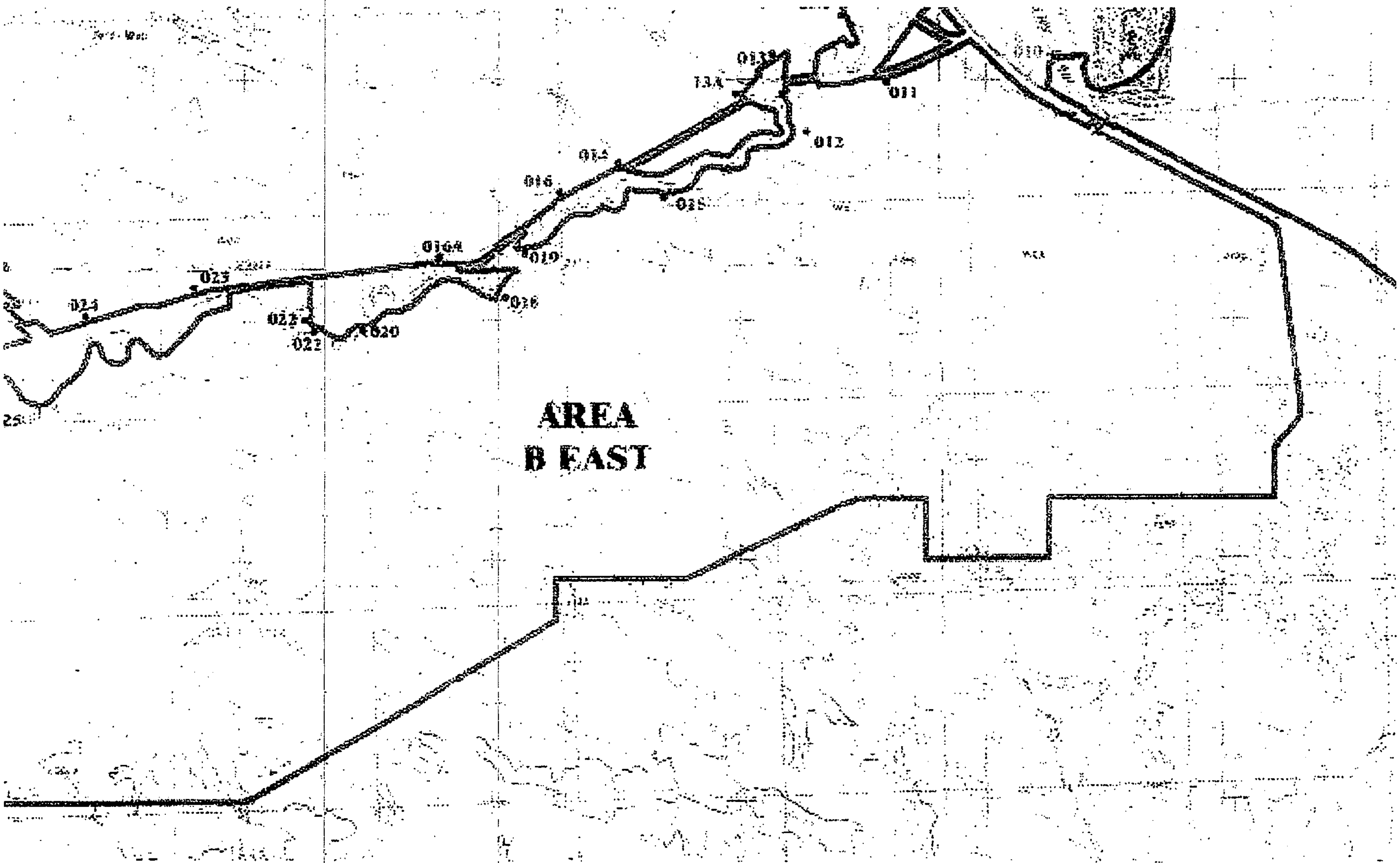
ATTACHMENT I - FACILITY MAPS (Continued)



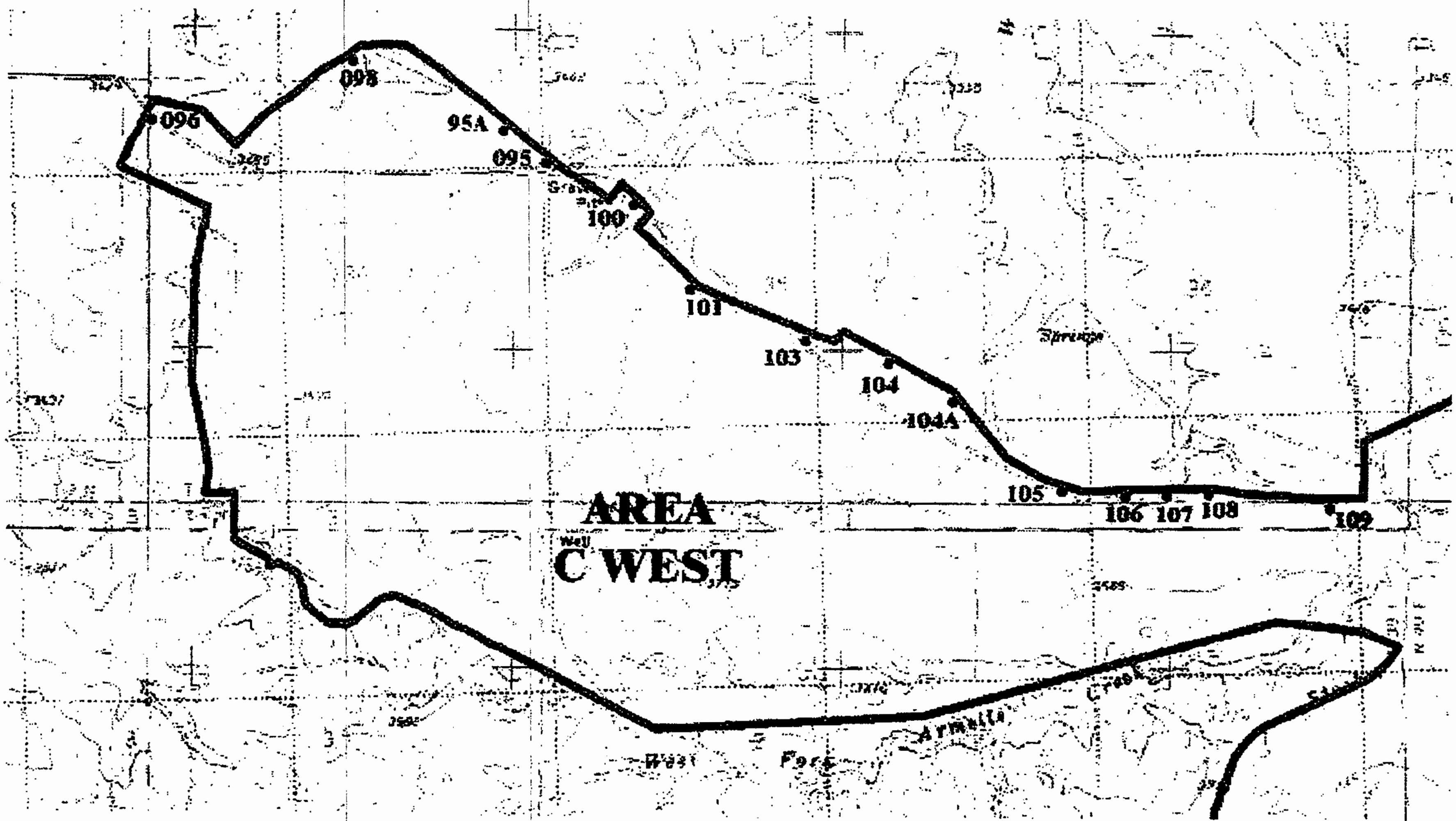
ATTACHMENT I - FACILITY MAPS (Continued)



ATTACHMENT I - FACILITY MAPS (Continued)



ATTACHMENT I - FACILITY MAPS (Continued)



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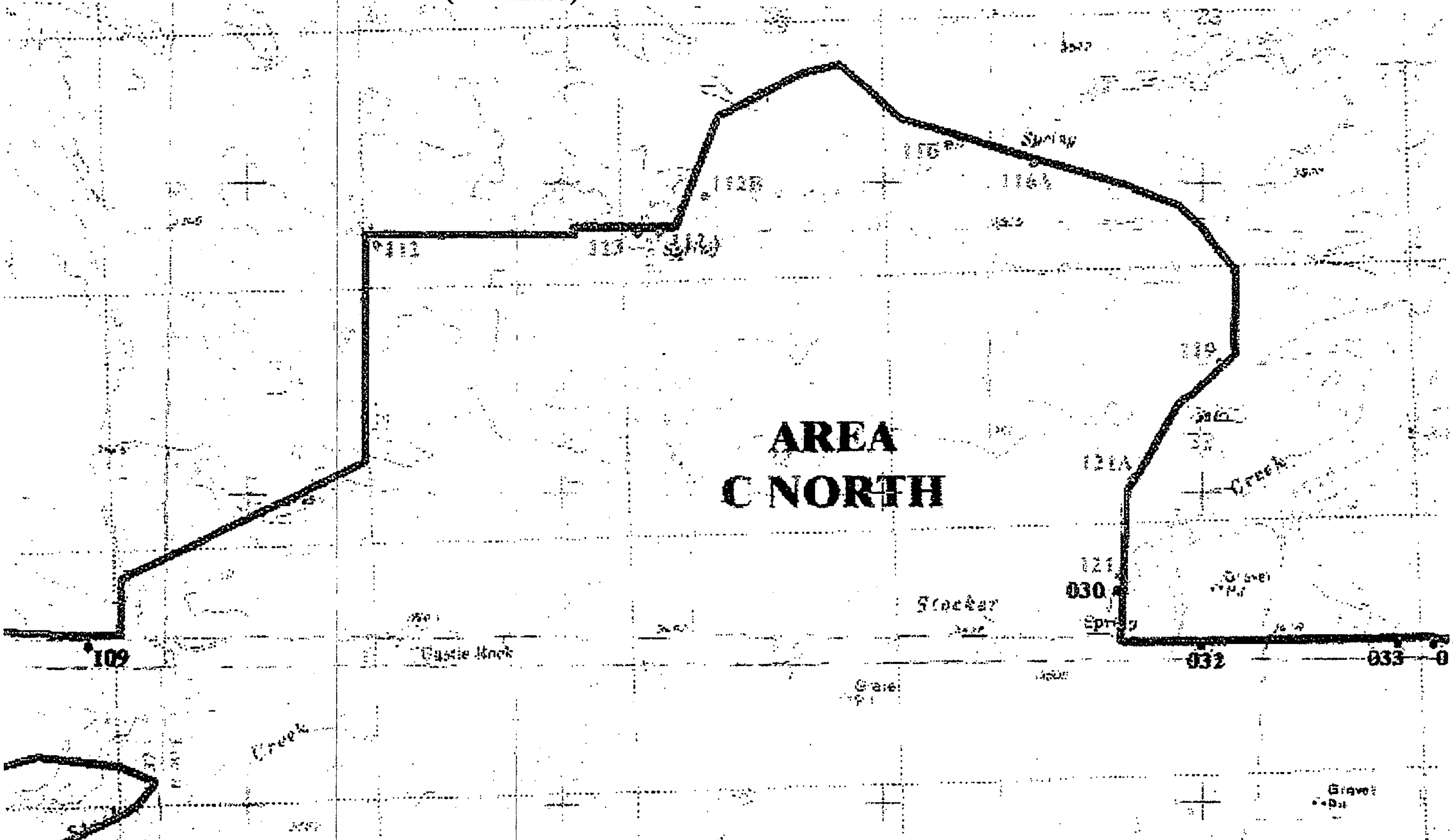
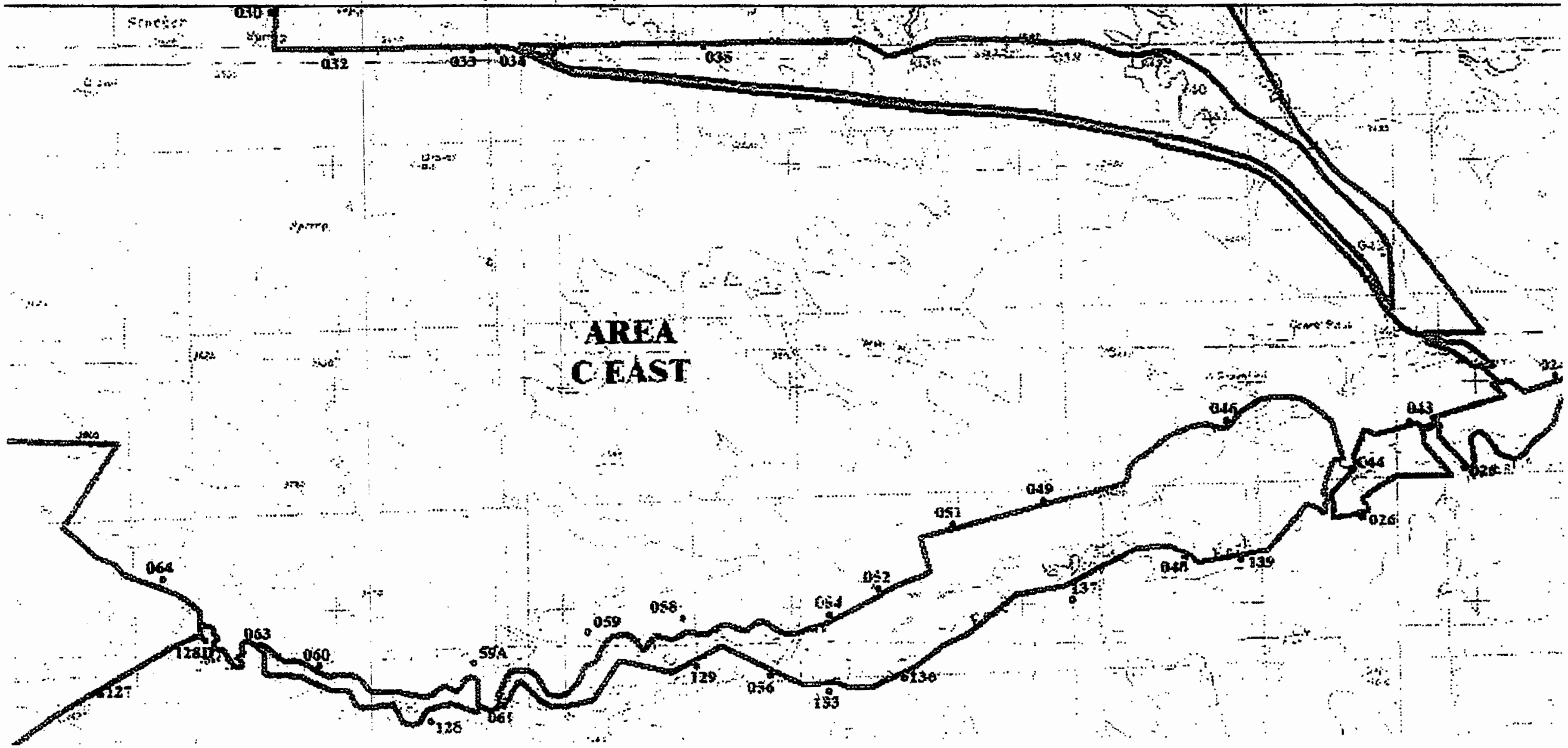
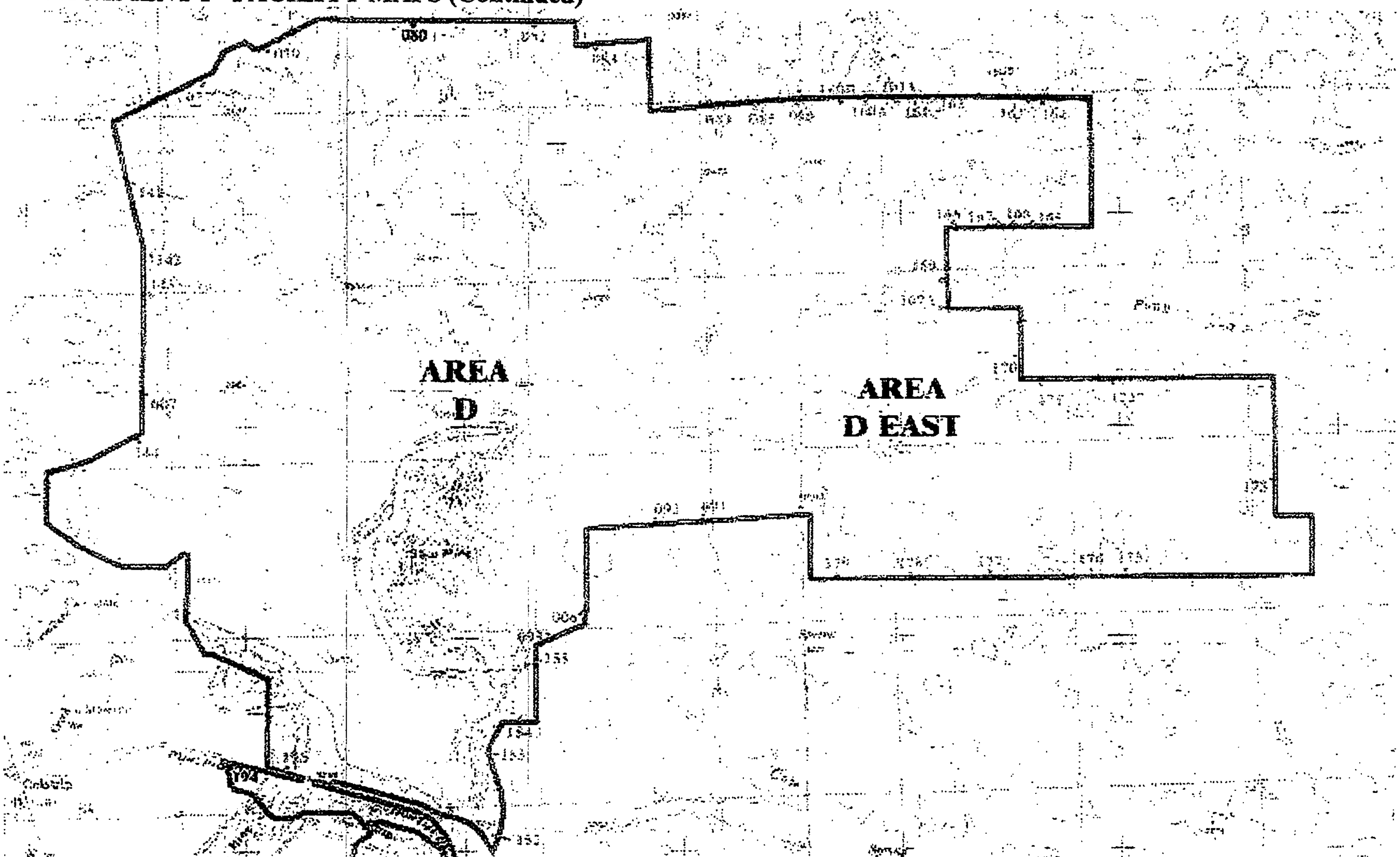


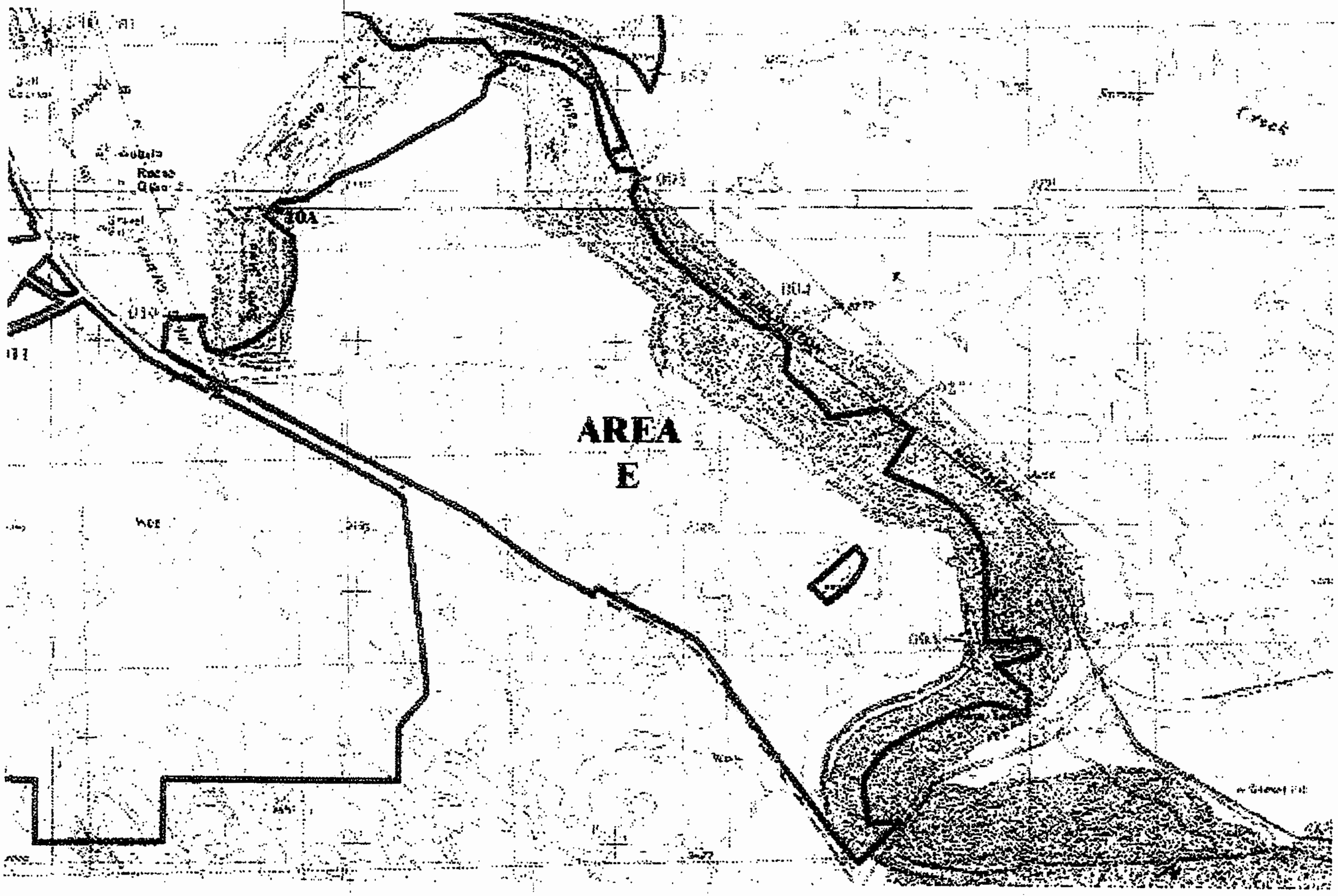
ATTACHMENT I - FACILITY MAPS (Continued)



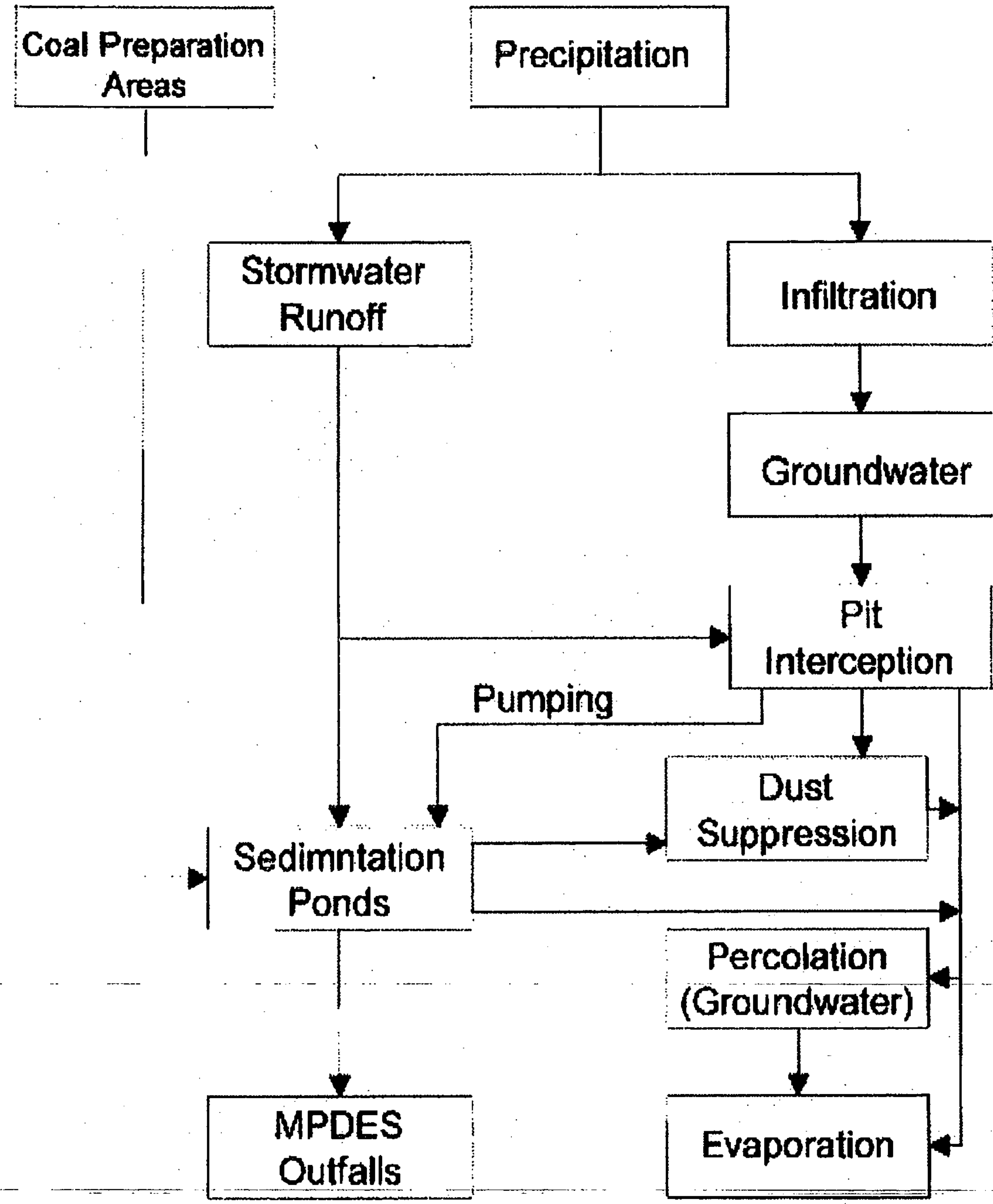
ATTACHMENT I - FACILITY MAPS (Continued)



ATTACHMENT I - FACILITY MAPS (Continued)



ATTACHMENT II – FLOW SCHEMATIC



NOTES:
(1) The Rosebud Mine does not intercept any perennial streamflows and as such inflows are a result of precipitation
(2) Water balance can not be determined due to the variability in precipitation events (intensities, duration, etc.)
(3) A Listing of individual outfalls can be found in Table (2)
(4) This water process is representative of all outfalls under MPDES Permit #MT-0023965.

ATTACHMENT III – FACT SHEET

Attachment B

ARCADIS

ARCADIS U.S., Inc.
1687 Cole Blvd.
Suite 200
Lakewood
Colorado 80401
Tel 303 231 9115
Fax 303 231 9571

MEMO

To:
Western Energy Company

Copies:

From:
Penny Hunter, ARCADIS
Jason Vogel, ARCADIS

Date:
December, 2014

ARCADIS Project No.:
CO001837.00001

Subject:
Western Energy - Rosebud
Aquatic Survey Assessment

---

1. INTRODUCTION

The following letter report describes the results of the aquatic habitat assessment and benthic community survey work performed by ARCADIS on October 9, 2014 within the East Fork Armells Creek (EFAC).

2. SAMPLE LOCATIONS

Aquatic surveys within EFAC were conducted to support existing permitting efforts for surface water discharges, per recent comments received by Montana Department of Environmental Quality (MDEQ). These recent comments included a June 3rd, 2014 MDEQ letter to Western Energy Company (WEC) stating that their application for Permit ID C1984003B Amendment AM4 was deficient and that WEC needed to "confirm, based on current and future anticipated concentrations in the stream, that uses have not or will not be impaired (MDEQ 2014)." In addition, MDEQ requested that WEC "conduct a current aquatic survey along stretches of East Fork Armells Creek (EFAC) adjacent to the Rosebud Mine permit areas (Areas A, B, and C) to identify assemblages of aquatic life using the stream habitat." MDEQ states the data collected from the aquatic survey will be used for future permit revisions in Area A and Area C.

Prior to conducting the aquatic survey, two ARCADIS scientists performed a reconnaissance along the stretch of EFAC adjacent to the Rosebud Mine permit areas (Areas A, B, and C) on October 9, 2014. The reconnaissance was performed to confirm existing drainage conditions (i.e., wetted extents and potential habitat types) that would be representative of the current EFAC aquatic community. Based on the largely homogeneous aquatic habitat observed, consisting of primarily low-gradient drainage with minimal flow, heavy siltation, and riparian and emergent wetlands, two representative locations were selected to survey the current benthic community. The attached Figure 1 indicates the locations of EFAC1 and EFAC2. Location EFAC1 is positioned lower in the EFAC drainage. Compared to more upstream stretches, EFAC1was less impounded, had more visible flow sections and a higher degree of meander and sinuosity patterns in the drainage. This location had an established riparian zone with herbaceous, shrub, and tree vegetation layers, and some in-channel woody debris. Location EFAC2 is found in the middle portion of the EFAC drainage and near the upper extent of the wetted conditions observed during the reconnaissance. EFAC2 represents a low-gradient drainage. Compared to EFAC1, this location had a minimally developed flowing channel, relatively wider and more impounded wetted channel, and less meander and sinuosity. The riparian zone contained emergent vegetation.

3. SURVEY METHODS

Benthic macroinvertebrates were surveyed on October 9, 2014. Survey protocols and taxonomic identification of the benthic community organisms followed both MDEQ's sampling and analysis protocols *Sample Collection, Sorting, Taxonomic Identification, and Analysis of Benthic Macroinvertebrate Communities Standard Operating Procedure* (MDEQ SOP) (MDEQ 2012) and USEPA's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers* (RBP) (Barbour et al. 1999). The MDEQ SOP details a semi-quantitative reach wide sampling technique to collect samples from a known area, which allows the estimation of population density, in addition to diversity and abundance. This sampling technique includes the use of a d-frame net at a total of 11 transects within a sampling reach to be collected as kick samples working downstream to upstream. Barbour et al. (1999) recommends either 40 times the wetted stream width or a representative 100 meter reach (as a minimum for smaller-sized streams) for sampling. Based on drainage conditions, an approximate 100 meter reach was established at each benthic community survey location. Following RBP methodologies, general aquatic habitat conditions were detailed to include measurements of water quality parameters and physical characterization of riparian vegetation, instream features, presence of aquatic vegetation and large woody debris, and sediment and substrate components.

Based on existing habitat observed, the number of transects to provide a representative benthic community sample was reduced down from 11 to 8. Based on professional judgment, the MDEQ SOP methodology and its applicability to these low gradient survey reaches was compromised by the lack of riffles, exposed inorganic substrate, and the largely homogeneous habitat observed within each of the survey reaches. The individual area (1 ft^2 – 0.093 m^2) sampled within each survey reach was increased slightly (1.3 ft^2 – 0.12 m^2) to account for the difference and to obtain a representative 1 m^2 area sampled for the reach. Benthic organism abundance was noted throughout the collection process and available habitats were sampled to provide the representation of the existing community. For EFAC1, this included kick net samples, sweeps of emergent vegetation, and hand-picking and rinsing of functional large woody debris. For EFAC2, the primary habitat was emergent vegetation and exposed root mats of emergent vegetation within a limited free-flowing narrow channel, which was sampled primarily by sweeping emergent vegetation and kicking substrate and root mat and detritus into kick net.

A representative area (approximately a 1.3 ft^2 quadrat) was selected along each transect to collect each of the kick samples. In an area of flow, the kick sample was collected within the representative area, by using hands with a hand trowel or by feet to disturb the area and wash and large rocks, sticks, or debris into the net for a period of 30 seconds. For slackwater habitats with emergent vegetation, the kick net was swept through the vegetation for 30 seconds within the representative area. All individual kick net samples were composited into a 5 gallon bucket and then elutriated to remove large debris. Contents were sieved using a standard #35 (500 micron) mesh size and then transferred to a wide-mouthed plastic sample jar. Samples were preserved with 90% isopropyl alcohol, and sent to Normandeau Environmental Consultants (Normandeau) in Stowe, Pennsylvania, for taxonomic identification. Normandeau taxonomic identification and community sample processing followed by MDEQ protocols to subsample an approximate 500 ± 10% organisms.

Water quality parameters were collected using a YSI 556 multimeter and a Hach 2100P turbidity meter at representative locations within EFAC1 and EFAC2.

4. RESULTS

The aquatic conditions of EFAC are indicative of low-gradient streams, with influences from a mixture of water origins (seasonal runoff, groundwater), and supportive of a tolerant benthic community. Existing habitat is characterized by heavy siltation, low flow, and high amount of organic substrates, with prevalent emergent vegetation along riparian zones.

Table 1 provides a summary of the temperature, specific conductance, dissolved oxygen, pH and turbidity measured at each location. Table 2 summarizes the main physical characteristics and substrate observations for both EFAC1 and EFAC2. Attachment 1 includes observations included during the RBP assessment of aquatic habitat and a set of photographs detailing the habitats surveyed at EFAC1 and EFAC2.

Table 3 provides the results of the taxonomic identification for the EFAC1 and EFAC2 benthic community samples. Community diversity and abundance was similar between the two locations, with a total of 25 and 26 taxa identified at EFAC1 and EFAC2, respectively. Communities were represented by eight orders of aquatic organisms, including aquatic worms, snails, amphipods, mayflies, damselflies, caddisflies, beetles, midges, and fly larvae. Within EFAC1, the side swimmer amphipod within the genus of *Hyalella* was the most dominant benthic organism observed. Within EFAC2, the non-biting midge within the genus of *Paramerina* was the most dominant benthic organism observed. For both locations, mainly tolerant Dipteran taxa comprised over 50% of the community, with *Hyalella* following closely at nearly 25% and above within the community. Based on the MDEQ protocols, a community indicator metric (Hilsenhoff Biotic Index [HBI]) was calculated using Montana-specific tolerance values for identified taxa. The HBI metric represents the relative sensitivity of the sample to nutrient perturbation. The HBI, based on 2005 operable Taxonomic Units (taxonomic endpoints) found in Appendix A of the MDEQ SOP, was calculated for both locations (6.98, 7.90), and indicates "fairly poor" to "poor" conditions (Hilsenhoff 1987).

In summary, the aquatic habitat assessment and benthic community survey was conducted in general accordance with RBPs and MDEQ SOP protocols to satisfy the current deficiency letter and to support the potential for future permitting within existing areas A, B, C within the EFAC.

Attachments

Figure 1 – Aquatic Habitat Assessment and Benthic Community Survey Locations

Table 1 – Water Quality Parameters for East Fork Armells Creek

Table 2 – Physical Characterization and Substrate Summary for East Fork Armells Creek

Table 3 – Benthic Community Samples for East Fork Armells Creek

Attachment 1 – Photolog

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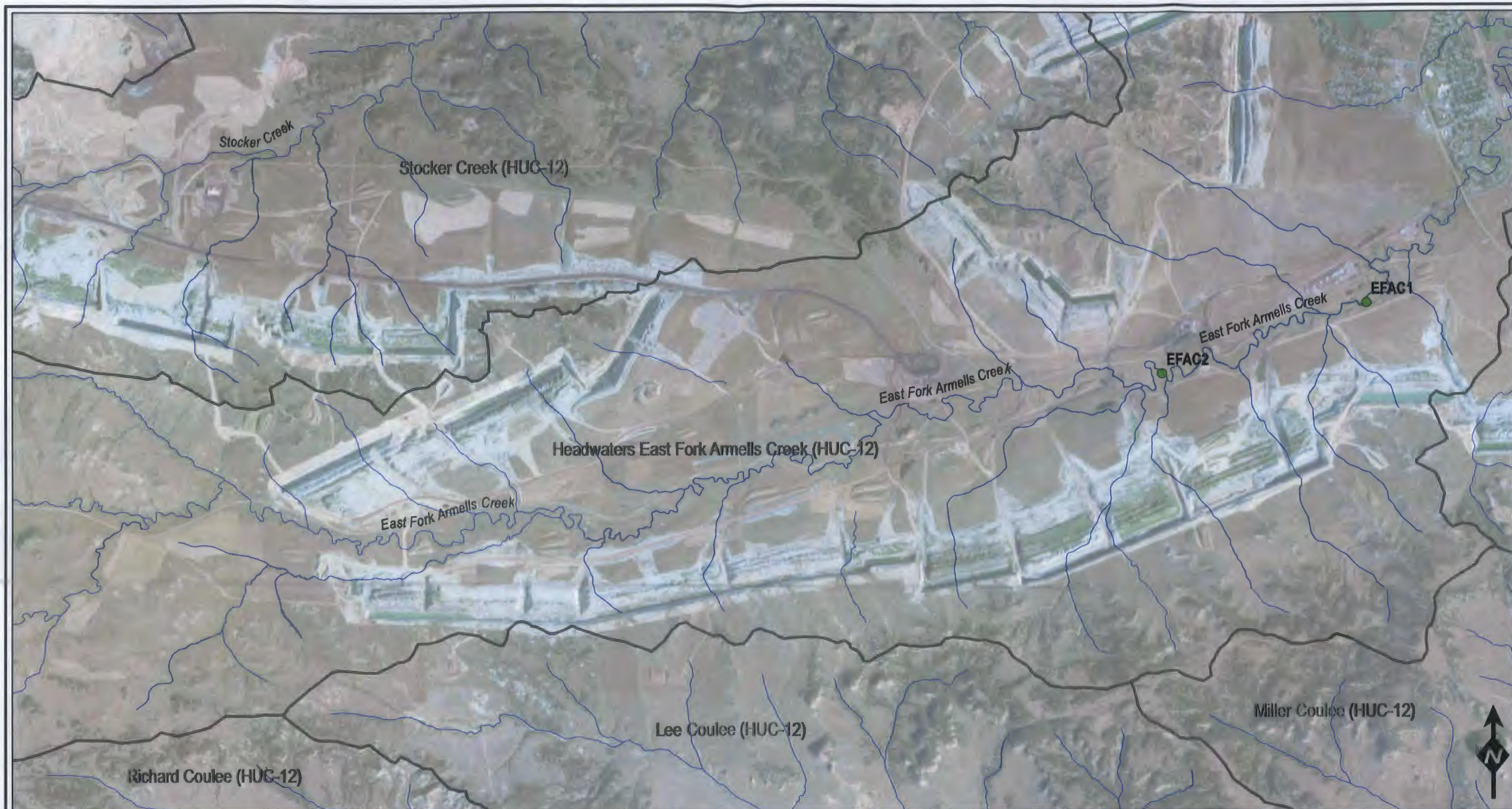
FIGURE AND TABLES



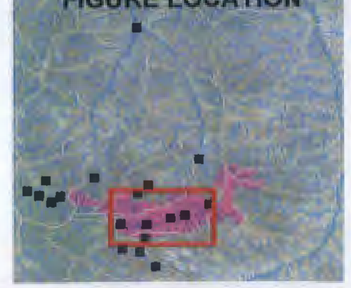
Aquatic Habitat Assessment and Benthic Community Survey Location

- Benthic Community Survey
- USGS NHD Streams
- Watershed Boundaries (HUC12)

0 2,000 4,000 Feet
GRAPHIC SCALE

Notes:
Projection: UTM Zone 13 NAD83
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

FIGURE LOCATION



WESTERN ENERGY - ROSEBUD MINE
COLSTRIP, MONTANA
AQUATIC HABITAT ASSESSMENT AND BENTHIC COMMUNITY SURVEY

EAST FORK ARMELLS CREEK AREA

ARCADIS

FIGURE 1

Document Path: Z:\GISPROJECTS_ENV\Western_Energy_Rosebud\MXD\2014\WE_Rosebud Benthic Community Assessment 0001.mxd

Table 1. Water Quality Parameters for East Fork Armells Creek (Rosebud, MT)

Parameter	EFAC1	EFAC2
Temperature (°C)	16.9	12.9
Specific Conductance (mS/cm)	2.5	2.4
Dissolved Oxygen (mg/L)	9.90	3.52
pH (std units)	8.8	8.4
Turbidity (NTU)	2.49	25.4

Notes:
°C = degress Celsius
mS/cm = milliSiemens per centimeter
mg/L = milligrams per liter
NTU = Nephelometric Turbidity Units

Table 2. Physical Characterization and Substrate Summary for East Fork Armells Creek (Rosebud, MT)

Parameter	EFAC1	EFAC2
Reach Length (m)	100	100
Average Wetted Width (m)	1.9	5.3
Average Stream Depth (in)	5.4	4.5
Average Stream Velocity (ft/sec)	0.22	0.078
Large Woody Debris (m^2)	40	0
Aquatic Vegetation (%)	60	90
Detritus (%)	75	60
Muck-Mud (%)	25	40
Inorganic Substrate Type (Dominant, %)	100% Silt	100% Silt

Notes:

m = meter

in = inch

ft/sec = feet per secon

m^2 = square meter

Table 3. Benthic Community Samples for East Fork Armells Creek (Rosebud, MT)

Sample Date: October 9, 2014
Gear: Kick Net (Montana DEQ: 500-specimen sub-sample)

Taxon	Tol.*	Common name	EFAC1 Number	EFAC1 Percent	EFAC2 Number	EFAC2 Percent
Nematoda	5	round worm			2	0.4%
Haplotaxida						
Enchytraeidae	4	earth worm	2	0.4%		
Tubificinae						
Ilyodrilus	10	tube worm			3	0.5%
Limnodrilus	10	tube worm	1	0.2%	1	0.2%
Basommatophora						
Lymnaeidae						
Fossaria	6	pond snail	15	3.1%		
Physidae						
Physa/Physella	8	pouch snail	6	1.2%	22	4.0%
Amphipoda						
Hyalellidae						
Hyalella	8	side swimmer	187	38.6%	134	24.4%
Ephemeroptera						
Baetide						
Callibaetis	9	mayfly	1	0.2%	4	0.7%
Odonata						
Coenagrionidae	7	damselfly	11	2.3%	16	2.9%
Argia	7	damselfly			25	4.5%
Trichoptera						
Limnephilidae	3	caddisfly			2	0.4%
Coleoptera						
Dytiscidae						
Agabus	5	diving beetle	7	1.4%		
Hydroporini	5	diving beetle			1	0.2%
Diptera						
Chironomidae						
Alotanypus	-	midge			4	0.7%
Apsectrotanypus	8	midge	42	8.7%	18	3.3%
Chironomus	10	midge			1	0.2%
Diplocladius	5	midge	11	2.3%		
Heterotrissocladius	0	midge			7	1.3%
Micropsectra	4	midge	63	13.0%	6	1.1%
Natarsia	-	midge			4	0.7%
Orthocladiinae	10	midge	5	1.0%		
Paramerina	-	midge	25	5.2%	211	38.4%
Parametriocnemus	5	midge			3	0.5%
Paratendipes	10	midge	2	0.4%	4	0.7%
Tanypodinae	-	midge	4	0.8%	42	7.6%
Tanytarsus	6	midge	59	12.2%	1	0.2%
Thienemannimyia gr.	-	midge	16	3.3%		
Other Diptera						
Ceratopogonidae						
Atrichopogon	6	sand fly			1	0.2%
Culicoides	10	sand fly	8	1.7%	28	5.1%
Dasyhelea	6	sand fly	1	0.2%	1	0.2%
Palpomyia gr.	6	sand fly	5	1.0%	8	1.5%
Probezzia	6	sand fly	7	1.4%		

Table 3. Benthic Community Samples for East Fork Armells Creek (Rosebud, MT)

Sample Date: October 9, 2014
Gear: Kick Net (Montana DEQ: 500-specimen sub-sample)

Taxon	Tol.*	Common name	EFAC1 Number	EFAC1 Percent	EFAC2 Number	EFAC2 Percent
Other Diptera (continued)						
Empididae						
Chelifera	5	dance fly	1	0.2%		
Ephydridae	6	shore fly			1	0.2%
Simuliidae						
Simulium	5	black fly	3	0.6%		
Tipulidae						
Limnophila	3	crane fly	1	0.2%		
Ormosia	6	crane fly	1	0.2%		
Total Individuals			484	100.0%	550	100.0%
Total Taxa			**25**		**26**	
Hilsenhoff Biotic Index			**6.98**		**7.90**	
(water quality rating: from Hilsenhoff, 1987)			(fairly poor)		(poor)	

Reference:*
Tol = Tolerance values as found in Appendix A of:
Montana Department of Environmental Quality (MT DEQ). 2012. Sample Collection, Sorting, Taxonomic Identification, and Analysis of Benthic Macroinvertebrate Communities Standard Operating Procedure. MT DEQ, WQPBWQM - 009

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ATTACHMENT 1

ARCADIS **PHOTOGRAPHIC LOG**

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No.	Date:
1344	10/9/14

Direction Photo Taken:

Facing northwest

Description:

Wetland area on EFAC approximately 0.4 stream miles downstream of EFAC1 survey location. Standing water present.

Lat: 45.869200
Long: -106.63763

ARCADIS **PHOTOGRAPHIC LOG**

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No.	Date:
1345	10/9/14

Direction Photo Taken:

Facing southeast

Description:

Wetland area on EFAC approximately 0.4 stream miles downstream of EFAC1 survey location. Standing water extends under Castle Rock Road through culvert.

Lat: 45.868820
Long: -106.637500

ARCADIS		PHOTOGRAPHIC LOG
Property Name: Rosebud Mine	**Location:** Rosebud, Montana	**Project No.** CO1837.0001

Photo No. 1348

Date: 10/9/14

Direction Photo Taken:

Facing northwest

Description:

Wetland area on EFAC approximately 0.8 stream miles downstream of EFAC2 survey location. Proximate to intersection of EFAC, Castle Rock Road, and haul road.

Lat: 45.861580
Long: -106.652240

ARCADIS		PHOTOGRAPHIC LOG
Property Name: Rosebud Mine	**Location:** Rosebud, Montana	**Project No.** CO1837.0001

Photo No. 1349

Date: 10/9/14

Direction Photo Taken:

Facing northwest

Description:

Wetland area on EFAC approximately 0.5 stream miles downstream of EFAC2 survey location. Castle Rock Road in distance

Lat: 45.860400
Long: -106.656270

ARCADIS PHOTOGRAPHIC LOG

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No. 1351

Date: 10/9/14

Direction Photo Taken:

Facing west

Description:

Upstream extent of EFAC wetland area. Standing water present. Approximately 0.2 stream miles upstream of EFAC2 survey location. Dry conditions observed continuing upstream.

Lat: 45.859860
Long: -106.664020

ARCADIS PHOTOGRAPHIC LOG

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No. 1352

Date: 10/9/14

Direction Photo Taken:

Facing southwest

Description:

Dry channel approximately 0.75 stream miles upstream of EFAC2 survey location. Castle Rock Road observed on right edge of photo.

Lat: 45.859930
Long: -106.670680

ARCADIS — **PHOTOGRAPHIC LOG**

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No. 1353

Date: 10/9/14

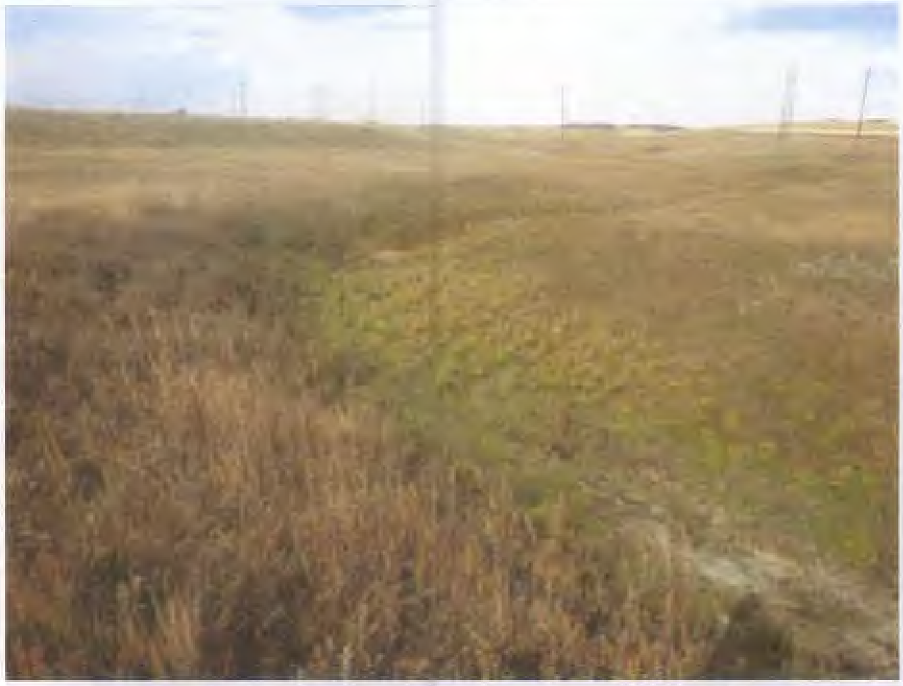
Direction Photo Taken:

Facing northwest

Description:

Dry channel approximately 1.1 stream miles upstream of EFAC2 survey location. Castle Rock Road observed n upper right of photo.

Lat: 45.857170
Long: -106.675190



ARCADIS — **PHOTOGRAPHIC LOG**

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No. 1354

Date: 10/9/14

Direction Photo Taken:

Facing northeast

Description:

Dry channel approximately 2.3 stream miles upstream of EFAC2 survey location.

Lat: 45.854550
Long: -106.686500

ARCADIS

PHOTOGRAPHIC LOG

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No.	Date:
1355	10/9/14

Direction Photo Taken:

Facing downward into water

Description:

Downstream extent of EFAC1 at EFAC1-1 transect. Kicksweep area. Substreate consists of detritus and much/mud. Principally silt.

Lat: 45.86633
Long: -106.63821

ARCADIS

PHOTOGRAPHIC LOG

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No.	Date:
2356	10/9/14

Direction Photo Taken:

Facing southwest - upstream

Description:

Near to downstream extent of EFAC1 at EFAC1-2 transect. Kicksweep area. Substreate consists of detritus and muck/mud. Principally silt. Woody debris present.

Lat: 45.86628
Long: -106.63821

ARCADIS | **PHOTOGRAPHIC LOG**

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No. 1360 | **Date:** 10/9/14

Direction Photo Taken:

Facing northeast - downstream

Description:

Near to midstream extent of EFAC1 at EFAC-1-6. Sample collected from sweeping of watercress. Silt streambed material. Emergent vegetation, woody debris, and coarse plant material.

Lat: 45.86595
Long: -106.63861

ARCADIS | **PHOTOGRAPHIC LOG**

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No. 1362 | **Date:** 10/9/14

Direction Photo Taken:

Facing west - downstream

Description:

Upstream extent of EFAC1 at EFAC-1-8. Kick area. Silt streambed material. Emergent vegetation, woody debris, and coarse plant material.

Lat: 45.86581
Long: -106.63855

ARCADIS **PHOTOGRAPHIC LOG**

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No. **1363**

Date: 10/9/14

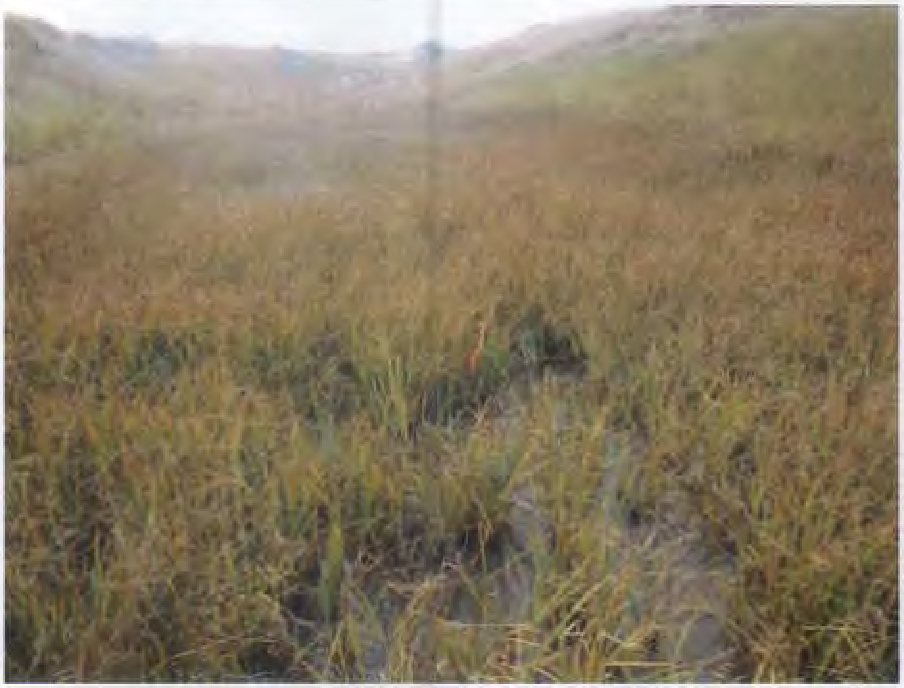
Direction Photo Taken:

Facing northwest - upstream

Description:

Downstream extent of EFAC2 at EFAC2-1 transect. Shows extent of survey area. Decaying root matt. Silty/fine/muck and mud bed. Sedges present in area.

Lat: 45.85940
Long: -106.66233



ARCADIS **PHOTOGRAPHIC LOG**

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No. **3364**

Date: 10/9/14

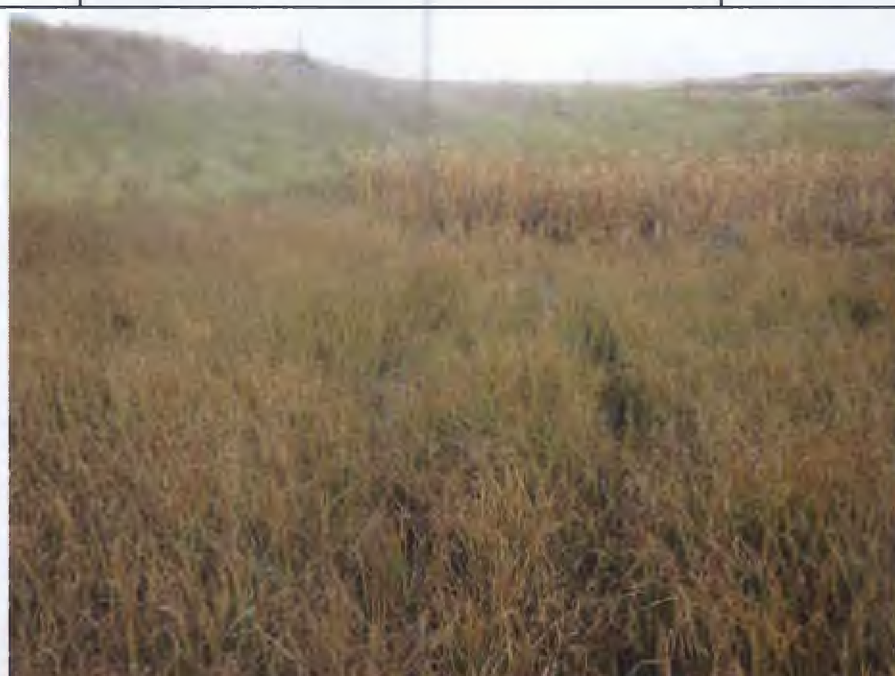
Direction Photo Taken:

Facing southeast - downstream

Description:

Downstream extent of EFAC2 at EFAC2-1 transect. Shows downstream of survey area. Sedges in foreground and cattails in background downstream.

Lat: 45.85940
Long: -106.66233



PHOTOGRAPHIC LOG

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No. **1370**

Date: 10/9/14

Direction Photo Taken:

Facing northwest - upstream

Description:

Near to upstream extent of EFAC2 at EFAC-2-7 transect. Open water and decaying sedges. Cattails in area. Silt bottom and iron oxide sheen present.

Lat: 45.85970
Long: -106.66307

PHOTOGRAPHIC LOG

Property Name:	Location:	Project No.
Rosebud Mine	Rosebud, Montana	CO1837.0001

Photo No. **1372**

Date: 10/9/14

Direction Photo Taken:

Facing southeast - downstream

Description:

Upstream extent of EFAC2 at EFAC-2-8 transect. Upstream of cattail os photo 1370. Silty bed. Decaying sedges and root matt.

Lat: 45.85976
Long: -106.66317

Attachment C

Report
Assessment of East Fork Armells Creek Vicinity of Areas A and B

Prepared for:

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Report
Assessment of East Fork Armells Creek
Vicinity of Areas A and B
by
Michael E. Nicklin, PhD, PE

1.0 BACKGROUND

The purpose of this report is to provide a synopsis of the nature of the relationship between the groundwater and the East Fork Armells Creek (EFAC) in the portion of the Western Energy Company's Rosebud Mine between permitted Areas A and B. The focus of this investigation was to assess if it is likely or not that this portion, or portions, of this creek should be considered as ephemeral or intermittent.

The following activities were performed in this assessment:

- Reviewed prior reports completed by others.
- Assessed alluvial well hydrographs in the vicinity of Areas A and B.
- Collected supplemental survey elevations of the EFAC channel thalweg at locations near selected alluvial wells. The evaluation focused on locations where pre-mining water level data were available.
- Evaluated the significance of other influences, such as mining, Montana Pollutant Discharge Elimination System (MPDES) discharges, etc. to alluvial aquifer conditions and potentially to surface water flows between Areas A and B.

2.0 PREVIOUS INVESTIGATIONS

One of the more relevant prior investigations which addressed the hydrologic conditions of the EFAC between Areas A and B was conducted by Van Voast, et al (1977). Pre-mine data up to 1976 were considered in the Van Voast investigation. The following are selected/relevant excerpts from the Van Voast, et al report:

> *"Most streams flow only during periods of snow-melt and after infrequent events of high-intensity rainfall. Rosebud Creek and East Fork Armells Creek downstream from Colstrip have perennial flow generated by continuous ground-water discharge. . . ."*

> Pertinent to Areas A and B:

> *"Flow of ground water in alluvium along East Fork Armells Creek is almost parallel to the water course. The alluvium is recharged vertically from precipitation and streamflow, and laterally from subcrops of bedrock aquifers. Most water in the alluvium is transmitted within the basal gravel beds. . .".*
>
> *"Upstream from Colstrip, East Fork Armells Creek is generally dry except for water holes where its channel locally penetrates the water table."*

Hence, it seems that Van Voast, et al characterizes this section to be a losing reach, i.e., water infiltrates from the stream into the alluvial aquifer. Thus, if EFAC flows were present, they were not dependent upon base flow from groundwater.

Another study was the alluvial valley floor (AVF) evaluation conducted for WECo by Hydrometrics (1982). That report described groundwater flow nearly parallel to the watercourse, similar to the interpretations defined in Van Voast et al (1977). That same report also described flow or standing water in short sections of the creek above Colstrip much of the year in the AVF evaluation.

A significant factor described in both studies that will affect the hydraulic communication between a stream and an adjacent alluvial aquifer is the nature of the geologic substrate between the stream channel and that underlying aquifer. Both the Van Voast, et al and AVF studies described a significant thickness of silt and clay between the base of the EFAC channel and the underlying alluvial aquifer. Such a condition will limit to some degree, any potential surface water and groundwater interaction.

The Environmental Impact Statement (EIS) for Area C (MDSL, 1982) states that the East Fork Armells Creek is intermittent in the vicinity of Area C.

Hence, it is clear that differences of opinion exist regarding the nature EFAC in the reach of interest. Therefore, the focus of this evaluation is to provide better resolution of the nature of the channel in the EFAC vicinity near Areas A and B.

3.0 OTHER FACTORS AND RECENT OBSERVATIONS

There are two primary human factors that affect EFAC flow in the Colstrip area and they are:

- Importation of Yellowstone River water to Colstrip, and
- Mining of coal at the Rosebud Mine.

Other human factors which can be locally influential include the presence of local stock ponds and roadway culverts, etc.

3.1 Importation of Yellowstone River Water to Colstrip

The overall water balance of the hydrogeologic regime in the Colstrip area has been altered via the importation of Yellowstone River water for use at the power plant. This imported water is stored in the surge pond (Castle Rock Lake). This imported water also serves to provide water supplies to Colstrip. Some portions of this imported water contribute recharge from pond leakage. For instance, leakage results from the surge pond and it is discussed in Van Voast et al. Another example is discharge of municipal waste water which leads to recharge and increased flow in EFAC within and downstream of Colstrip.

All these factors have resulted to increases in the EFAC alluvial water levels in the Colstrip area. Given that the EFAC alluvial aquifer is hydraulically continuous throughout the Colstrip area, some increase in the alluvial aquifer water levels is anticipated to have occurred in eastern portions of EFAC between Areas A and B as a consequence. The relative degree of this effect is not simple to quantify and is not evaluated in this report.

3.2 Influence of Mining Activity

Mining activity also influences the relative relationship between surface water conditions of EFAC and the underlying alluvial aquifer system. The following counterbalancing effects have been observed during mining:

- Dewatering of the Rosebud coal during mining reduces groundwater flows in the alluvium near EFAC. When water is taken from a coal seam during mining, water flows out of the alluvial aquifer and groundwater levels decline. The amount of this flow induction (and water level decline) is dependent upon the degree of hydraulic connectivity between the coal seams mined and the EFAC alluvium. The degree of connectivity, in large part, depends upon the proximity of mine passes to the alluvium. Between Areas A and B, the Rosebud coal is in contact with the EFAC alluvium. The EFAC alluvial deposits are much nearer mine passes in Area B when compared to mining in Areas A and E. Hence, mining in northern portions of Area B affects the aquifer most. The degree of the mining impacts from a water quantity perspective diminishes as Area B mine passes move away (generally south) from the EFAC alluvium, and as spoils are placed between the alluvium and the active mining passes.

- Recovery of alluvial water levels is dependent upon recharge from a combination of following sources:

- Runoff can be a major source of groundwater recharge along the main stem of EFAC. In some years, significant runoff occurs in association with either snowmelt and/or precipitation.
- Local recharge to nearby land surfaces also occurs but this recharge is much less significant compared to recharge from EFAC channel runoff.
- Recharge during mining results from MPDES discharges to the EFAC channel. This factor has been particularly dominant in years when precipitation and runoff is above average. The net result of above normal precipitation is that much greater volumes of water are retained/detained in ponds and mine pits. This stored water is then discharged to the EFAC channel over an extended period of time. Hence, a large volume of recharge occurs. Table 1 provides a summary of documented MPDES flow volumes into the EFAC drainage. Substantial discharges were observed in water years 2000, 2011, 2012 and 2013.

  Based upon observations of WECo mine staff, the MPDES discharges directed to EFAC infiltrate from the channel base, thus recharging the underlying alluvial aquifer. Such recharge has led to rapid recovery of water levels and even increases in alluvial groundwater levels exceeding pre-mine water level conditions. Thus, the key effect of MPDES discharges is to act a major recharge source to the EFAC alluvium between Areas A and B.

It is instructive to compare the significance of mining activity and the effects of MPDES discharges using observation well WA-101 (see Figure 1). The surveyed EFAC channel elevation (as interpolated) near this well is 3291.04 feet (see Figure 2). This elevation is compared to water level elevations of alluvial well WA-101. The following is an interpretative summary of the groundwater levels in this well over time:

- Water levels in this alluvial well prior to mining in the area showed a seasonal response likely related to early season runoff and the consequent increase in recharge to the alluvium from this runoff. Water levels tend to oscillate above and below the projected channel thalweg. The levels are more likely to be above the thalweg during runoff season and more likely to be below the thalweg during the drier portion of the year.
- Mining in Area B and Area C commenced near this well in 1983. As a result, water levels in the alluvium were drawn down slightly and were more likely to be below the channel base. After 1988 the groundwater levels remained persistently below the channel until about 1993.
- When mining in Areas B and C moved away from the EFAC alluvium near WA-101, water levels began to recover gradually over time until they were at,

or above, pre-mine levels by about 1994. The water levels continued to increase over time to reach levels exceeding pre-mine conditions. This increase is likely due to a combination of distance to mining passes, natural recharge, and discharge from mine pits/ponds into the EFAC drainage above or near this well.

- Beginning in 2011, water levels at WA-101 increased well above pre-mine conditions. This latter response is associated with the substantial MPDES discharges into EFAC since that year (Refer to Table 1). It was also likely affected to a lesser degree by natural recharge primarily related to runoff contributed from more up-gradient portions of the drainage during these years.

4.0 OTHER HYDROGRAPH EVALUATIONS

In addition to WA-101, other observation wells in the EFAC alluvium were compared to nearby surveyed channel thalweg elevations. Each of these is discussed below. Refer to Figure 2 for location and hydrographs for each respective well discussed.

Before proceeding with well specific discussions, it is noted that direction of alluvial groundwater flow will tend to follow the primary axis of the alluvial valley floor as opposed to following the sinuous alignment of the channel thalweg. This is especially true if there is little or no hydraulic connection between the stream channel and the alluvium. Channel thalweg elevations were collected as near to each specific alluvial well as feasible, and, along an equivalent projected potentiometric head elevation. The purpose was to provide a comparison of pre-mine alluvial groundwater levels to channel bases in the vicinity. In three instances, interpolated elevations from the survey data were employed.

WA-114 versus thalweg elevation - 3321.27 feet

See Figure 2 for the location of channel thalweg survey point and the hydrograph for alluvial well WA-114.

Early water levels (prior to 1982) for alluvial well water WA-114 indicate groundwater levels were interpreted to be about two feet below the base of East Fork Armells Creek at the surveyed thalweg location. In 1982, water levels increased abruptly during late winter and early spring at this well potentially indicating that channel recharge had occurred in association with a snow-melt and/or precipitation runoff event. The well water levels had risen above the surveyed channel thalweg elevation. Thereafter, water levels were observed to decline to below the surveyed channel thalweg elevation. The seasonal increase in groundwater levels in 1982 was likely affected significantly by the runoff water captured in a nearby stock pond embankment. When this stock pond captures EFAC surface water flow, it tends to infiltrate (recharge) the underlying alluvium. Hence, it is difficult to quantify what "normal" water level conditions would be at WA-114 had it not been for the pond.

Additional evaluations are presented in Section 5.0 discussing the potential for historical/current existence of ephemeral or intermittent conditions for EFAC in the vicinity of WA-114.

Mining commenced in the vicinity of WA-114 in late 1983 resulting in substantial drawdown beginning in early 1984. Since 1984, water levels had persistently remained well below pre-mine levels until about 2011. At that time, water levels had recovered to near, if not slightly above, pre-mine levels. This recovery is interpreted to be from the far above average precipitation/runoff/recharge beginning in 2011. A substantial fraction of this recharge is a result of the increased MPDES discharges into the EFAC channel which subsequently infiltrated into the underlying alluvium. Again, the pond embankment also causes significantly increased recharge in this area. Even with the increased recharge from the MPDES discharges and the pond embankment, groundwater levels at this well have remained below the surveyed thalweg elevation.

EX-40 versus thalweg elevation (interpolated) – 3313.66 feet

See Figure 2 for location of channel thalweg survey point and hydrograph for alluvial well EX-40.

Alluvial well EX-40 (abandoned) has a limited water level data set extending from June 1980 to July 1983. All data were collected at this well prior to mining in its vicinity which commenced in the latter part of 1983. The water levels in this well are interpreted to have varied from below to slightly above the channel thalweg. It is likely that the higher water levels are associated with early year runoff. For instance, as in the case of WA-114, the water levels increased beginning early 1982, probably as a result of increased recharge associated with a significant snowmelt/precipitation runoff event(s) that occurred that year. As in the case for WA-114, the local groundwater elevations at this location may have been affected to some degree by nearby stock pond(s) [see Figure 2]. This includes the pond described in the vicinity of WA-114. There was also a stock pond very near EX-40. As a result, it is difficult to project what "normal" water level conditions at EX-40 would have been without the ponds being present.

Additional evaluations are presented in Section 5.0 discussing the potential existence of ephemeral or intermittent conditions for EFAC in the vicinity of EX-40.

WA-101 versus thalweg elevation (interpolated) – 3291.04 feet

See prior discussion for this well in Section 3.0.

<u>EX-27 versus thalweg elevation (interpolated) – 3282.30 feet</u>

See Figure 2 for locations of channel thalweg survey point (interpolated) and hydrograph for alluvial well EX-27.

Alluvial well EX-27 (abandoned) has a limited water level data set extending from June 1980 to May of 1987. Mining commenced in the vicinity of this well location in the latter part of 1983. The water levels in this well are interpreted as being substantially below the channel thalweg for the entirety of its observation history.

<u>WA-128 versus thalweg elevation – 3271.51 feet</u>

See Figure 2 for location of channel thalweg survey point and hydrograph for alluvial well WA-128.

This alluvial well has a water level measurement history from late 1980 to present. Based upon the data set one water level measurement of 3269.1 feet was taken prior to mining commencing in this vicinity of Area B in early 1981. That measurement is about 2.4 feet below the surveyed channel thalweg elevation of 3271.51 feet.

As in the case of WA-101 and WA-114, water levels in WA-128 show a historic response to the effects of drawdown from mining, and in turn, the recovery of water levels over time, particularly in response to MPDES discharges. Notable responses in this well's hydrograph correspond to MPDES release that occurred in year 2000, 2007 and 2011 (refer to Table 1 for MPDES discharges by year).

Recent water levels have been persistently about three feet above the pre-mine water level measurement collected in December 1980. Water levels since 2011 have also been observed to be persistently above the surveyed channel thalweg demonstrating the significance of the MPDES discharges into EFAC.

<u>WA-126 versus thalweg elevation – 3265.97 feet</u>

See Figure 2 for locations of channel thalweg survey point and hydrograph for alluvial well WA-126.

This alluvial well has a water level measurement history from late 1980 to present. One water level measurement of 3265.1 feet was taken prior to mining commencing in this vicinity of Area B in early 1981. That measurement is about 0.9 feet below the surveyed channel thalweg elevation of 3265.97 feet.

The water levels in this well exhibited a historic response to nearby mining activity. Water levels since 2011 have been above the thalweg elevation, due primarily to the effects of MPDES discharges to EFAC.

<u>WA-124 versus thalweg elevation – 3258.91 feet</u>

See Figure 2 for locations of channel thalweg survey point and hydrograph for alluvial well WA-124.

This alluvial well has a water level measurement history from late 1980 to present. Based upon the data set one water level measurement of 3254.7 feet was taken prior to mining commencing in this vicinity of Area B in early 1981. That measurement is about 4 feet below the surveyed channel thalweg elevation of 3258.91 feet.

Note that water levels did show increases from about 1982 to 1983 as mining in Area B had been on-going. A logical explanation for this increase is that groundwater collected during mining was being discharged into EFAC near, or just upgradient of, this alluvial well. Water levels were ultimately drawn down to about 9 feet below the thalweg in the late 1980s to mid-1990s. Presently, water levels in this well are very near the surveyed channel thalweg elevation.

<u>P-04 versus thalweg elevation – 3245.96 feet</u>

See Figure 2 for locations of channel thalweg survey point and hydrograph for alluvial well P-04.

This alluvial well has a water level measurement history from late 1974 to present.

Water levels in this well are likely affected by a down-gradient ponded area. The embankment causing this impoundment is possibly a relic embankment associated with a road alignment shown on United States Geological Survey topographic mapping.

The historic water levels prior to mining in Area B exhibited relatively regular seasonal variation centered about the surveyed thalweg elevation. This seasonal variation may, at least in part, be a result of seasonal runoff and pond storage.

The water levels in this well declined to below the thalweg when Area B mining commenced. In about 1990, water levels recovered to levels similar to those that were observed prior to Area B mining. Area B mining had gradually moved away from the alluvial channel vicinity by this time.

Since approximately 1993, water levels in P-04 have been well above the channel thalweg. Presently, the water levels at this location have been at their highest in year 2000 and since 2011. These high water levels are associated with the elevated MPDES discharges as defined in Table 1.

5.0 INTERPRETATIVE DEFINITION OF STREAM DESIGNATION

The information and interpretations provided previously, coupled with evaluation of recent aerial photography, allows for better resolution of the "point" along EFAC where it transitions from ephemeral to intermittent conditions. Figure 3 presents aerial photography for the following dates:

- August 11, 2009
- July 16, 2011
- July 21, 2013

An evaluation of the EFAC channel condition between observation wells WA-114 (upgradient) and WA-101 (downgradient) was conducted. Note that prior evaluations had indicated the existence of intermittent channel conditions near WA-101. The conditions near up-gradient (west) wells WA-114 and EX-40 (see Figure 2) were less conclusive because of the existence of pre-mine stock ponds.

Figure 3 also includes water level hydrographs for alluvial wells WA-114 and WA-101. The following are noted on Figure 3:

- Water levels at WA-101 were observed to be above pre-mine observations for 2009, 2011 and 2013.
- Water levels at WA-114 were observed to be near pre-mine observations for 2009, 2011 and 2013.

Hence, the channel conditions near/between these wells for the above aerial photographs should provide information regarding the following:

- Was the channel ephemeral or intermittent historically (pre-mine)?
- What is the current condition as consequence of mining activity and other factors?

The aerial photographs were each evaluated to determine if channel (standing/flowing) water was present. Note that channel water may be associated with either direct surface runoff and/or groundwater. This analysis makes no attempt to distinguish between standing water versus flowing water from the aerial photographs.

On the August 11, 2009 aerial photograph the first channel water was interpreted to begin at the point designated as A1 (upper left on Figure 3). No significant precipitation/runoff events were documented near this date. Hence, the presence of channel water at A1 is interpreted to be from groundwater. In summary, the channel was dry up-gradient (west) of A1. Based upon the 2009 aerial photograph, the EFAC between from the vicinity of WA-114 to A1 is ephemeral. The channel below A1 is intermittent.

On the July 16, 2011 aerial photograph some localized surface water (SW) were interpreted to be present up-gradient (west) of A1. It is noteworthy that a major precipitation event occurred on July 15, 2011. Hence, there is a significant likelihood that the localized surface water observed in the channel is from direct runoff event as opposed to being an expression of groundwater.

On the July 21, 2013 aerial photograph the first channel water was interpreted to begin at the point designated as B1 (lower left on Figure 3). No significant precipitation/runoff events could be discerned near this date. Hence, the presence of channel water at B1 is interpreted to be from groundwater. In summary, the channel was interpreted to be dry upgradient (west) of B1. Based upon the 2013 aerial photograph, the EFAC between from the vicinity of WA-114 to B1 is ephemeral. The channel below B1 is intermittent.

Given that groundwater levels at WA-101 are elevated (increased) relative to historical conditions, it is likely that the "transition point" between an ephemeral to an intermittent condition has migrated up-gradient slightly from what it was historically. Again, the increased water levels are largely attributable to an increase in recharge from the MPDES discharges necessitated from the far above average precipitation that has been observed in recent years (see Table 1).

Finally, even with elevated groundwater levels, there is no evidence of channel water near WA-114. Hence, the channel near WA-114 is deemed to have been ephemeral historically as well as currently.

6.0 SUMMARY AND CONCLUSIONS

ARM 17.30.602 defines an ephemeral stream as a stream or part of a stream which flows only in direct response to precipitation in the immediate watershed or in response to the melting of snow and ice whose channel bottom is always above the local water table.

Based upon the opinions expressed by Van Voast, et al, and based upon the evaluation conducted herein, I conclude the following:

- Based upon the aforementioned ARM definition, the transition point where the EFAC is interpreted to become ephemeral under current conditions is located up-gradient (west) from observation well WA-101 (point B1 in Figure 3). For historic conditions it is more likely that the ephemeral conditions began nearer vicinity of point A1 (Figure 3).
- Imported water for use at the power plant and for municipal purposes has affected groundwater levels in the vicinity of Colstrip.

- Mining has had a dual impact on the relationship between the EFAC between areas A and B and the alluvial aquifer as follows:
    - When mining was nearer the EFAC alluvium, groundwater level declines resulted.
    - MPDES discharges increased the groundwater levels. When significant discharges occurred, those discharges ultimately led to groundwater level conditions well above base-line conditions.
- The recent groundwater level conditions, and the current persistent flows observed in the EFAC, are not indicative of the natural condition for this portion of the creek. The water levels have been affected by far above average precipitation and the resultant increase in MPDES discharges that have occurred since 2011. Other human caused changes, such as stock ponds, have affected water levels and flows in EFAC as well.
- It is projected that when precipitation/runoff conditions return nearer to normal the following will transpire:
    - Alluvial groundwater levels will decline; and
    - Flows in EFAC will return nearer to pre-mine baseline conditions
- Finally, there are other factors and limitations to the evaluation that was conducted including the following:
    - In some areas, such as the very eastern portion of Area B, there is only one pre-mine groundwater elevation. Therefore, it is difficult to project with scientific certainty normal groundwater levels.
    - There are other factors affecting the degree of communication, or lack thereof, between a stream and an aquifer. One of these factors is existence of silt and clay between the EFAC channel thalweg and the underlying aquifer. This natural barrier reduces the degree of any potential surface water and groundwater interaction. Apparently though, the observations of mine staff are that MPDES discharges do infiltrate into the alluvium. Given that well hydrographs do respond (rise) accordingly, there is some degree of hydraulic connection between the EFAC channel and the underlying alluvial aquifer.

REFERENCES

Hydrometrics. 1982. Comprehensive alluvial valley floor investigation – East Fork Armells Creek Stocker Creek and Cow Creek. Report prepared for Western Energy Company.

Montana Department of State Lands and US Office of Surface Mining, 1982. Final Environmental Impact Statement, Western Energy Company's Rosebud Mine, Area C, Block 1.

Van Voast, W.A., R.B. Hedges, J.J. McDermott. 1977. Hydrogeologic conditions and projections related to mining near Colstrip, Southeastern Montana. Montana Bureau of Mines and Geology. Bulletin 102. June, 1977.

Table 1

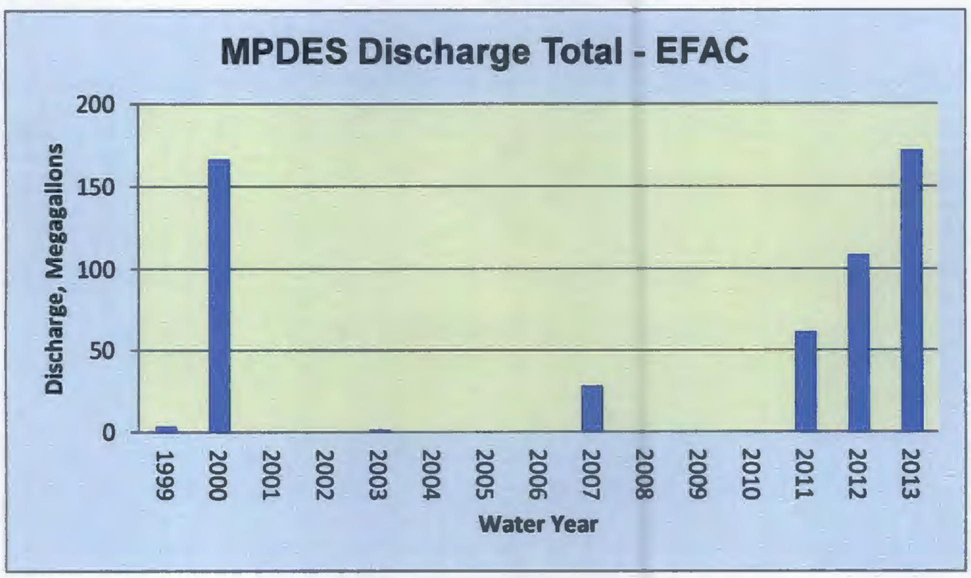
Total MPDES Discharge from 1999 through 2013 at Rosebud Mine, MT.

Water Year	Total discharge (megagallons)	Total Discharge in EFAC drainage (megagallons)
1999	4	4
2000	167	167
2001	6	0
2002	0	0
2003	2	2
2004	0	0
2005	3	0
2006	46	0
2007	102	28
2008	20	0
2009	44	0
2010	3	0
2011	173	61
2012	136	109
2013	185	172

Notes

No flow measurements are available for some unplanned discharges in WY 2000, 2001, 2008 and 2011.

EFAC = East Fork Armells Creek



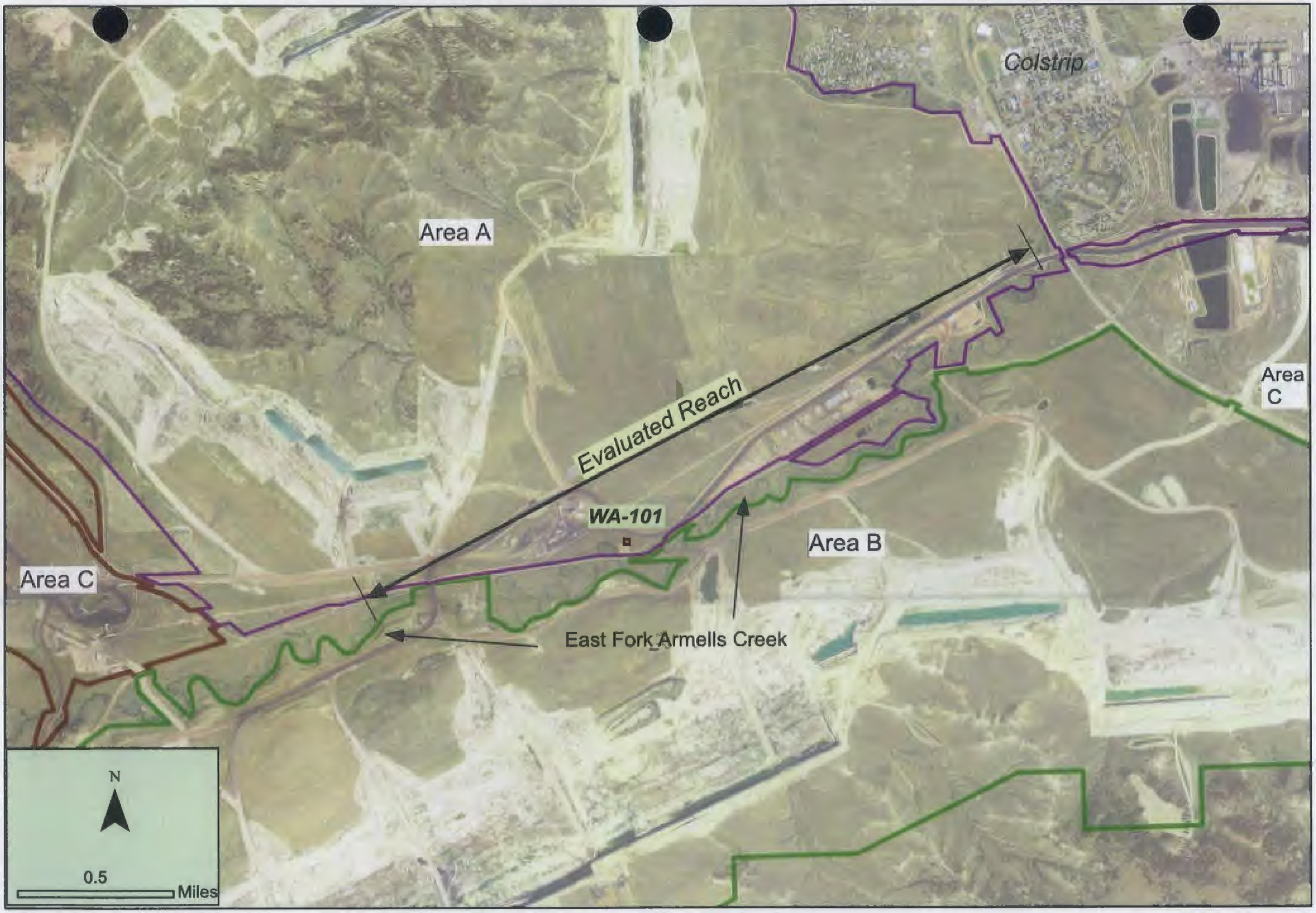


Figure 1. Reach evaluated along East Fork Armells Creek.

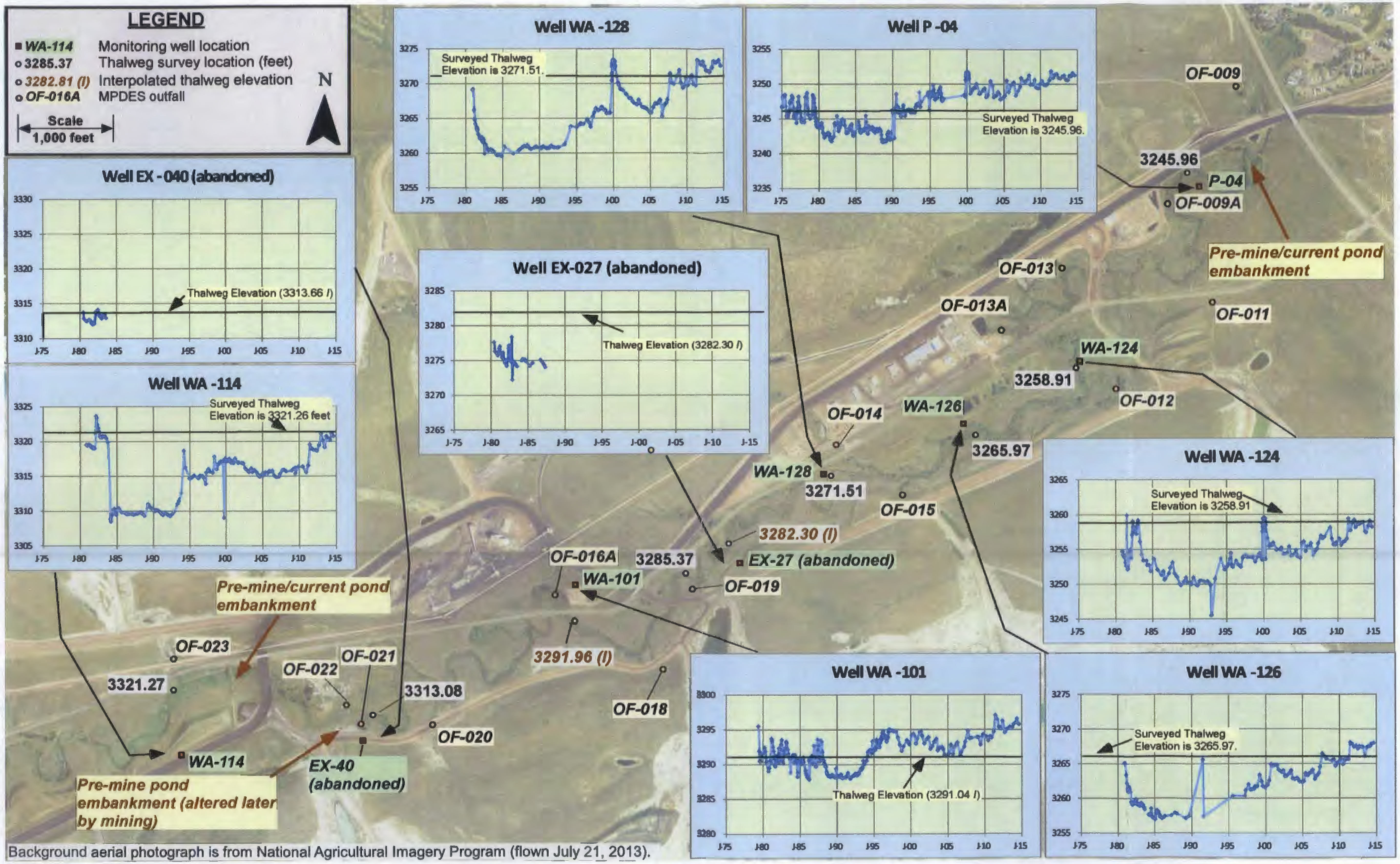
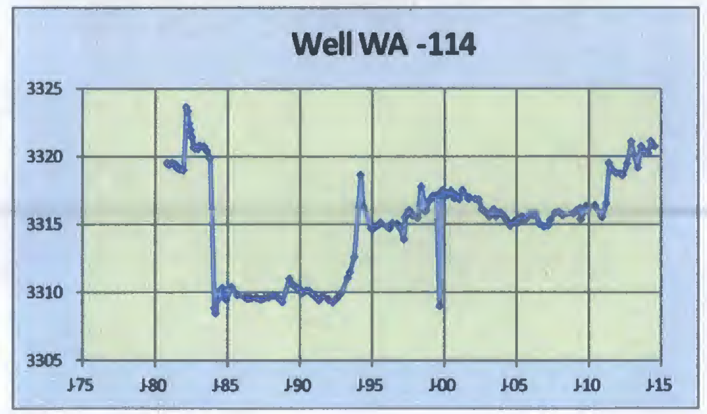
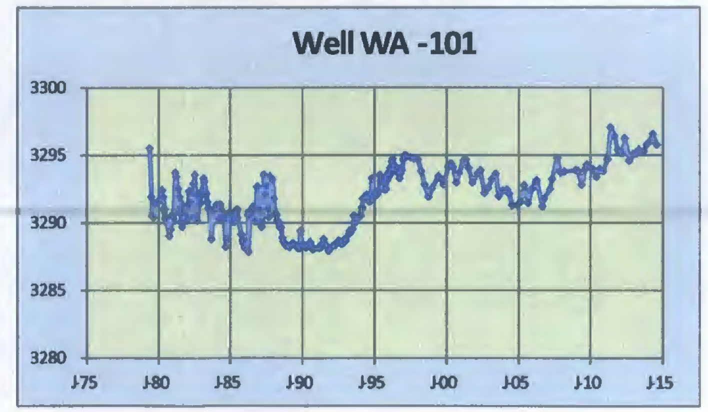


Figure 2. Comparison of East Fork Armells Creek alluvial well hydrographs to nearby surveyed channel thalweg elevations (feet).

N
Scale not indicated

Figure 3. Evaluation of transition from ephemeral to intermittent channel.





2009 summary .

1. Channel condition dry above point A1. Channel water observed downgradient of point A1.
2. Hydrograph at WA-114 shows water levels below pre-mine conditions.
3. Hydrograph at WA-101 shows water levels above pre-mine conditions.

2011 summary (a major precipitation/runoff event occurred on July 15, 2011).

1. Some limited zones of standing water (SW) observed upgradient (west) of point A1. Given the near coincidence of runoff event to aerial photography, the source of the standing water observed is inter preted to be from direct runoff (as opposed to groundwater).
2. Hydrograph at WA-114 shows water levels have recovered to pre-mine conditions.
3. Hydrograph at WA-101 shows water levels well above pre-mine levels.

2013 summary

1. Some standing water (SW) interpreted to be present at point B1 with some limited pooling downgradient.
2. Hydrograph at WA-114 shows water levels at or above pre-mine conditions. Yet, no standing water near this well. Hence, the channel near WA-114 is deemed ephemeral.
3. Hydrograph at WA-101 shows water levels above pre-mine levels.

Attachment D

Memorandum

January 11, 2015

To: Westmoreland MPDES Team

From: Bill Schafer, Schafer Limited LLC

Re: Issues Related to Deriving Effluent Limits for Intermittent Reaches

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Background

A reach of East Fork Armells Creek (EFAC) may have an intermittent flow regime. If this is the case, then MDEQ indicated that effluent limits would need to be re-evaluated for outfalls on the intermittent reach of EFAC. I was asked to comment on the approach to be used by the MDEQ for determining which parameters to include in the revised permit limits for affected outfalls, and also on the methodology to be used to set numeric water-quality based effluent limits (WQBEL).

There are three different issues of importance to consider, namely;

- Do the Nondegradation requirements pertain to the outfalls on the intermittent stream reach?
- What parameters would be considered to have a reasonable potential to degrade and what numeric WQBEL limits would apply?
- Should effluent limits be derived separately for Planned versus Unplanned discharges?

Nondegradation

None of the outfalls along the reach of EFAC in question constitute "new or increased sources" as of April 29, 1993 and as such the Nondegradation significance determination does not apply.

Effluent Limits

MDEQ policy is to apply numeric limits to any high quality water. Ephemeral stream reaches are not high quality by definition. This exclusion may not apply to intermittent stream reaches. We know from previous discussions with the Department about this permit that they will use a Reasonable Potential Analysis (RPA) as a means of determining new applicable effluent limits. The RPA was developed by EPA as a means of determining which parameters have the potential to degrade the water quality in a receiving water and as such require derivation of a numeric effluent limit. The equation [1] for the RPA is:

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$$C_e*Q_e + C_{rw}*Q_{rw} / [Q_e + Q_{rw}] < C_s \quad [1]$$

- C_e is the 95th % concentration of a constituent in effluent
- Q_e design flow rate of the effluent
- C_{rw} is the 25th to 75th % concentration of a constituent in receiving water
- Q_{rw} is the design flow rate of the receiving water (usually set at the 7Q10)
- C_s is the applicable water quality criterion for the constituent

It is evident based on the Montana water quality rules that the MDEQ review procedures should address two issues, 1) whether the discharge would likely cause violation of an applicable water quality criterion and 2) whether the constituent level in effluent is higher than background conditions. The basis for this premise is that specific designated uses are protected under the Montana Water Quality and Federal Clean Water Act. Montana statutes also instruct that there is no requirement to treat an effluent to cleaner than background conditions. *See* MCA 75-5-306.

The RPA approach addresses the first premise above (e.g., protection of water quality criteria) and was specifically designed for this purpose when applied to perennial receiving water. However, this stretch of EFAC is intermittent and as such has a 7Q10 of zero. If the 7Q10 were to be used as the design flow in the receiving water, which would be the case for planned discharges, the Q_{rw} is zero, so [1] simplifies to:

$$C_e < C_s \quad [2]$$

The simplified form of the RPA equation that pertains to streams with 7Q10 of zero does not include any consideration of background water quality (C_{rw}). Clearly, the RPA approach does not address the second premise in the paragraph above: whether the constituent level is higher than background conditions. Therefore, the RPA approach should be amended in a way that background conditions are also addressed.

The need for a separate comparison between effluent characteristics and background water hinges on whether a discharge to a dry stream reach needs to meet water quality criteria or whether it is exempt from meeting water quality criteria for reaches where natural background water also exceeds standards. It seems logical that any designated uses of water would continue to be supported if discharge water had the same character as background water. Therefore, some comparison to background chemistry should be performed.

Using this expanded review approach, the effluent limit would be the **greater** of the result of the RPA analysis or the background chemistry. It would appear based on effluent limits in other Montana permits that this is the approach used for Montana permits involving discharge to perennial streams (e.g. note the arsenic WQBEL for Great Falls POTW is set at the 25th % arsenic in the Missouri River, which is higher than the MCL for arsenic).

The conservative statistical approach used in the RPA is also problematic when it comes to its use for comparison to background. The design concentration value used for the effluent is usually based on the 75th to 95th percentile of measured values in effluent. If effluent data are sparse, the mean effluent value is multiplied by a factor in Table 1 to derive a design effluent concentration. The design effluent value is then generally compared to the 25th percentile in the receiving water. This approach reduces the probability of false positive errors (e.g., minimizes the potential that water is discharged at higher than background), but increases false negative errors (e.g., unnecessarily restricts discharge of water that is equal to background levels). Therefore, an unbiased statistical test procedure such as a Student t test is recommended for comparison of background and effluent levels.

Another obvious challenge to use of MDEQ protocols for deriving effluent limits is that limits are derived to protect uses that are not supported. The most stringent WQBEL levels are for protection of aquatic life, which is absent in intermittent streams.

Table 1. Multiplication factors for the Reasonable Potential Analysis.

Table 3-2. Reasonable Potential Multiplying Factors: 95% Confidence Level and 95% Probability Basis

Number of Samples	Coefficient of Variation																			
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
1	1.4	1.9	2.6	3.6	4.7	6.2	8.0	10.1	12.6	15.5	18.7	22.3	26.4	30.8	35.6	40.7	46.2	52.1	58.4	64.9
2	1.3	1.6	2.0	2.5	3.1	3.8	4.6	5.4	6.4	7.4	8.5	9.7	10.9	12.2	13.6	15.0	16.4	17.9	19.5	21.1
3	1.2	1.5	1.8	2.1	2.5	3.0	3.5	4.0	4.6	5.2	5.8	6.5	7.2	7.9	8.6	9.3	10.0	10.8	11.5	12.3
4	1.2	1.4	1.7	1.9	2.2	2.6	2.9	3.3	3.7	4.2	4.6	5.0	5.5	6.0	6.4	6.9	7.4	7.8	8.3	8.8
5	1.2	1.4	1.6	1.8	2.1	2.3	2.6	2.9	3.2	3.6	3.9	4.2	4.5	4.9	5.2	5.6	5.9	6.2	6.6	6.9
6	1.1	1.3	1.5	1.7	1.9	2.1	2.4	2.6	2.9	3.1	3.4	3.7	3.9	4.2	4.5	4.7	5.0	5.2	5.5	5.7
7	1.1	1.3	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.1	3.3	3.5	3.7	3.9	4.1	4.3	4.5	4.7	4.9
8	1.1	1.3	1.4	1.6	1.7	1.9	2.1	2.3	2.4	2.6	2.8	3.0	3.2	3.3	3.5	3.7	3.9	4.0	4.2	4.3
9	1.1	1.2	1.4	1.5	1.7	1.8	2.0	2.1	2.3	2.4	2.6	2.8	2.9	3.1	3.2	3.4	3.5	3.6	3.8	3.9
10	1.1	1.2	1.3	1.5	1.6	1.7	1.9	2.0	2.2	2.3	2.4	2.6	2.7	2.8	3.0	3.1	3.2	3.3	3.4	3.6
11	1.1	1.2	1.3	1.4	1.6	1.7	1.8	1.9	2.1	2.2	2.3	2.4	2.5	2.7	2.8	2.9	3.0	3.1	3.2	3.3
12	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.0
13	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.5	2.6	2.7	2.8	2.9
14	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.3	2.4	2.5	2.6	2.6	2.7
15	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.8	1.9	2.0	2.1	2.2	2.2	2.3	2.4	2.4	2.5	2.5
16	1.1	1.1	1.2	1.3	1.4	1.5	1.6	1.6	1.7	1.8	1.9	1.9	2.0	2.1	2.1	2.2	2.3	2.3	2.4	2.4
17	1.1	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.7	1.8	1.9	1.9	2.0	2.0	2.1	2.2	2.2	2.3	2.3
18	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.6	1.6	1.7	1.7	1.8	1.9	1.9	2.0	2.0	2.1	2.1	2.2	2.2
19	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.7	1.8	1.8	1.9	1.9	2.0	2.0	2.0	2.1	2.1
20	1.1	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.5	1.6	1.7	1.7	1.8	1.8	1.8	1.9	1.9	2.0	2.0	2.0

Use of Tiered Flow Regime for Setting Limits

It should be possible to derive effluent limits separately for Planned and Unplanned discharges. For the purposes of the MPDES permit, the definition of an Unplanned discharge is a release that occurs as a direct result of runoff from a storm or snowmelt event that exceeds the runoff from a 10-year 24-hour design storm used for engineering the Sediment Pond embankments. Any other discharge would be considered to be a Planned discharge.

Planned Discharge

The use of a 7Q10 of zero is reasonable for Planned discharges, so the discussion in the section above pertains to this condition. The majority of water released historically have been for Planned discharges.

When deriving effluent limits for Planned discharges, it is important to restrict the use of effluent data to flow conditions that are consistent with less than 10-year 24-hour design events. While most newer effluent data collected since 2011 are for Planned discharge conditions (<10-yr, 24-hr events), there may be some older effluent data for which the flow regime was not specified. The flow regime becomes especially important when it comes to metals data. As an illustration, the relationship between total iron and TSS is shown for receiving waters in the Colstrip area (Figure 1). There is a strong correlation between TSS and total iron. Furthermore, there is a Technology-based limit for TSS for Planned discharges that is predicated on the expectation that settling would reduce TSS to less than 35 mg/L. At TSS levels of 35 mg/L or less, iron would not be expected to ever exceed 3.5 mg/L – the original permit limit for iron. Therefore, by controlling TSS, the potential for high total iron is also controlled. Similar patterns have been observed for other metals such as copper.

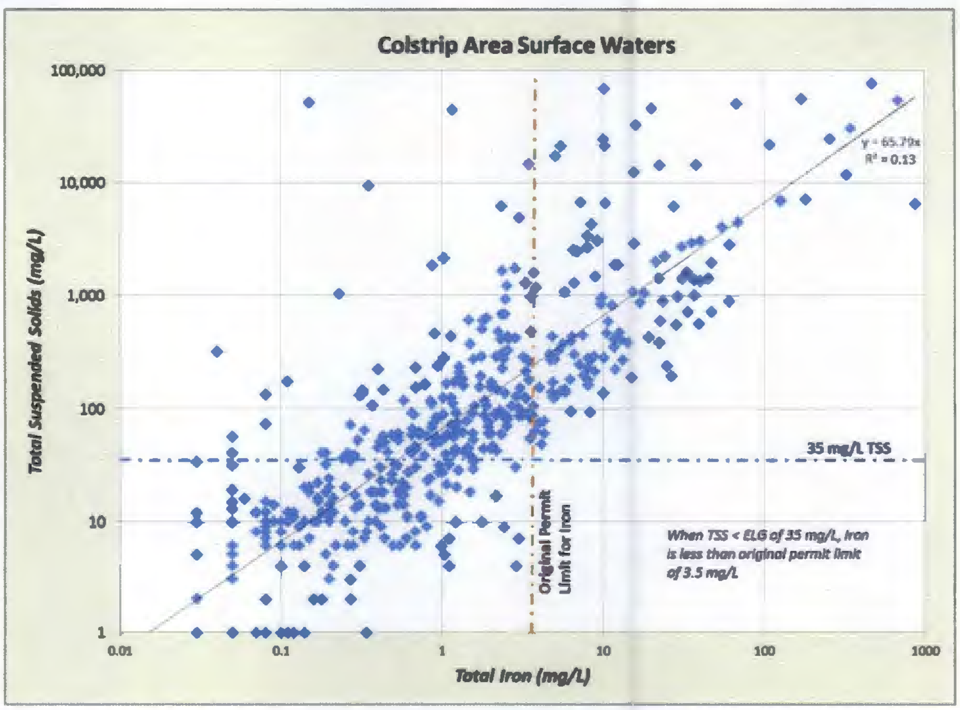

Figure 1. Relationship between TSS and total recoverable iron for natural surface waters near Colstrip.

Unplanned Discharges

Unplanned discharges are associated with periods of high runoff. Therefore, it is not appropriate to use the assumption that the flow in the receiving water is zero. In fact, there would be dilution by receiving water for any Unplanned discharge event. The challenge in deriving effluent limits would be to select an appropriate receiving water flow or dilution factor to use for each outfall. A suitable runoff model could be used to assess dilution ratios for the overall basin or individually for specific ponds and outfalls.

An example follows for determining the dilution ratio defined as (Q_{rw}/Q_c). In this illustration based on EFAC, a basin area of 22,125 acres was used for the receiving water and 3,799 acres was used for the contributing area for ponds. A conservative assumption was that any event exceeding a 10-yr, 24-hour event would begin to contribute marginally to an Unplanned discharge. In reality, the pond freeboard would push this point beyond the 10-yr, 24-hour event threshold. The illustration in Figure 2 uses the TR-55 method (runoff curve number, equation [3]), and an assumed curve number of 86 for Sediment Ponds, and a curve number of 69 the unmined receiving water basin.

$$Q = \frac{(P - I_a)^2}{P - I_a + S} \qquad [3]$$

where

Q is runoff ([L]; in)

P is rainfall ([L]; in)

S is the potential maximum soil moisture retention after runoff begins ([L]; in)

Ia is the initial abstraction ([L]; in), or the amount of water before runoff, such as infiltration, or rainfall interception by vegetation; and it is generally assumed that Ia = 0.2 S

The value of S and Ia are then related to a curve number

$$S = \frac{1000}{CN} - 10$$

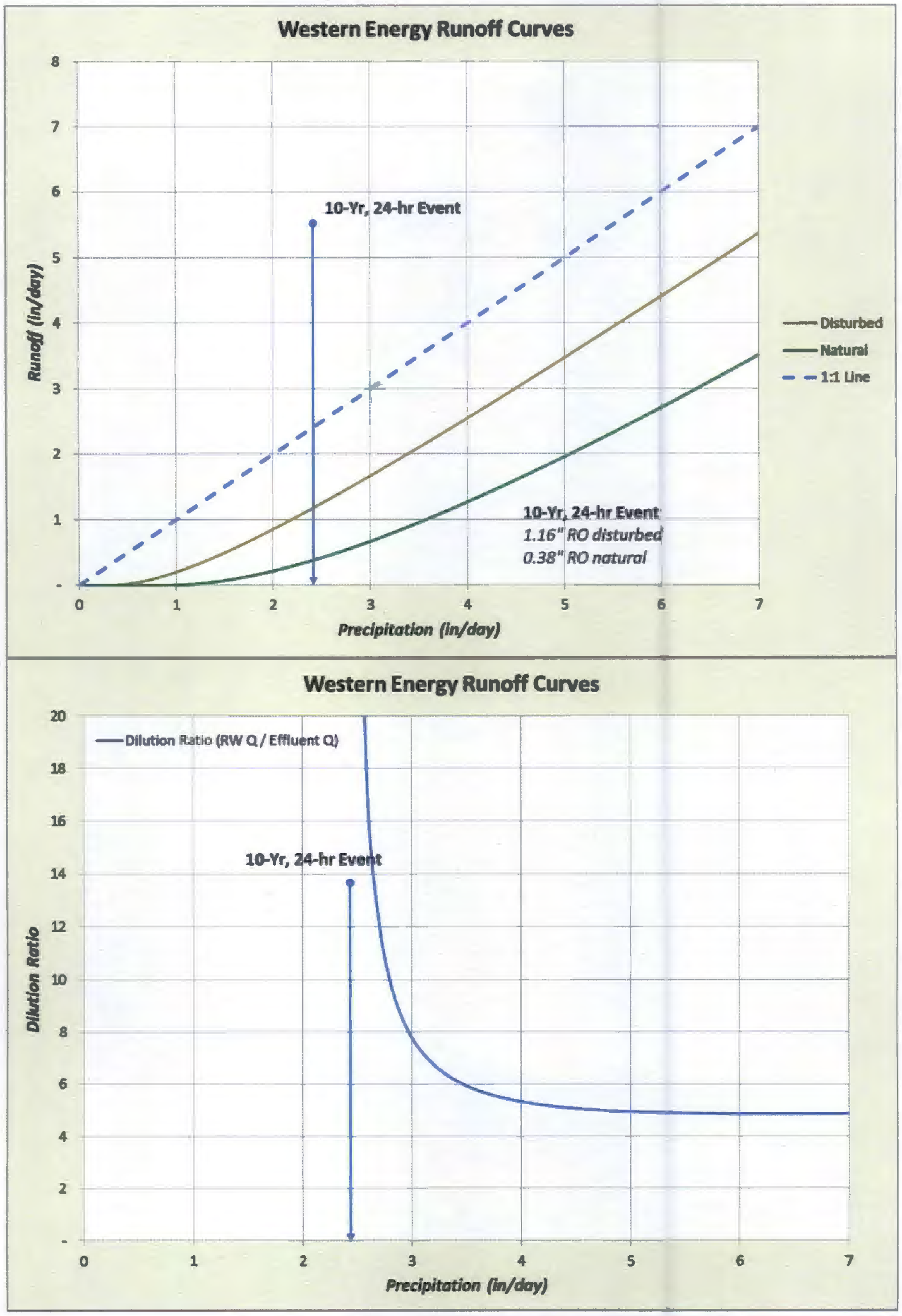

Figure 2. Computed runoff from mined and natural basin (above) and dilution ratio for various storm magnitudes (below).

Figure 2 (above) shows the expected runoff for a range of storm amounts from zero to 7 inches per day. Runoff occurs for storms larger than about 0.5 inches for the mined area and larger than about 1.2 inches for the unmined areas. Based on design requirements for sedimentation ponds, all runoff from mined areas are retained for storms up to 2.3 inches per day. Therefore, at the point that any water could be released from ponds, there should be available receiving water due to runoff from the unmined watershed. Figure 2 (lower) also shows the dilution rate based on storm size. No values are shown for less than the design storm because no runoff occurs. As storm size increases above the design storm, dilution declines from very large values (>8:1 or larger) for storms less than 3 inches to about 5 to 1 for very large storms.

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Western Environmental Law Center

October 10, 2014

Sent via email and post

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Attn: Nate Arave
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Miles City, MT 59301
blm_mt_mcfo_WECO_EA@blm.gov

RE: Scoping Comments—Rosebud Mine Lease Modification EA

Dear Mr. Arave:

Please accept these comments, which are submitted to assist BLM's NEPA analysis of the proposed lease modification by providing relevant information and identifying significant issues. These comments are submitted on behalf of the Montana Environmental Information Center and the Sierra Club (collectively, Citizens).

Montana Environmental Information Center ("MEIC") is a 501(c)(3) nonprofit organization founded in 1973 with approximately 3,000 members throughout the United States and the State of Montana. MEIC is dedicated, in part, to the preservation and enhancement of the natural resources and natural environment of Montana and to the gathering and disseminating of information concerning the protection and preservation of the human environment through education of its members and the general public concerning their rights and obligations under local, state and federal environmental protection laws and regulations. MEIC is also dedicated, in part, to assuring that federal officials comply with and fully uphold the laws of the United States that are designed to protect and enhance the environment from pollution. MEIC and its members have intensive, long-standing recreational, aesthetic, scientific, professional, and spiritual interests in the responsible production and use of energy, the reduction of greenhouse ("GHG") pollution as a means to ameliorate our climate crisis, and the land, air, water, and community impacted by climate change. MEIC submits these comments on its own behalf and on behalf of its adversely affected members.

Sierra Club is America's oldest and largest grassroots environmental organization. Sierra Club has 1.4 million members and supporters. Founded in 1892, the Sierra Club has been working for well more than a century to protect communities, wild places, and the planet itself. Sierra Club is dedicated to exploring, enjoying, and protecting the wild places of the Earth; to practicing and promoting the responsible use of the Earth's resources and ecosystems; to educating and enlisting humanity to protect and restore the quality of the natural and human environment; and to using all lawful means to carry out these objectives. Sierra Club's concerns encompass the exploration, enjoyment and protection of the lands and waters of Montana. Sierra Club submits these comments on its own behalf and on behalf of its adversely affected members.

1. Proposal

The Western Energy Company (WECo) has proposed to add 160 acres to its existing lease at the Rosebud coal strip-mine. The 160 acres are apparently located in the vicinity of Area C Central and Area B Extension.

2. Background

The Northern Pacific Railway began strip mining coal from the Rosebud coal seam in the early Twentieth Century as a non-union shop in order to power its locomotives and to unburden itself of the costs of dealing with the underground coal miners' unions.[1] Hence the birth of Colstrip. The Colstrip coal significantly undercut the prices of coal from underground mines near Bozeman and Red Lodge, allowing Northern Pacific to save significant amounts on fuel, while undermining the more labor intensive mines and the unions in the other towns. "It is ironical, however, that the commitment to Colstrip delayed the Northern Pacific from converting to diesel fuel for many years and hence it was, in the end, more costly than profitable."[2] Thus, from the beginning strip mining in Colstrip undermined labor, created jobs at the expense of more, and delayed the transition to superior energy sources.

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[1] K. Ross Toole, The Rape of the Great Plains: Northwest America, Cattle, and Coal 99 (1976).

[2] *Id.* at 100.

The Montana Power Company (MPC) and its wholly owned subsidiary WECo took over the mine in 1959 in anticipation of construction of coal-fired power plants.[3] Not long thereafter, MPC, along with Puget Sound Power and Light, announced its intention to construct the massive mine-mouth power complex that exists today.[4] From the beginning, there was massive opposition to the project. The original proposal to construct the first two units at Colstrip received over 3000 public comments, 95% of which steadfastly opposed the short-sighted and destructive projects.[5]

Units 1 and 2 were planned to have a 30-year operational life.[6] It has long been acknowledged that construction of the Colstrip mine-mouth energy project placed short-term profits (30 years of strip-mining) above long-term social and environmental harms. In its EIS for the first two units at the Colstrip Station, the Montana Department of Health and Environmental Sciences wrote: "The long-term adverse effects may well outweigh the short term gains."[7] The EIS further noted the likelihood that construction of the plant and mine would create a boom that would be followed by a bust from closure of the plant:

> An economy based on the exploitation of the coal is developed in the coal fields, as well as where the electrical energy is being consumed. The short term gains to the Colstrip area are made known by the interests involved in building the plant and mining the coal. Jobs are created and money enters the local economy from these jobs. As long as the coal is mined and the power is generated, the flow of money through the community is assured. When the coal is exhausted, *or its use for production of electricity becomes obsolete, the economy and way of life dependent upon the exploitation of that coal will suffer. Many feel that this consequence is inevitable; that only its magnitude and timing are in question.* Improper reclamation of the land may destroy the original economic base of the region; the land used for agriculture. Numerous examples of boom and bust cycles can be cited. There is

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3 *Id.*
4 *Id.* at 101; Mont. Dep't of Health & Envtl. Sciences, Environmental Impact Statement on the Proposed Montana Power Compay Electrical Generating Plant at Colstrip, Montana ii, 87 (Mar. 1973).
5 Mont. Dep't of Health & Envtl. Sciences, Environmental Impact Statement on the Proposed Montana Power Compay Electrical Generating Plant at Colstrip, Montana at 87.
6 *Id.* at iii.
7 *Id.* at ii (emphasis added).

> little evidence that this sort of thing will not happen in the Fort Union Region.[8]

The EIS also noted the likelihood of long-term impacts from environmental degradation from the mine-power-plant complex:

> The possible local destruction and regional degradation of the ecosystem by the proposed Colstrip plant also has long term implications. Land use changes adversely affecting food production, modification or loss of recreational areas for present and future generations, and changes in natural species may be more significant to our descendants than our use of electricity over the next several decades. Residents of the area will be subjected to changes in social and psychological pressures from this industrial economy and life style, as the change is made from an agricultural base to a more industrial one. Future residents may encounter the reverse situation; that is, adapting to an agrarian life style should the industrial form be removed or altered.[9]

The EIS ended with a cautionary note regarding the nature of short-term decision making and the potential gravity of future repercussions:

> It is also much easier to accept decisions that have more personal and quicker results than ones less personal and farther removed in time. It is, therefore, easier to decide in favor of a power plant that will prevent a small power shortage in one's own town in four years than to be concerned with the fate of a large portion of the United States society fifty years from now. Even though some very serious problems for mankind seem to loom in the future if he continues on his present course, he is reluctant to give up his immediate comforts. This concept is well illustrated by our attitude towards energy in this society. *When evaluated at some future date, the proposed Colstrip plant may prove to have been very efficient at solving one immediate problem, but in doing so having created other problems of much greater scope and duration.*[10]

Looking back from a distance of forty years, this cautionary note seems prescient. The short-term gains from building the plant and developing the Rosebud strip-mine have caused and contributed to significant long-term environmental problems, both local and global: (1) the long term destruction of the ground and

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[8] *Id.* at 83.
[9] *Id.* at 84.
[10] *Id.* at 85.

surface water sources in and around Colstrip, which makes it almost certain that the town of Colstrip will have no viable water sources upon the plant's inevitable closure, and (2) climate change, which is not a global crisis and will be among the greatest challenges and threats to this and future generations throughout the 21st century and after.

As MDHES's original EIS makes clear, it is not as if people did not see this coming. The 3,000 Montanans who originally opposed construction of the Colstrip mine-power plant complex knew this is how the project would play out. The same thing had happened before in Montana at Bannack, Virginia City, Butte. What was more troubling was the knowing decision of government to place short term profits over the long term public good. On this topic, Wendell Berry has thoughtfully observed, with regard to coal mining in Appalachia:

> The history of coal mining in Kentucky is the extreme instance that bespeaks our general failure to acquire any knowledge of where we live, or any effective sense of the good care we owe to the land we once were so fortunate to come to in our need. This history proves that industrial corporations will stop at nothing, will do anything, to achieve the highest possible income at the least possible cost. It proves at the same time the unwillingness of our people and our politicians to set limits and impose restraints upon any gigantic economic power. In the official political and academic view, the economy of Kentucky has no connection with the land of Kentucky. This is the definition of an economic ignorance that is conventional, criminal, and suicidal.[11]

3. Purpose and Need

Critical to a hard look NEPA analysis is development of a proper purpose and need statement. The purpose and need statement "shall briefly specify the underlying purpose and need to which the agency is responding in proposing the alternatives including the proposed action." 40 C.F.R.§ 1502.13. "[A]n agency must not define the objectives of its action in terms so unreasonably narrow that only one alternative from among the environmentally benign ones in the agency's power would accomplish the goals of the agency's action, and the EIS would become a foreordained formality." *Friends of Southeast's Future v. Morrison*, 153 F.3d 1059, 1066 (9th Cir. 1998).

Critically, agencies many not "adopt[] private interests to draft a narrow purpose and need statement that excludes alternatives that fail to meet specific private

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[11] Wendell Berry, *Starting from Loss*, in It All Turns on Affection 67, 71 (2013).

objectives." *Nat'l Parks & Conservation Ass'n v. BLM*, 606 F.3d 1058, 1072 (9th Cir. 2009). In *National Parks & Conservation*, BLM received a private proposal to develop a landfill, but drafted the purpose and need statement so unreasonably narrow that all action alternatives were variants on how to accomplish the narrow private objective of building the landfill. *Id.* The agency, therefore, did not consider in detail alternatives, such as waste diversion, that would obviate the need to construct the landfill in the first place. *Id.*

Here, it is clear WECo's private objective is to strip-mine coal and sell the coal to the Colstrip Power Plant, realizing private profits. But this narrow private objective does not suffice for NEPA. Rather, BLM must consider the public goals and policies that govern public management of public resources. Under the Federal Land Policy and Management Act (FLPMA), BLM must manage public land "in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological value." 43 U.S.C. § 1701(a)(8). And, while BLM is also guided by the policy to manage public lands in a manner that "recognizes the Nation's need for domestic sources of minerals . . . from the public lands," the agency must also take any action necessary to "prevent unnecessary or undue degradation of the lands." *Id.* §§ 1701(a)(12), 1732(b). The agency is also obliged to assure that its leasing decisions bring a fair return to the public for sale of a public resource. Thus the agency's broad public goals are to develop energy resources and earn positive returns for the public. Accordingly, BLM must weigh the costs and benefits of coal leasing—including the cost of carbon emissions from coal mining and combustion—against the costs and benefits of not leasing the coal or pursuing development of alternative energy sources.

4. Direct Impacts

Under NEPA, the process of scoping serves to define the scope of an EIS and to identify "significant issues to be analyzed in depth in the" EIS. 40 C.F.R. § 1501.7(a)(2). An EIS must address direct, indirect, and cumulative impacts associated with a proposed action. *Id.* § 1508.25(c). Direct effects are those effects "caused by the action" which "occur at the same time and place." *Id.* § 1508.8(a).

A. Water Resources

All evidence shows that the mining at the Rosebud Mine has deleteriously impacted water resources. All portions of the principally impacted surface water, East Fork Armells Creek, fail to meet water quality standards for aquatic life. The Montana Department of Environmental Quality (MDEQ) has identified coal mining as the probable source of this impairment.[12] Numerous studies demonstrate that increased levels of salts, as measured by TDS, electrical conductivity, or salinity are harmful to aquatic organisms.[13] EPA has long warned that the impacts of increased salinity from coal mining are "especially acute" in "intermittently flowing river basins where expanded mining activities are expected, such as Rosebud Creek around Colstrip."[14] BLM's NEPA analysis must assess whether continued mining will contribute to or aggravate the impairment of either the upper or lower sections of East Fork Armells Creek. BLM must further assess impacts of coal falling into East Fork Armells Creek from the mine's coal delivery system, as previous mine inspection by the U.S. Environmental Protection Agency reported that blowing coal and dust from the delivery system was "impact[ing] the mining drainage areas."[15]

MDEQ has also raised concerns about potential nuisance algae growth in Rosebud Creek that may be caused by increased groundwater discharge from mining operations.[16] This matter must be addressed in BLM's NEPA analysis, given that the lease expansion appears to open federal lands draining into Lee Coulee and Rosebud Creek. The analysis must also consider whether the mine expansion will lead to violations of water quality standards. The numeric water quality standard for all tributaries to Rosebud Creek for electrical conductivity (EC) is 500 microSiemens/cm. The water quality standards for EC in tributary streams were established to prevent salt accumulation that would be detrimental to irrigated agriculture, particularly hay and alfalfa crops.[17] In recent comments on its renewed

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[12] *See* MDEQ, Water Quality Standards Attainment Record for East Fork Armells Creek, Headwaters to Colstrip (2014) (attached as Exhibit 1); MDEQ, Water Quality Standards Attainment Record for East Fork Armells Creek, Colstrip to Mouth (2014) (attached as Exhibit 2).

[1313] *E.g.*, Duane A. Klarich & Stephen M. Regele, Structure, General Characteristics, and Salinity Relationships of Benthic Macroinvertebrate Associations in Streams Draining the Southern Fort Union Coalfield Region of Southeastern Montana (1980) (attached as Exhibit 2a1); U.S. EPA, Assessment of Energy Resource Development Impact on Water Quality (1979) (attached as Exhibit 2a2); EPA, A Field-Based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams (2011) (attached as Exhibit 2a3).

[14] EPA, Assessment of Energy Resource Development, *supra* at 109.

[15] Ltr. from Rosemay Rowe, EPA, to Robert Montgomery, WECo (Aug. 17, 2006) (attached as Exhibit 2a).

[16] MDEQ, Water Quality Standards Attainment Record for Rosebud Creek (2014) (attached as Exhibit 3)

[17] MDEQ, A Review of the Rationale for EC and SAR Standards (2011) (attached as Exhibit 4).

MPDES discharge permit, WECo asserted that this standard is "not . . . attainable."[18] Mining the source aquifers of Rosebud Creek tributaries and replacing them with spoils aquifers will significantly aggravate the salinity problems. The lease modification NEPA analysis must consider these impacts.

In addition to evaluating surface water quality, BLM's NEPA analysis must assess surface water quantity. The strip-mining process, MDEQ has acknowledged, can "reduce or eliminate intermittent stream flow or ponding during mining operations" by drawing down coal, overburden, and alluvial aquifers.[19] MDEQ has acknowledged significant drawdown in the alluvial aquifer of East Fork Armells Creek.[20] Strip-mining can also reduce and impair surface water flow by impounding precipitation in settling ponds. Indeed, MDEQ has determined that additional mining in Area B could reduce ground water discharge to Lee Coulee, which the agency described as a "long term, major impact."[21] Such reduction in surface water quality can have deleterious impacts on aquatic life: "Where augmentation of stream flow and stream underflow is reduced because of the lowering of the water table and the lack of discharge into streams from underground sources, aquatic life will be affected as well."[22] Assessment of the impacts to surface water quantity is critical because WECo has attempted to evade responsibility for effectively destroying East Fork Armells Creek by asserting that the creek is only ephemeral. MDEQ has, however, previously determined that "[t]wo adjacent intermittent flow reaches have been described in EFAC [East Fork Armells Creek], beginning near the west end of the amendment area (NE1/4 section 17, T1N, R40E) and continuing two miles downstream to SE1/4 section 10 (T1N, R40E)."[23]

BLM's NEPA assessment must also assess impacts to ground water. WECo acknowledges that dissolved solids (TDS) increase up to 200% in groundwater that resaturates pits backfilled with spoils.[24] WECo also admits that increases in salt

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18 Ltr. from WECo, to MDEQ (June 13, 2012) (attached as Exhibit 4a).
19 MDEQ, Cumulative Hydrologic Impact Assessment for Rosebud Area B: Surface Water (attached as Exhibit 5).
20 MDEQ, Cumulative Hydrologic Impact Assessment for Rosebud Area B: Groundwater (Attached as Exhibit 6).
21 *Id.* at 6.
22 National Research Council, Coal Mining and Ground Water Resources in the United States 146 (1981) (attached as Exhibit 6a).
23 MDEQ, Cumulative Hydrologic Impact Assessment for Rosebud Area B: Surface Water at 4.
24 WECo, Probable Hydrologic Consequences Analysis Area F at 314-22 (attached as Exhibit 7).

concentrations will "peak at concentrations potentially two to three times that of the baseline" water quality.[25] MDEQ acknowledges that "[h]igher concentrations of TDS typically correlate with significantly higher concentrations of sulfate . . . ."[26] This is significant because the USGS has determined that in the area of the Rosebud Mine, TDS and sulfates do not attenuate as polluted spoils water migrates through unmined coal and away from the mine area.[27] Recent research further shows that stock are more susceptible to harmful impacts from water containing high sulfate levels than previously expected—concentrations should be kept below 1,000 mg/L.[28] BLM must also address potential impacts from increased lead pollution that could be caused by mining,[29] as well as potential pollution from nitrate released from mine-related blasting.[30] MDEQ has acknowledged potential contamination of the McKay coal aquifer by water pollution from mine spoils.[31] These impacts are particularly important because the Rosebud Coal aquifer, which WECo intends to strip-mine, is the "most continuous and reliable aquifer in the area."[32]

Strip mining will also dramatically impact quantity of available ground water—the most important water source in the area. BLM must assess the amount of time required for ground water to recover post mining. WECo suggests that this may

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[25] *Id.*

[26] MDEQ, Cumulative Hydrologic Impact Assessment for Rosebud Mine Area C-North, at 8 (attached as Exhibit 8).

[27] David W. Clark, USGS, Geochemical Processes in Ground Water Resulting from Surface Mining of Coal at the Big Sky and West Decker Mine Areas, Southeastern Montana at 14-16 (1995).

[28] M.F. Raisbeck et al., Water Quality for Wyoming Livestock and Wildlife: A Review of Literature Pertaining to Health Effects of Inorganic Contaminants 47 (2008) (attached as Exhibit 9).

[29] Van Voast et al., Hydrologic Conditions and Projections Related to Coal Mining Near Colstrip, Southeastern Montana (1977) (documenting high levels of lead in Colstrip area).

[30] William Woessner, et al., The Impacts of Coal Mining on the Hydrologeologic System of the Northern Great Plains: Case Study of Potential Impacts on the Northern Cheyenne Reservation, 43 J. of Hydrology 445, 449-50 (1979) (attached as Exhibit 10).

[31] MDEQ, MDEQ, Cumulative Hydrologic Impact Assessment for Rosebud Area B: Groundwater at 8.

[32] MDEQ, Cumulative Hydrologic Impact Assessment for Rosebud Mine Area C-North, at 2.

take as long as 200 years.[33] Other estimates indicate that this could take over a millennium.[34]

BLM must also evaluate impacts to alluvial valley floors (AVFs). Under the Surface Mining Control and Reclamation Act, a regulatory authority may not approve an application for strip-mining that will damage AVFs. 30 U.S.C. § 1260(b)(5). This prohibition is a reflection of the importance of AVFs to sustainable agricultural operations in the west. As noted in previous comments,[35] which are incorporated here by reference, WECo's application does not present adequate information to determine whether AVFs may exist in the project area. BLM must fully assess whether AVFs are present in the area of the proposed expansion. If there are AVFs, they may not be mined.

Finally, the NEPA assessment must address the dynamic relationship between surface and ground water, both in terms of water quality and quantity. "Poor-quality groundwater resulting from spoil leaching can degrade down-gradient groundwater supplies and surface-water bodies at points of ground water discharge."[36] "One problem [with mining] is contamination of ground water by infiltration from mining operations. This effect could ultimately impact nearby intermittent streams since water that infiltrates through spoils materials into shallow aquifers as ground water eventually discharges into streams."[37] This is of particular concern given that the two major receiving waters, East Fork Armells Creek and Rosebud Creek, cannot tolerate increased discharges of dissolved salts: Armells Creek is impaired due to high salinity levels and WECo has claimed that it cannot meet the water quality standards for salinity in Rosebud Creek's tributaries.

In addition, and as elaborated further below, the impacts of coal mining to both surface and ground water are compounded by the indirect impacts of coal mining—coal combustion at the Cosltrip Power Plant. BLM must consider these impacts as well in its NEPA analysis.

B. Wildlife

Under the Endangered Species Act (ESA) federal agencies must assure that their actions do not jeopardize threatened or endangered species or cause

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33 WECo, Probable Hydrologic Consequences Analysis Area F at 314-22.
34 William Woessner, et al, *supra*, at 460.
35 Ltr. from WELC to Chris Yde, MDEQ (Oct. 1, 2012) (attached as Exhibit 10a).
36 William Woessner, et al, *supra*, at 451.
37 EPA, Assessment of Energy Resource Development, *supra* at 106.

destruction or adverse modification of critical habitat. 16 U.S.C. § 1536(a)(2). In order to insure this substantive protection, agencies are under a procedural obligation to consult with the U.S. Fish and Wildlife Service (FWS) prior to undertaking any action that "may affect" threatened or endangered species or critical habitat. 50 C.F.R. § 402.14(a). In considering whether an action "may affect" species or habitat, agencies must broadly consider the effects of their action, which is defined as

> the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions that are contemporaneous with the consultation in progress. Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

Id. § 402.02 (definition of "effects of the action"). Given this broad definition, the determination of whether the action "may affect" any species or habitat must consider the effects of coal combustion at the Colstrip Station and Rosebud Power Plant, as combustion of coal at these plants is an interrelated and interdependent action, and the resultant air pollution and coal combustion waste (CCW) are indirect effects of the proposed lease modification. BLM must also evaluate these impacts in its NEPA analysis.

FWS lists such species, including species proposed for listing and candidate species, that may be present in Rosebud County: Black-Footed Ferret (*Mustela negripes*), Interior Least Tern (*Sterna antillarum athalassos*), Pallid Sturgeon (*Scaphirhynchus albus*), Red Knot (*Calidris canutus rufa*), Greater Sage Grouse (*Centrocercus urophasianus*), and Sprague's Pipit (*Anthus spragueii*). Other species in Montana that may potentially be affected by air, water, and soil pollution from coal combustion at the Colstrip and Rosebud plants include: whooping crane (*Grus Americana*) and Ute Ladies'-tresses (*Spiranthes diluvialis*). The Citizens have noted, at some length, the multifarious ways that the direct, indirect, and cumulative impacts of strip-mining at the Rosebud Mine and subsequent combustion of the coal can negatively impact these and other species.[38]

C. Greenhouse Gas Emissions and the Social Cost of Carbon

BLM must evaluate direct GHG emissions resulting from the proposed lease modification. Direct GHG emissions result from diesel engines used at the mine, as well as emissions of methane that are caused by the mining process. In order to adequately assess these GHG impacts, BLM should use the social cost of carbon and the social cost of methane.

Research conducted by the National Research Council has confirmed the fact that the negative impacts of energy generation from fossil fuels are not represented in the market price for such generation.[39] In other words, failing to internalize the externalities of energy generation from fossil fuels—such as the impacts to climate change and human health—has resulted in a market failure that requires government intervention. Executive Order 12866 directs federal agencies to assess and quantify such costs and benefits of regulatory action, including the effects on factors such as the economy, environment, and public health and safety, among others. *See* Exec. Order No. 12866, 58 Fed. Reg. 51,735 (Sept. 30, 1993). The Ninth Circuit has ruled that agencies must include the climate costs and benefits of a significant regulatory action in federal cost-benefit analyses to comply with EO 12866:

> [T]he fact that climate change is largely a global phenomenon that includes actions that are outside of [the agency's] control ... does not release the agency from the duty of assessing the effects of its actions on global warming within the context of other actions that also affect global warming.

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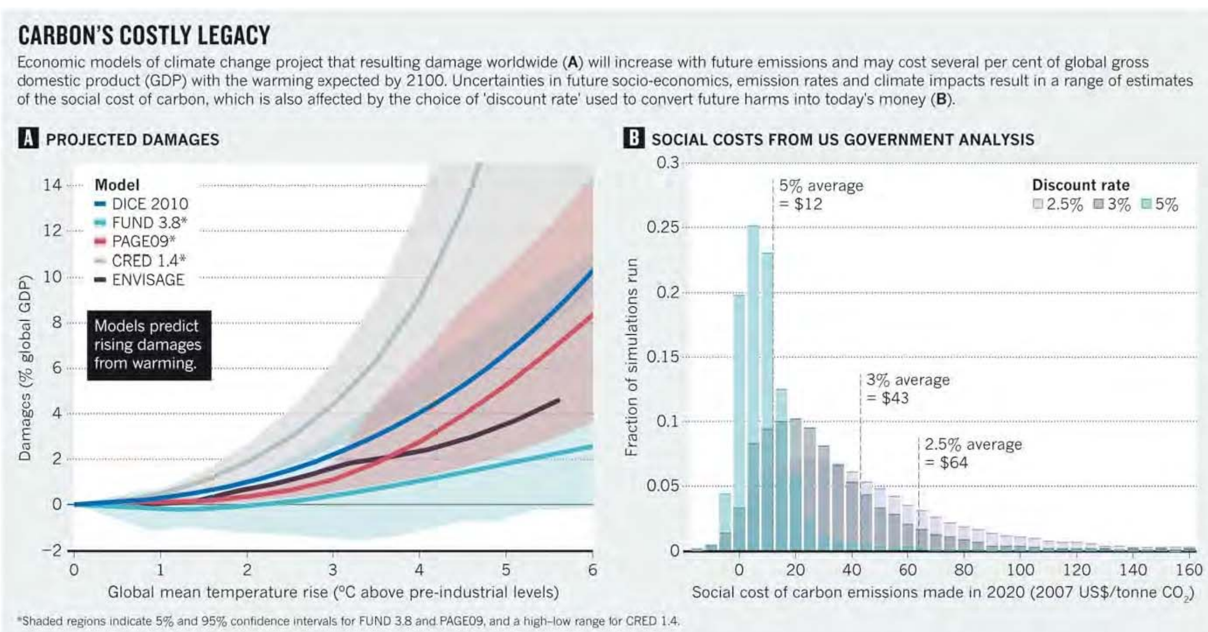
[38] Ltr., from Western Environmental Law Center to Frank Bartlett, Office of Surface Mining at 27-31 (Oct. 11, 2013) (attached as Exhibit 11).

[39] National Research Council, Hidden Costs of Energy (2010) (attached as Exhibit 12); Nicholas Z. Muller et al., Environmental Accounting for Pollution in the United States Economy 101 Am. Economic Review 1649 (2011) (cost of economic harm from coal vastly exceeds market value generated by coal) (attached as Exhibit 13); Ben Machol & Sarah Razk, Economic Value of U.S. Fossil Fuel Electricity Health Impacts 52 Env't Int'l 75 (2013) (fossil fuel generation costs nation $361-886 billion annually in externalized costs) (attached as Exhibit 14); Paul R. Epstein et al., Full Cost Accounting for the Life Cycle of Coal 1219 Ann. N.Y. Acad. Sci. 73 (2011) (life cycle of costs from coal causes $175 to 523 billion in damages in United States annually) (attached as Exhibit 15).

Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin., 538 F.3d 1172, 1217 (9th Cir. 2008) (quotations and citations omitted); *see also Border Power Plant Working Grp. v. U.S. Dep't of Energy*, 260 F. Supp. 2d 997, 1028-29 (S.D. Cal. 2003) (finding agency failure to disclose project's indirect carbon dioxide emissions violates NEPA).

In response, an Interagency Working Group (IWG) was formed to develop a consistent and defensible estimate of the social cost of carbon—allowing agencies to "incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that impact cumulative global emissions."[40] "The SCC is an estimate of the monetized damages associated with an incremental increase in greenhouse gas emissions in a given year." [41] In other words, SCC is a measure of the benefit of reducing greenhouse gas emissions now and thereby avoiding costs in the future. The charts below depict, (A) dramatically increasing damages from global warming over time, as well as (B) the social cost of these carbon emissions based on 2013 TDS values.[42]



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[40] Interagency Working Group on Social Cost of Carbon, Technical Support Document: Technical Update on the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (May 2013) (attached as Exhibit 16).
[41] Ruth Greenspan Bell & Dianne Callan, More than Meets the Eye: The Social Cost of Carbon in U.S. Policy, in Plain English at 2 (2011) (attached as Exhibit 17).
[42] *See* Richard Revesz, et al., *Global warming: Improve economic models of climate change,* NATURE 508, 173-175 (April 10, 2014) (attached as Exhibit 17).

Leading economic models all point in the same direction: that climate change causes substantial economic harm, justifying immediate action to reduce emissions.[43] The interagency process to develop SCC estimates—originally described in the 2010 interagency technical support document ("TSD"), and updated in 2013—developed four values based on the average SCC from three integrated assessment models (DICE, PAGE, and FUND), at discount rates of 2.5, 3, and 5 percent, as well as a fourth value demonstrating the cost of worst-case impacts.[44] These models are intended to quantify damages, including health impacts, economic dislocation, agricultural changes, and other effects that climate change can impose on humanity. While these quantifying these values involves some uncertainties, a recent GAO report has confirmed the soundness of the methodology in which the IWG's SCC estimates were developed, further underscoring the importance of integrating SCC analysis into the agency's decisionmaking process.[45] In fact, certain types of damages remain either unaccounted for or poorly quantified in IWG's estimates, suggesting that the SCC values are conservative and should be viewed as a lower bound.[46]

The updated interagency SCC estimates for 2020 are $12, $43, $65 and $129 (in 2007$).[47] The IWG does not instruct federal agencies which discount rate to use, suggesting that the 3 percent discount rate ($43 per ton of CO_2) as the "central

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[43] *Id.*
[44] *See* Interagency Working Group on Social Cost of Carbon, *supra* at 2.
[45] Government Accountability Office, Regulatory Impact Analysis: Development of Social Cost of Carbon Estimates, GAO Rpt.-14-663 (July 24, 2014) (attached as Exhibit 18).
[46] *See* Peter Howard, et al., EDF et al., *Omitted Damages: What's Missing From the Social Cost of Carbon*, (March 13, 2014) (attached as Exhibit 19) (providing, for example, that damages such as "increases in forced migration, social and political conflict, and violence; weather variability and extreme weather events; and declining growth rates" are either missing or poorly quantified in SCC models); *see also* Frank Ackerman & Elizabeth A. Stanton, Climate Risks and Carbon Prices: Revising the Social Cost of Carbon (2010) (finding that the SCC significantly underestimates certain damages).
[47] *See* Interagency Working Group on Social Cost of Carbon, *supra* at 3 (including a table of revised SCC estimates from 2010-2050). To put these figures in perspective, in 2009 the British government used a range of $41-$124 per ton of CO_2, with a central value of $85 (during the same period, the 2010 TSD used a central value of $21). Greenspan & Callan, *supra* at 4. The UK analysis used very different assumptions on damages, including a much lower discount rate of 1.4%. The central value supports regulation four times a stringent as the U.S. central value. *Id.*

value," but further emphasizing "the importance and value of including all four SCC values[;]" i.e., that the agency should use the range of values in developing NEPA alternatives.[48]

The agency's obligation to analyze the costs associated with GHG emissions through NEPA was directly affirmed by the court in *High Country Conservation Advocates v. U.S. Forest Service*, ___F.Supp.2d___, 2014 WL 2922751 (D.Colo. June 27, 2014). In his decision, Judge Jackson identified the IWG's SSC protocol as a tool to "quantify a project's contribution to costs associated with global climate change." *Id.* at 17.[49] To fulfill this mandate, they agency must disclose the "ecological[,] . . . economic, [and] social" impacts of the proposed action. 40 C.F.R. § 1508.8(b).

An agency must "consider every significant aspect of the environmental impact of a proposed action." *Baltimore Gas & Elec. Co. v. Natural Resources Defense Council*, 462 U.S. 87, 107 (1983) (quotations and citation omitted). This includes the disclosure of direct, indirect, and cumulative impacts of its actions, including climate change impacts and emissions. 40 C.F.R. § 1508.25(c). The need to evaluate such impacts is bolstered by the fact that "[t]he harms associated with climate change are serious and well recognized," and environmental changes caused by climate change "have already inflicted significant harms" to many resources around the globe. *Massachusetts v. EPA*, 549 U.S. 497, 521 (2007); *see also id.* at 525 (recognizing "the enormity of the potential consequences associated with manmade climate change."). Among other things, the agency's analysis must disclose "the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity[,]" including the "energy requirements and conservation potential of various alternatives and mitigation measures." 42 U.S.C. § 4332(2)(c); 40 C.F.R. § 1502.16(e). Agencies must "insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economical and technical considerations." 42 U.S.C. § 4332(2)(B). As explained by CEQ, this requires agencies to "analyze total energy costs, including possible hidden or indirect costs, and total energy benefits of proposed actions." 43 Fed. Red. 55,978, 55,984 (Nov. 29, 2978); *see also* Executive Order 13514, 74 Fed. Reg. 52,117 (Oct. 5, 2009) (requiring

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[48] *See* Interagency Working Group on Social Cost of Carbon, *supra* at 12.

[49] *See also id.* at 18 (noting the EPA recommendation to "explore other means to characterize the impact of GHG emissions, including an estimate of the 'social cost of carbon' associated with potential increases in GHG emissions.") (citing Sarah E. Light, *NEPA's Footprint: Information Disclosure as a Quasi-Carbon Tax on Agencies*, 87 Tul. L. Rev. 511, 546 (Feb. 2013)).

government agencies to disclose emissions information annually from direct and indirect activities). Failing to perform such analysis undermines the agency's decisionmaking process and the assumptions made.

Here, BLM's NEPA analysis must quantify the direct and indirect GHG emissions from the proposed lease modification, along with those of all connected and cumulative actions (especially, downstream coal combustion). The agency must then monetize the impacts in order to properly account for the costs of these GHG emissions. The agency may use different values for the SCC, but must recognize the central value of $43/ton.

With regard to methane emissions from the mine, BLM must account for that gas's higher global warming potential. Methane is a potent GHG with a global warming potential that is significantly greater—approximately 34 times over a 100-year period and 86 times over a 20-year period—than carbon dioxide.[50] Because of methane's greater global warming potential, the social cost of methane is significantly greater.[51] To calculate the social cost of methane, BLM must quantify expected methane emissions, multiply those emissions by either 86 (to calculate the 20-year warming potential of methane) or 34 (to calculate the 100-year warming potential), and then multiply that number by the various values for the SCC.

In addition to valuing the SCC, BLM must accurately value the significant non-carbon externalities of coal mining and combustion. As noted, these impacts are tremendous and potentially dwarf the already significant impacts of GHG emissions.[52]

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50 *See, e.g.*, IPCC, Fifth Assessment Report Climate Change at 8-56 (2013) (attached as Exhibit 21); Drew T. Shindell, *Improved Attribution of Climate Forcing to Emissions*, 326 Science 716 (2009) (attached as Exhibit 22).
51 Drew Shindell et al., Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security, 335 Science 183 (2012) (attached as Exhibit 23); Gernot Wagner, Expert Rebuttal Report and Rebuttal Written Testimony of Gernot Wagner, Ph. D., Characterizing the Economic Benefits of Anticipated Methane Reductions for the Proposed Amendment to Colorado's Proposed Oil and Gas Regulation with Respect to Climate Change (Jan. 30, 2014) (attached as Exhibit 24).
52 *E.g.*, National Research Council, *supra*; Muller et al., *supra*; Ben Machol & Sarah Razk, *supra*; Paul R. Epstein et al., *supra*.

5. Connected and Cumulative Actions

In determining the scope of a NEPA analysis, an agency "shall consider 3 types of actions." 40 C.F.R. § 1508.25. This includes connected and cumulative actions. *Id.* "Actions are connected if they: (i) Automatically trigger other action which may require environmental impact statements. (ii) Cannot or will not proceed unless other actions are taken previously or simultaneously. (iii) Are interdependent parts of a larger action and depend on the larger action for their justification." *Id.* § 1508.25(a)(1). Cumulative actions are actions which "when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact statement." Connected and cumulative actions may include actions by state or private parties. *E.g.*, *Alpine Lakes Protection Soc'y v. USFS*, 838 F. Supp. 478 (W.D. Wash. 1993).

Here, there are a number of connected and cumulative actions that must be included in this NEPA analysis. First, BLM must include the two other proposed mine expansions: Area B and Area F. Both actions are interdependent parts of the ongoing mining and combustion complex that consists of the Rosebud Mine and the Colstrip Power Plant. All of the expansions depend on ongoing operations of the larger mine/power plant complex for their justification. None of the mine expansions on its own would economical if it were not connected to the larger complex. *See Cady v. Morton*, 527 F.2d 786, 795 (9th Cir. 1975) (approval of small portion of larger mining operation must consider entire operation). Accordingly, they must be considered together. Similarly, because the other mine expansions will have cumulatively significant impacts on multiple resources, including groundwater (the Rosebud coal aquifer), surface waters (Rosebud Creek and East Fork Armells Creek), wildlife, ranching operations, and reclamation, they are cumulative actions, which must be considered together with the proposed lease modification.

Additionally, the combustion of the coal at the Colstrip Power Plant is a connected and cumulative action. There is no question that the coal from the proposed lease modification is destined to be burned primarily at the Colstrip Power Plant (with high sulfur waste coal potentially going to the Rosebud Plant). The coal would not be burned but for combustion at the Colstrip Power Plant, and the power plant would not be able to operate without this coal, as it is limited by permit to burning coal from the Rosebud seam.[53] Further, power plant operations are a

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[53] MDEQ, Operating Permit No. OP0513-06 ("The applicant will utilize only coal from the Rosebud seam."); *see also* Ltr. from WELC to Greg Hallsten, MDEQ (Nov. 5, 2012) (attached as Exhibit 13) (these comments related to the connected and

cumulative action. The plant's leaking ash ponds together with salt pollution from the mine are, as acknowledged by MDEQ, contributing to the impairment of East Fork Armells Creek.[54] Additionally, WECo apparently accepts a certain quantity of toxic coal ash and other coal combustion waste (CCW) for use and burial at the mine. Not only must the impacts of this use of coal ash be discussed, but they also underscore that the mine and plant are connected and cumulative actions.

6. Indirect Impacts

BLM's NEPA analysis must also consider indirect effects. 40 C.F.R. § 1508.25(c)(2). Effects are indirect if they are "caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable." *Id.* § 1508.8(b). Downstream impacts of fossil fuel extraction, such as transportation and combustion, are indirect effects that must be analyzed. *Mid-States Coalition for Progress v. Surface Transportation Board*, 345 F.3d 520, 532 (8th Cir. 2003); *Border Power Plant Working Group v. Department of Energy*, 260 F. Supp. 2d 997, 1006, 1017 (S.D. Cal. 2003); *Northern Plains Resource Council, Inc. v. Surface Transportation Board*, 668 F.3d 1067, 1081-82 (9th Cir. 2011). Here, downstream transportation of coal to the Colatrip and Rosebud power plants, combustion of the coal, and disposal of coal combustion waste are foreseeable indirect impacts of the proposed lease modification.

A. Coal Combustion

The Colstrip Station is one of the largest sources of air pollution in the nation. The massive plant emits between 14 million and 18 million tons of CO_2 annually, placing it among the top 15 point sources of GHG pollution in the nation.[55] Carbon dioxide, as elaborated below, is the principle pollutant driving the crisis of global climate change. Colstrip is also the seventeenth largest source of mercury emission in the nation, emitting over 900 lbs. of the toxin annually, approximately 1% of total

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cumulative Area F expansion are incorporated wholly into this comment letter by reference).

54 MDEQ, Water Quality Standards Attainment Record for East Fork Armells Creek, Colstrip to Mouth (2014).

55 Envtl. Integrity Project, Dirty Kilowatts: America's Most Polluting Power Plants 7 (July 2007) (attached as Exhibit 25); EPA, Facility Level Information on Greenhouse Gases Tool, http://ghgdata.epa.gov/ghgp/main.do.; Environment America, America's Dirtiest Power Plants: Their Oversized Contribution to Global Warming and What We Can Do About It at 28 (2013) (attached as Exhibit 26).

mercury emitted by coal plants in the nation.[56] Mercury is a potent toxin that "damages the central nervous system, thyroid, kidneys, lungs, immune system, eyes, gums, and skin," it causes permanent brain impairment, and it is most threatening to fetuses and young children.[57] Colstrip is the ninth largest source of nitrogen oxides (NO_x) in the nation, emitting approximately 33,000 tons annually.[58] Nitrogen oxides when exposed to sunlight create ground-level ozone, which is responsible for multiple forms of respiratory impairment.[59] Additionally, NO_x emissions cause nitrogen loading in water bodies, which accelerates eutrophication and oxygen depletion.[60] The Colstrip Station is also among the largest emitters of lead pollution in the nation, emitting nearly 800 pounds of lead annually.[61] The plant also emits significant amounts of particulate matter (PM), sulfur dioxide (SO_2), and selenium.[62] BLM must consider the impacts of continued emissions from the Colstrip Station, as well as the Rosebud Power Plant, that will result from the lease modification and the associated connected and cumulative actions, including the Area B and Area F mine expansions.

OSM must fully address the climate implications continued GHG emissions. As the Citizens elaborated in their comments to DEQ, there is an overwhelming scientific consensus that GHG emissions from human activities are altering the atmosphere and global climate; coal combustion is the worst offender—the authorities cited in the Citizens' previous comments are incorporated here by reference.[63] It is also clear that the impacts of climate change are currently being

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[56] Envtl. Integrity Project, Dirty Kilowatts, *supra* note 82, at 2, 22.
[57] United Nations Environmental Program, Mercury: Time to Act 23 (2013) (attached as Exhibit 24).
[58] Envtl. Integrity Project, Dirty Kilowatts, *supra* note 82, at 17.
[59] *Id.* at 15.
[60] *Id.*
[61] Environmental Integrity Project, America's Top Power Plant Toxic Air Polluters 14 (Dec. 2011) (attached as Exhibit 27).
[62] Mont. Dep't of Health & Envtl. Sciences, Environmental Impact Statement on the Proposed Montana Power Compay Electrical Generating Plant at Colstrip, Montana at 29-33, A-6 to A-9.
[63] *See supra* Ltr. from WELC to Greg Hallsten, MDEQ; *see also* Cook et al., *Quantifying the Consensus on Anthropogenic Global Warming in the Scientific Literature* 8 Env't Research Letters 1 (2013) (attached as Exhibit 26) (concluding that 97% of peer-reviewed scientific papers on climate change agreed with the scientific consensus that global warming is occurring and is caused by human acitivities); *see also* Intergovernmental Panel on Climate Change, Working Group 1

felt across the nation, including the mountains and plains of Montana.[64] Warmer temperatures are driving outbreaks of forest pests that have devastated millions of acres of forest throughout the Rocky Mountains, including large areas in Montana.[65] Climate warming is causing and is predicted to continue to cause warmer water temperatures in streams and rivers and low summer flows, harming cold-water fish, such as trout, and destroying their habitat.[66] Hotter temperatures and earlier spring snowmelt is also causing and expected to continue to cause longer and more damaging wildfire seasons.[67] It is also melting the glaciers in Glacier National Park—with all of the park's fabled glaciers to be melted by 2025.[68] These impacts to natural systems are, in turn, harming important sectors of Montana's economy: the state's $300 million annual sports fishing industry has suffered due to climate impacts to fish and streams, the destruction of forests from increased fires and forest pests outbreaks is harming and will continue to harm the state's timber industry, higher temperatures and water shortages have harmed and are projected to continue to harm the agricultural sectors of the state's economy, and reduced snow pack and earlier snow melt is harming and is projected to continue to harm the skiing and winter sports industries.[69] Additionally, climate change is causing

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Contribution to the IPCC Fifth Assessment Report *Climate Change 2013: The Physical Science Basis*, Summary for Policy Makers (2013) (attached as Exhibit 28).

64 See text and sources cited in Ltr. from WELC to Greg Hallsten, MDEQ, *supra* at 6-10.

65 Jeffery B. Mitton & Scott M. Ferrenberg, *Mountain Pine Beetle Develops an Unprecedented Summer Generation in Response to Climate Warming* 179 Am. Naturalist E163 (2012) (attached as Exhibit 29); U.S. Global Change Research Program, Global Climate Change Impacts in the United States, 136-37 (2009) (attached as Exhibit 30); Jesse A. Logan, *Climate Change Induced Invasions by Native and Exotic Pests*, U.S.D.A. Forest Service (2006) (attached as Exhibit 31).

66 Daniel J. Isaak, et al., *The Past as Prelude to the Future for Understanding 21st-Century Climate Effects on Rocky Mountain Trout*, 37 Fisheries 542 (2012) (attached as Exhibit 32); U.S. Global Change Research Program, Global Climate Change Impacts in the United States, *supra*, at 137; Stephen Saunders et al., Rocky Mtn Climate Org. & NRDC, Hotter and Drier: The West's Changed Climate at 31 (2008) (attached as Exhibit 33); Nat'l Wildlife Fed'n, Swimming Upstream: Freshwater Fish in a Warming World (2013) (attached as Exhibit 34).

67 U.S. Global Change Research Program, Global Climate Change Impacts in the United States, *supra*, at 136-37; Hotter and Drier, *supra*, at 20-21; Climate Central, The Age of Western Wildfires (2012) (attached as Exhibit 35).

68 Hotter and Drier, *supra* at 25-26.

69 *Id.* at 29-34; U.S. Global Change Research Program, Global Climate Change Impacts in the United States, *supra* at 133, 136-37.

and is projected to continue to threaten public health, causing, for example, increased spread of vector borne diseases such as West Nile virus, hantavirus, Lyme disease, and Rocky Mountain spotted fever.[70] And the impacts of climate change are imperiling some of Montana's most iconic species—wolverines and grizzly bears.[71] In short, climate change "threatens the basic elements of life for people around the world [and Montana]—access to water, food production, health, and use of the land and the environment."[72] BLM's NEPA analysis must discuss how continued coal combustion will contribute to climate change and how those impacts will continue to harm numerous aspects of Montana's economy, ecology, and society. To the degree that there is uncertainty about the future impacts of climate change due to potentially different emissions scenarios, BLM must construct different climate scenarios. *See Save Our Ecosystems v. Clark*, 747 F.2d 1240, 1246 n.9 (9th Cir. 1984) ("Reasonable forecasting and speculation is . . . implicit in NEPA, and we must reject any attempt by agencies to shirk their responsibilities under NEPA by labeling any and all discussion of future environmental effects as 'crystal ball' inquiry.").

B. Health Impacts of Combustion

In evaluating the air pollution impacts of continued operations at the massive Colstrip Station and the Rosebud Plant, BLM should give specific attention to the tremendous impacts that coal pollution has on public health. 40 C.F.R. § 1508.25(c) (must consider direct, indirect, and cumulative impacts); *id.* § 1508.27(b)(2) (must consider impacts to public health and safety); 42 U.S.C. § 4331(b)(1) (NEPA is intended to assure that "all Americans have "safe, healthful, productive, and esthetically and culturally pleasing surroundings"); *id.* § 4331(c) (everyone has a right to a "healthful environment" and correspondingly "a responsibility to contribute to the preservation and enhancement of the environment"); Mont. Const.

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70 U.S. Global Change Research Program, Global Climate Change Impacts in the United States, *supra* at 95-96; *see also* AP, *West Nile Virus Appears in 6 Montana Counties*, Billing Gazette (Aug. 16, 2013), *available at*, http://billingsgazette.com/news/state-and-regional/montana/west-nile-virus-appears-in-montana-counties/article_cff4551c-ffbc-567c-9a8c-60d969d59cab.html.

71 *See* 78 Fed. Reg. 7,863, 7,874-77 (Feb. 4, 2013) (finding that climate change is threatening wolverines in Montana); *Greater Yellowstone Coal., Inc. v. Servheen*, 665 F.3d 1015, 1024-30 (9th Cir. 2011) (explaining science showing that climate change, by causing massive die-off of white bark pine, is threatening grizzly bears in the Greater Yellowstone Ecosystem).

72 Nicholas Stern et al., Stern Review: The Economics of Climate Change vi (2006) (attached as Exhibit 36).

art. II, § 3 (right to a "clean and healthful environment" is an inalienable right of all Montanans).

An abundance of evidence demonstrates that coal combustion has devastating impacts on public health, causing hundreds of thousands of deaths annually.[73] One recent study by the Clean Air Task Force found the following health impacts for coal combustion in the United States:

Health Impact	**Incidence (annual)**	**Valuation (in $millions)**
Mortality	13,200	$96,300
Hospital Admissions	9,700	$230
ER Visits for Asthma	12,300	$5
Heart Attacks	20,400	$2,230
Chronic Bronchitis	8,000	$3,560
Asthma Attacks	217,600	$11
Lost Work Days	1,627,800	$150[74]

The annual costs to the economy from these health impacts is staggering: over $100 billion.[75] When all of the externalities of coal are added up, the harm caused by coal to our national economy has been estimated at $175-$860 billion annually.[76]

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[73] Clean Air Task Force, The Toll from Coal 10 (Sept. 2010) (13,000 annual mortalities in US) (attached as Exhibit 36a); Conservation Action Trust, Urbanemissions.info, Greenpeace, Coal Kills: An Assessment of Death and Disease Caused by India's Dirtiest Energy Source at 1 (2012) (80,000 to 115,000 premature deaths annually) (attached as Exhibit 36b); Health and Environment Alliance, The Unpaid Health Bill: How Coal Power Plants Make Us Sick, at 5 (March 2013) (estimating 18,500 premature deaths due to coal pollution annually in European Union) (attached as Exhibit 36c); Edward Wong, *Air Pollution Linked to 1.2 Million Premature Deaths in China*, N.Y. Times (Apr. 1, 2013) (reporting 1.2 million premature deaths annually due to air pollution in China) (attached as Exhibit 36d).

[74] Clean Air Task Force, The Toll from Coal, *supra* at 10.

[75] *Id.*

[76] Paul R. Epstein, et al., *Full Cost Accounting for the Life Cycle of Coal*, *supra.*

Indeed, it appears that the cost of the harms from burning coal is greater than the benefit derived from using coal forenergy.[77] These health impacts are cumulative effects of coal combustion, which must be acknowledged, addressed, quantified, and monetized in BLM's NEPA analysis.

The Clean Air Task Force has specifically found that the Colstrip Station is responsible for 31 premature deaths annually, 48 heart attacks annually, 530 asthma attacks, 22 hospital admissions, 19 cases of chronic bronchitis, and 31 ER visits for asthma.[78] The impacts must be identified, evaluated, and quantified in BLM's NEPA analysis. Further, the EIS must consider whether the externalities caused by the Rosebud strip mine and coal combustion at the Colstrip and Rosebud plants is greater than the value created by such activities. *See* 42 U.S.C. § 4332(2)(B); 40 C.F.R. § 1502.23.

C. Disposal of Coal Combustion Waste

Disposal of CCW is a reasonably foreseeable effect of the proposed lease modification. *See* 40 C.F.R. § 1508(b) (indirect effects). It is also a connected action, as the coal is unquestionably destined to the power plants, and the Colstrip power plant is mandated by permit to burn only coal from the Rosebud coal seam, as noted. CCW contains numerous hazardous pollutants, including "antimony, arsenic, barium, beryllium, cadmium, chromium, lead, mercury, nickel, selenium, silver, and thallium." 75 Fed. Reg. at 35,138. The CCW impoundments that serve the Colstrip plant have been leaking and contaminating the underlying aquifer with toxics and pollutants since their construction, impacting the water quality of both ground and surface water as well as the ecological and human communities that depend on that water. The Montana DEQ and Colstrip's owners have known about this for three decades.[79] Despite regulators being "very concerned" and plant operator's commitment to make "all efforts" to stop the leakage, attempts to control or abate the pollution have been without success.[80] In all likelihood, this problem will become legacy pollution, remediation of which will be passed on to taxpayers and community members.

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[77] Nicolas Z. Muller et al., *Environmental Accounting for Pollution in the United States Economy*, *supra*; Ben Machol & Sarah Rizk, *Economic Value of U.S. Fossil Fuel Electricity Health Impacts*, *supra*.

[78] Clean Air Task Force, Interactive Map: Existing Power Plants, http://www.catf.us/fossil/problems/power_plants/existing/map.php?state=Montana.

[79] *Order Issued on Colstrip Seep*, Montana Standard (June 6, 1981) (attached as Exhibit 37).

[80] *See* Letter from Earthjustice to MDEQ (July 25, 2013) (attached as Exhibit 38).

It is highly probable that approval of the proposed modification will ultimately result in further coal combustion and CCW disposal that will further pollute the aquifer surrounding Colstrip's CCW impoundments. And because of the interaction of surface and ground waters, noted above, the CCW disposal will result in additional pollution to East Fork Armells Creek (from the impoundment for units 1 and 2), as well as, Rosebud Creek (from the impoundments for units 3 and 4). BLM must assess the impacts of CCW to each water system.

BLM's NEPA analysis should also consider the impacts of CCW that has been backfilled in the mine and used as fill and road base (among other things) throughout the mine operation.[81] How much CCW has been backfilled in the Rosebud Mine? Where has this backfill occurred? Is CCW still being backfilled in the mine and used as road base (and for other purposes)? Where will the CCW created by combustion of the coal in the proposed lease modification area be disposed? What is the long term plan for the disposal site?

7. Cumulative Effects

BLM must also assess cumulative effects. 40 C.F.R. § 1508.25(c). Cumulative effects are the impacts "on the environment which result[] from the incremental impact of the action when added to other past, present, and reasonably foreseeable future acts, regardless of what agency (Federal or non-Federal) or person undertakes such other actions." *Id.* § 1508.7. Consideration of cumulative effects is particularly important in environmental assessments. *Kern v. BLM*, 284 F.3d 1062, 1077 (9th Cir. 2002).

First, BLM must consider the cumulative effects of the proposed lease modification, along with all prior and reasonably foreseeable future mining. All mining has affected and continues to affect ground and surface waters throughout the Colstrip area. As noted, strip-mining coal has significant impacts on quality and quantity of surface and ground water. Further, future mining in Area B and Area F, as well as other potential mine expansions, will lead to additional cumulative impacts. BLM must consider these "past, present, and reasonably foreseeable future acts" in its cumulative impacts analysis.

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[81] Mont. Dep't of Health & Envtl. Sciences, Environmental Impact Statement on the Proposed Montana Power Company Electrical Generating Plant at Colstrip, Montana at 51 (noting "stated intention" to backfill CCW in mined-out pits and the potential of water pollution to result).

BLM's cumulative impact analysis must further evaluate the cumulative impacts of coal mining operations at Rosebud and CCW disposal at the Colstrip Power Plant, in the Rosebud Mine (and potentially also in the Big Sky mine), as well as the impacts of CCW that has been used around the mine site (for example on roads). MDEQ has noted that both the leaking ash ponds of the Power Plant and coal mining are responsible for increased salts and impairment in East Fork Armells Creek below the town of Colstrip.[82] Thus, it is clear that coal mining and CCW disposal are having cumulative impacts. The extent of these impacts must be assessed.

BLM must also assess cumulative impacts from mining and air emissions from the Colstrip Power Plant. Strip mining at Colstrip releases sulfates that then contaminate surface and ground waters.[83] Sulfate in waters negatively affects livestock.[84] The power plant is also a major emitter of sulfur.[85] This widespread dispersion of sulfur can harm grass and lead to additional sulfur uptake by cattle, leading to cumulative harms to livestock.[86] There is also potential for cumulative effects from power plant emissions and nitrogen oxide emissions caused by blasting at the mine.[87] BLM must assess these impacts as well.

BLM must also assess the cumulative effects of the proposed lease modification and the proposed Tongue River Railroad, which would lead to significant synergistic effects.[88] The Tongue River Railroad is proposed to ship coal from Otter Creek to the

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[82] MDEQ, Water Quality Standards Attainment Record for East Fork Armells Creek, Headwaters to Colstrip, *supra*.

[83] MDEQ, Cumulative Hydrologic Impact Assessment for Rosebud Mine Area C-North, *supra*; David W. Clark, USGS, Geochemical Processes in Ground Water Resulting from Surface Mining of Coal at the Big Sky and West Decker Mine Areas, Southeastern Montana, *supra* at 14-16.

[84] M.F. Raisbeck et al., Water Quality for Wyoming Livestock and Wildlife: A Review of Literature Pertaining to Health Effects of Inorganic Contaminants, *supra* at 47.

[85] Mont. Dep't of Health & Envtl. Sciences, Environmental Impact Statement on the Proposed Montana Power Compay Electrical Generating Plant at Colstrip, Montana at 29-33, A-6 to A-9.

[86] *See* M.F. Raisbeck et al., Water Quality for Wyoming Livestock and Wildlife: A Review of Literature Pertaining to Health Effects of Inorganic Contaminants, *supra* at 47.

[87] *See* Ltr. WildEarth Guardians, to OSM (Apr. 14, 2014) (attached as Exhibit 39); 79 Fed. Reg. 43326 (July 25, 2014).

[88] 78 Fed. Reg. 17752 (Mar. 22, 2013).

BNSF mainline via Colstrip, Montana.[89] Railroad construction would further stress ranching operations that are already suffering due to pollution and activities at the Rosebud Mine. Additionally, the coal trains from the proposed Otter Creek Mine that would be hauled via the Tongue River Railroad would have multiple cumulative impacts, including increased air pollution from train diesel emissions and coal dust, increased water pollution from construction and coal dust from the trains, and increased noise pollution. All of these impacts would be additive to and aggravate the air, water, and noise pollution from the Rosebud Mine.

As noted in the Citizens' earlier comments, which are incorporated here by reference, the impacts of the strip-mine over the next two decades will be magnified by the effects of climate change (for which the mine itself is in part responsible).[90] The hydrologic conditions at the outset of strip-mining are simply no longer present and these conditions are expected to change still further.[91] Climate change is causing both more frequent and severe drought and more frequent extreme precipitation events.[92] Precipitation patterns are also shifting.[93] Heat and water stress, along with increases in pests, will affect crops and rangeland.[94] Thus, re-vegetation and reclamation of strip-mined lands will become even less feasible than it is presently. Further, the changing climate will continue to cause changes in wildlife habitat, most importantly habitat for sage grouse.[95] These changes will magnify the impacts to habitat from the proposed lease modification. These combined effects of climate change and strip-mining must be considered together in BLM's NEPA analysis.

Finally, BLM must assess cumulative impacts of continued coal mining and potential oil and gas development. Oil and gas development occurring throughout the area impacts water quality and quantity, contributes to air pollution, and fragments wildlife habitat. All of these impacts create cumulative problems when added to the impacts of coal mining, including the proposed lease modification. As such, they must be considered in the cumulative effects analysis.

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[89] *Id.*
[90] Ltr. from WELC to Chris Yde, MDEQ, *supra*, at 2-4.
[91] *Id.*; U.S. Global Change Research Program, Global Climate Change Impacts in the United States, *supra*, at 123-28.
[92] U.S. Global Change Research Program, Global Climate Change Impacts in the United States, *supra*, at 123-28.
[93] *Id.*
[94] *Id.*
[95] U.S. Global Change Research Program, Climate Change Impacts in the United States: U.S. National Climate Assessment at 449 (2014) (attached as Exhibit 40).

8. Reclamation

Reclamation of strip-mined land should occur "as contemporaneously as practicable with the surface mining operations." 30 U.S.C. § 1265(b)(16). Where full reclamation is "not feasible," strip-mining operations may not be conducted. *Id.* §§ 1202(c), 1272(a)(2). The Surface Mining Control and Reclamation Act (SMCRA) employs a bonding procedure to assure that reclamation occurs. *Id.* § 1269. Under this procedure, the strip-mining company is required to secure a bond that should be sufficient for full reclamation, and then after mining, the company is supposed to receive portions of its bond as it progresses through the various stages of reclamation. *Id.* § 1269(c).

There are significant concerns that full reclamation of coal mining operations in Montana, and particularly at the Rosebud strip-mine, is simply not feasible. This concern is borne out by the amount of strip-mined lands that have been fully reclaimed in the past 40 years: of the 40,028 acres that have been disturbed by strip-mining, only 67 acres have received full bond release indicating full reclamation.[96] OSM and the MDEQ insist that this near complete lack of full reclamation at any mine in Montana is due not to "the quality of reclamation and/or the ability to support the post-mine land use," but rather due to the fact that the standards for complete reclamation are onerous, requiring reclamation through an entire disturbed drainage basin before final bond release is available.[97] However, neither OSM nor DEQ has presented any evidence to support its asserted justification for lack of full mine reclamation, and they have offered similar excuses in the past.[98] More importantly, after nearly half a century of strip mining, they are unable to point to a single large-scale success in full reclamation. That full reclamation is simply not feasible on arid lands in Montana is underscored by recent statements by the operators of the Spring Creek mine, who have acknowledged that they have "no idea" what vegetation will grown on back-filled mining lands and admit having "no control over what seeded plant communities will

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96 Office of Surface Mining, Annual Evaluation Report for the Montana Regulatory Program 8 (2012) (attached as Exhibit 41); *see also* Office of Surface Mining, Contemporaneous Reclamation in Montana (EY 2012) 1-13 (2012) (attached as Exhibit 42) (showing that no mine of any significant size has obtained any final bond reclamation).

97 OSM, Contemporaneous Reclamation in Montana, *supra* at 13.

98 Harris Epstein et al., Undermined Promise: Reclamation and Enforcement of the Surface Mining Control and Reclamation Act 1977-2007 (2007) (attached as Exhibit 43).

result in reclaimed areas."[99] The possibility of restoration of vegetation on strip-mined lands—which the Spring Creek operators are having problems with—is rendered still less likely due to the documented history of cyclical drought in the region, and particular to Colstrip, the cumulative impact on vegetation from acid-rain producing sulfur dioxide (SO_2), among other air pollutants from the Colstrip Station.[100] All of these problems will be further exacerbated by the worsening impacts of climate change, which is causing increased extreme precipitation events, shifts in seasonal precipitation and runoff, decreased precipitation and runoff, and more severe and prolonged drought in the western United States.[101]

If operators admit complete lack control and understanding ("no idea" what vegetation will return) of revegetation, it is hard to see how they can assure reestablishment of the hydrologic regime following strip-mining. Indeed studies and commentators have long suggested that such hydrologic reclamation just can't be done in the arid west. For example, Woessner et al. (1979), in an analysis limited to water pollution from total dissolved solids (TDS), concluded that strip-mining results in significant degradation of ground water at the mine site that will persist for well over a century, and potentially over a millennium, after mining.[102] Acclaimed historian K. Ross Toole, in recounting the region's documented fragile ecology and history of cyclical drought, as well as settlers' repeated failure to understand this ecology, famously compared the conceit of strip-mining reclamation to "lipstick on a corpse."[103] Generalities aside, evidence specific to the Rosebud Mine suggests that reclamation of the water resources in the mine area is not feasible. WECo itself acknowledges that the strip-mining process will lead to significantly elevated levels of TDS after the pit is backfilled, that the TDS levels will exceed (i.e., violate) the standards for the current water classification and, consequently will require at least a temporary reclassification of the groundwater to a lower use-class, and that the levels will not decrease until the pit has fully recharged and emptied at least one time, a process that will at minimum take hundreds of years, and likely much longer.[104] And DEQ acknowledges that surface

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[99] OSM, Annaul Evaluation Report 2012, *supra* at 13.
[100] K. Ross Toole, The Rape of the Great Plains 151-56 (1976).
[101] U.S. Global Change Research Program, Global Climate Change Impacts in the United States, *supra* at 45-47, 124; National Climate Assessment, *supra* at 442-52.
[102] Woessner et al, *The Impacts of Coal Strip Mining on the Hydrologic System of the Northern Great Plains: Case Study of Potential Impacts on the Northern Cheyenne Reservation*, *supra*.
[103] Toole, *supra* note 50 at 144.
[104] Ltr. from WELC to Chris Yde, MDEQ, *supra* at 4-7 (citing Area F application).

waters affected by the mine—East Fork Armells Creek—are impaired due to the strip-mining operations.[105] In addition to the harm to surface- and ground-water caused by the Rosebud strip-mine, disposal of CCW at the Colstrip Station is causing significant groundwater contamination around the power plant's ash ponds.[106] Reclamation of hydrologic resources may likely be further impaired by historic backfilling of CCW from the power plant in the strip-mine's mine-out pits.[107]

Given the mandates of SMCRA and the uncertainty and controversy surrounding reclamation, BLM must carefully evaluate the feasibility of full reclamation in light of the aforementioned documented challenges to reclamation, and must fully address the lack of full reclamation in Montana. If contemporaneous reclamation is not feasible, no mining may be permitted.

9. Extreme Events, Tipping Points, Abrupt Climate Change, and Carbon Budgets

Under NEPA agencies are required to consider the reasonably foreseeable impacts of proposed actions. 40 C.F.R. § 1508.7-8. This includes "impacts which have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason." *Id.* § 1502.22(b).

should also consider extreme weather events that are becoming more frequent due to the crisis of climate change.[108] BLM must consider extreme events that could result from climate change. BLM should also consider how extreme events could exacerbate the impacts of operations of the mine and power plants.

BLM must also consider the possibility that the GHGs that will result from burning the coal in proposed modification may lead to or contribute to the surpassing of climate tipping points due to climate feedbacks (such as thawing

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105 MDEQ, Final Water Quality Integrated Report A-160 (2012).
106 *See* Letter from Earthjustice to MDEQ, *supra*.
107 Mont. Dep't of Health & Envtl. Sciences, Environmental Impact Statement on the Proposed Montana Power Compay Electrical Generating Plant at Colstrip, Montana at 51 (1973).
108 Thomas C. Peterson et al. (eds.), Explaining Extreme Events of 2012 from a Climate Perspective, Special Supplement to the Bulletin of the American Meteorological Society (Sept. 2013) (attached as Exhibit 43a).

methane deposits).[109] It is possible that a small amount of additional forcing could trigger some of these feedbacks, pushing the planet past points of no return. [110] This issue must be carefully evaluated.

BLM must also consider the potential effects of abrupt climate change, such as rapid melting of ice sheets in Antarctica or Greenland (causing rapid sea level increases), rapid release of arctic and sub-arctic methane deposits, changes in the Atlantic meridional overturning circulation, or a rapid shift in global precipitation patterns.[111] Relatedly, the EIS must consider the impacts of unabated climate change, including the possibility of social collapse and the impacts that are projected to most gravely harm impoverished populations and the developing parts of the world.[112]

BLM must also consider how continued mining at the Rosebud Mine will impact the world's carbon budget—the maximum amount of carbon that can be burned in the next fifty years without subjecting the planet to the worst impacts of climate change.[113]

10. Alternatives

NEPA requires agencies preparing any NEPA analysis to evaluate "alternatives to the proposed action." 42 U.S.C. § 4332(2)(C)(iii); *Id.* § 4332(2)(E). The alternatives analysis "is the heart of the environmental impact statement." 40 C.F.R. § 1502.14. This analysis must "rigorously explore and objectively evaluate all reasonable alternatives and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated." *Id.* § 1502.14(a). The agency must "devote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits." *Id.* § 1502.14(b). This analysis is critical to ensuring that NEPA analysis leads to "excellent action," rather than just an accumulation of paper. *Id.* § 1500.1(c).

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[109] James Hansen, Tipping Point: Perspective of a Climatologist (attached as Exhibit 43b).
[110] *Id.*
[111] U.S. Climate Change Science Program, Abrupt Climate Change at 2 (Dec. 2008) (attached as Exhibit 43c); Intergovernmental Panel on Climate Change, Climate Change 2007: Synthesis Report at 54 (2007) (attached as Exhibit 43d).
[112] World Bank, Turn Down the Heat: Why a 4° C Warmer World Must Be Avoided (Nov. 2012) (attached as Exhibit 43e).
[113] IPCC, Fifth Assessment Report Climate Change, *supra*.

> This requirement, like the "detailed statement" [EIS], seeks to ensure that each agency decision maker has before him and takes into proper account all possible approaches to a particular project (including total abandonment of that project) which would alter the environmental impact and the cost-benefit balance. Only in that fashion is it likely that the most intelligent, optimally beneficial decision will ultimately be made.

Calvert Cliffs Coordinating Comm., Inc. v. U.S. Atomic Energy Comm'n, 449 F.2d 1109, 1114 (D.C. Cir. 1971).

In its alternatives analysis, the agency must "include reasonable alternatives not within the jurisdiction of the lead agency." *Id.* § 1502.14(c). Agencies must also consider alternatives that would partially meet the purpose and need of a project. *NRDC v. Hodel*, 865 F.2d 288, 296 n.4 (D.C. Cir. 1988). "The existence of reasonable but unexamined alternatives renders a [NEPA] analysis inadequate." *Friends of Southeast's Future v. Morrison*, 153 F.3d 1059, 1065 (9th Cir. 1998).

Agencies "must look at every reasonable proposal within the range dictated by the nature and scope of the proposal." *Id.* Agencies may not limit, however, the scope of alternatives to the goals of a private project proponent. *Simmons v. U.S. Army Corps of Eng'rs*, 120 F.3d 664, 669 (7th Cir. 1997). Such limitation is a "losing proposition," and agencies have a "duty under NEPA to exercise a degree of skepticism in dealing with self-serving statements from a prime beneficiary of the project." *Id.* Further, courts have long interpreted the mandate to consider reasonable alternatives to require agencies contemplating energy projects to consider reasonable alternative forms of energy generation and energy conservation. *NRDC v. Morton*, 458 F.2d 827, 833-38 (D.C. Cir. 1972); *Hodel*, 865 F.2d at 295-97 (agency required to consider conservation alternatives in analysis of decision to issue oil and gas leases); *Libby Rod & Gun Club v. Poteat*, 457 F. Supp. 1177, 1186-8 (D. Mont. 1978), *aff'd in part and rev'd in part on other grounds*, 59 F.2d 742 (9th Cir. 1979).

Coal is fast becoming obsolete as an energy source on account of its excessive pollution, reduced social acceptance, and decreasing ability to compete economically. It is highly likely that the next two decades combustion of coal, especially from old polluting plants like the Colstrip Station, will no longer be an acceptable source of energy, for social and economic reasons. Accordingly, BLM must consider alternatives to continued continued coal mining at the Rosebud strip-mine and coal generation at Colstrip, such as increase deployment of renewable energy and increased energy conservation and efficiency.

A. Coal Is Losing Both Its Social License and Ability to Compete Economically

Coal fired power generation is fast becoming an obsolete and uneconomical source of electricity, as society is becoming less tolerant of the multifarious harms wrought by coal pollution. President Obama, in laying out his plan for action to combat the crisis of climate change, specifically singled out the need to stop the harm from coal and coal plants:

> Today, about 40 percent of America's carbon pollution comes from our power plants. But here's the thing: Right now, there are no federal limits to the amount of carbon pollution that those plants can pump into our air. None. Zero. We limit the amount of toxic chemicals like mercury and sulfur and arsenic in our air or our water, but power plants can still dump unlimited amounts of carbon pollution into the air for free. That's not right, that's not safe, and it needs to stop.
>
> So today, for the sake of our children, and the health and safety of all Americans, I'm directing the Environmental Protection Agency to put an end to the limitless dumping of carbon pollution from our power plants, and complete new pollution standards for both new and existing power plants.[114]

The President has clearly articulated what has been apparent for some time now: our country needs to transition away from dirty polluting energy from coal plants to renewable energy sources and more efficient use of energy.[115] Consistent with this plan, EPA has issued a proposal to regulate the GHG emissions from existing coal fired power plants, like the Colstrip plant.[116]

On national and international levels major investors—such as the World Bank, European Investment Bank, and the U.S. Import-Export Bank—have declined or refused to invest in coal energy.[117] It has been repeatedly noted that "coal is a dead

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114 Barak Obama, President of United States of America, Remarks on Climate Change at Georgetown University (June 25, 2013), *available at* http://www.whitehouse.gov/the-press-office/2013/06/25/remarks-president-climate-change (attached as Exhibit 44).

115 Executive Office of the President, The President's Climate Action Plan at 6-10 (June 2013) (attached as Exhibit 45).

116 Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 79 Fed. Reg. 34829 (June 18, 2014).

117 World Bank Group, Toward a Sustainable Energy Future for All: Directions for the World Bank Group's Energy Sector at 25 ("The WBG will provide financial

man walking."[118] Major private investors have recently announced that investments in coal are a dead end.[119] A recent report by Goldman Sachs sums up the current and projected state of the coal industry:

> Thermal coal has enjoyed a long period of strong demand growth but in our view the next 10 years will not be as benign. . . .
>
> Earning a return on incremental investment in thermal coal mining and infrastructure capacity is becoming increasingly difficult. Mines are long-lived assets with a long payback period, while thermal coal is a geographically abundant resource in an industry with relatively low barriers to entry. As coal demand becomes increasingly constrained, the competition among suppliers is likely to intensify. The change in outlook is reflected in the way diversified mining companies are reallocating their capital towards more attractive sectors.[120]

Among the reasons behind the impending obsolescence of coal are (1) decreasing acceptance of pollution from coal and, accordingly, increased regulation of coal pollution; (2) increased competition from other energy sources, such as renewables and natural gas; and (3) increases in energy efficiency.[121] A chief reason for the decreased social acceptance of coal is that its externalities—i.e., costs borne by society which are not included in the purchase price of coal—are tremendous,

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support for greenfield coal power generation only in rare circumstances.") (attached as Exhibit 46); European Investment Bank, Ex-Im Bank Move Away from Coal Financing, Sustainable Business (July 31, 2013), *available at* http://www.sustainablebusiness.com/index.cfm/go/news.display/id/25102.

[118] Steven Mufson, *Coal's Burnout: Have Investors Moved to Cleaner Energy Sources*, Wash. Post (Jan. 1, 2011), *available at* http://www.washingtonpost.com/wp-dyn/content/article/2011/01/01/AR2011010102146.html (quoting Kevin Parker, global head of asset management and member of the executive committee at Deutsche Bank); Derek Sands, *US Coal Industry "A Dead Man Walkin": New York Mayor*, Platts (Feb. 27, 2011) (quoting Michael Bloomberg, mayor of New York City), *available at* http://www.platts.com/latest-news/coal/Washington/US-coal-industry-a-dead-man-walking-New-York-6203214.

[119] *E.g.*, Anthony Yuen, The Unimaginable: Peak Coal in China, Citi Research (Sept. 4, 2013) (attached as Exhibit 47) (explaining expected decrease in coal consumption in China and global ripple effects); Bernstein Research, Asian Coal and Power: Less, Less, Less . . . The Beginning of the End of Coal (June 2013) (attached as Exhibit 48).

[120] Christian Lelong et al., Goldman Sachs, Rocks & Ores, The Window for Thermal Coal Investment Is Closing 3 (July 24, 2013) (attached as Exhibit 49).

[121] *Id.* at 20-29.

amounting annually to hundreds of billions of dollars in the United States alone.[122] As society has become better able to recognize and calculate these costs that are being foisted upon it, there has been an ever-growing rejection of coal as a legitimate energy source. Stock value of coal companies is plummeting; stock in Peabody, the largest private sector coal company, has been reduced dramatically.[123] Bankruptcy seems probable for some (e.g., Arch Coal).[124]

It is becoming increasingly clear that Colstrip's owners are also aware coal's obsolescence and are looking to divest themselves of their interests at Colstrip. The Vice President of Corporate Affairs of Puget Sound Energy, the largest owner of Colstrip, recently acknowledged, "[W]e know the end of coal is soon. . . . We know coal is a dead end."[125] Portland General Electric, another partial owner of Colstrip, recently commissioned a study to help that utility develop a low-carbon resource portfolio.[126] The study repeatedly noted that one option is "Colstrip displacement" (i.e., removing the Colstrip Station from its portfolio) and that to meet 2030 emissions targets, "displacing Colstrip by 2030 *is necessary*."[127] Furthermore, it is reported that even the operator (and partial owner) of Colstrip, Pennsylvania Power and Light (PPL), has decided, after failing to find a buyer, to transfer its interest in the plant to a spin off company, Talen Energy: the apparent motive—insufficient return on investment.[128] Low electricity rates have caused the Colstrip Station to

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[122] National Research Council, Hidden Costs of Energy, *supra*; Nicholas Z. Muller et al., Environmental Accounting for Pollution in the United States Economy *supra*; Ben Machol & Sarah Razk, Economic Value of U.S. Fossil Fuel Electricity Health Impacts *supra*; Paul R. Epstein et al., Full Cost Accounting for the Life Cycle of Coal *supra*.

[123] Moody's Investor Service, Moody's Downgrades Peabody to Ba2; Outlook Stable (Aug. 21, 2013), *available at* https://www.moodys.com/research/Moodys-downgrades-Peabody-to-Ba2-outlook-stable--PR_280688?source=email_rt_mc_body&app=n.

[124] Seeking Alpha, Arch Coal: Walking Dead (Sept. 2, 2012), *available at* http://seekingalpha.com/article/841941-arch-coal-walking-dead.

[125] Letter from Bruce Nilles, Sierra Club, and Anne Hedges, Mont. Envtl. Info. Ctr., to Mont. Pub. Serv. Comm'n 10-11 (Aug. 26, 2013) (attached as Exhibit 50).

[126] Energy+Environmental Economics, PGE Low Carbon IRP Portfolios (May 28, 2013) (attached as Exhibit 51).

[127] *Id.* at 5, 15, 30, 33

[128] Mike Dennison, *PPL Montana Putting Its Montana Power Plants Up for Sale, Industry Sources Say* Billings Gazette (Dec. 2013), *available at* http://billingsgazette.com/news/state-and-regional/montana/ppl-montana-putting-its-montana-power-plants-up-for-sale/article_81370bb7-a171-5d33-a05e-1b42a2c68ca1.html (attached as Exhibit 52); John Adams, *PPL to Spin Off Montana*

shut down for extended periods recently because it has been unable to sell its expensive power for a profit.[129] While electricity prices have been down, electricity generated by the Colstrip Station is expensive, as a recent report from the Montana Public Service Commission demonstrated: electricity from Colstrip Unit 4 was the most expensive source of electricity in the energy portfolio of NorthWestern Energy, the major Montana utility.[130] And that was without accounting for Colstrip's outsized externalities—CCW and carbon pollution—externalities that are likely to be constrained in the future.[131] Another reason that the forecast for Colstrip looks so bad is that the cost to mine coal from the Rosebud Mine is the highest in the region, costing approximately $16/ton, a price which is expected to increase over the next 20 years to over $20/ton.[132] And, as mentioned below, Colstrip is constrained by its air pollution permit, from obtaining coal from other sources.

The Sixth Conservation and Electric Power Plan (Sixth Power Plan) of the Northwest Power and Conservation Council (NPCC), a regional organization that maintains and develops power plans for the Northwest (Montana, Idaho, Oregon, and Washington) also foresees reduced coal generation. The NPCC's vision for the next twenty years is that "[c]onventional coal plants"—like Colstrip—"will operate with effective carbon-reducing technologies or be displaced by resources that emit less or no carbon."[133] "The resource strategy does not include any additional coal-fired generation to serve the region's needs. Further, the Council's plan demonstrates that meeting the Northwest power system's share of carbon

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Generating Assets in New Deal, Great Falls Tribune (June 10, 2014), *available at* http://www.greatfallstribune.com/story/news/local/2014/06/10/ppl-spin-montana-generating-assets-new-deal/10304991/.

129 Mike Dennison, *PPL Montana Putting Its Montana Power Plants Up for Sale Industry Sources Say*, *supra*.

130 Jason Brown, Mont. Pub. Serv. Comm'n, Historical Residential Electric Rates, Supply Portfolio and Unit Prices of NorthWestern Energy 11 (Sept. 2011) (attached as Exhibit 53).

131 *See* Obama *supra* note 16 (describing future regulation of carbon from existing coal plants); Hazardous and Solid Waste Management System; Identification and Listing of Special Wastes; Disposal of Coal Combustion Residues from Electric Utilities, 75 Fed. Reg. 35,128, 35,128 (June 21, 2010) (proposed rule to regulate CCW as solid or hazardous waste).

132 John T. Boyd Co., Powder River Basin Coal Resource and Cost Study: Campbell, Converse and Sheridan Counties, Wyoming; Big Horn, Powder River, Rosebud, and Treasure Counties, Montana at 4-6 (Sept. 2011) (attached as Exhibit 54).

133 Northwest Power and Conservation Council, Sixth Conservation and Electric Power Plan 1-14 (Feb. 2010) (attached as Exhibit 55).

reductions called for in some state, regional, and federal carbon-reduction goals will require reduced reliance on the region's existing coal plants."[134] Researchers see this forecast—continued reduced reliance on coal—for utilities across the nation.[135] It is highly unlikely that Colstrip will ever be retrofitted with equipment for carbon capture and sequestration (CCS), because such technology is not currently commercially competitive,[136] and is not likely to be in the future.[137]

B. Renewable Energy and Energy Efficiency and Conservation Are the Future

While the economics for coal in the United States and abroad look dismal for the future, development of renewable energy sources and investments in energy conservation and efficiency are promising.[138] In order to meet carbon reduction goals in the Northwest, the NPCC's Sixth Sixth Power Plan proposes "reduced reliance on coal" and a "carefully coordinated retirement of and *replacement of half the existing coal-fired generation serving the region with conservation, renewable generation, and lower carbon emitting resources*."[139] The Sixth Power Plan found that conservation is "by far the lowest-cost and lowest-risk resource available in the region."[140] This finding reflects the analysis of the Montana Public Service Commission showing that efficiency measures are four times more cost-effective than energy generated by Unit 4 of the Colstrip Station.[141] The plan also noted that "the most readily available and cost-effective renewable resource is wind power and it is being developed rapidly."[142] As the Montana Public Service Commission has

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[134] *Id.*

[135] Forrest Small & Lisa Frantzis, Ceres, The 21st Century Electric Utility: Positioning for a Low Carbon Future (July 2010) (attached as Exhibit 56)

[136] Northwest Power and Conservation Council, Sixth Conservation and Electric Power Plan at AP-13.

[137] *See* Amory B. Lovins & Rocky Mountain Inst., Reinventing Fire: Bold Business Solutions for the New Energy Era 185 (2011) (stating that CCS "faces challenges from its high costs and uncertain performance, which limit its access to capital").

[138] *See, e.g.*, Intergovernmental Panel on Climate Change, Renewable Energy Sources and Climate Change Mitigation: Special Report (2012) (attached as Exhibit 57).

[139] Sixth Power Plan, *supra*, at 7.

[140] *Id.* at 3 (emphasis added).

[141] Mont. Pub. Serv. Comm'n, *supra* note 10, at 11.

[142] Sixth Power Plan, *supra*, at 4.

acknowledged, "Montana has outstanding wind energy potential. The wind generation potential in Montana far exceeds what the state's utilities can use."[143]

Further, "[t]he region needs to devote significant effort to expanding the supply of cost-effective renewable resources, many of which may be small scale and local in nature."[144] Further, given the risk that coal producers will ultimately be required to pay for their carbon pollution, "some renewable generation is cost-effective even without renewable portfolio standards."[145]

In addition to wind, the Sixth Power Plan notes that other viable renewable and low carbon energy options include small scale geothermal projects, upgrades of existing hydropower projects, and bioresidue energy recovery.[146] The Plan also encourages commercialization of deep-water wind energy and wave energy projects.[147]

A highly detailed analysis of different future energy scenarios by Amory Lovins concluded that scenarios based on large scale renewable energy generation (called the "renew" scenario) and widespread distributed generation (the "transform" scenario) combined with aggressive energy efficiency measures have by far, the greatest social, economic, and environmental value. Such measures are affordable and feasible when compared with business as usual scenarios or scenarios involving significant development of nuclear power and coal with CCS.[148] And, the clincher, the renewable and distributed energy scenarios were superior in reliability, security benefits, environmental responsibility, public health benefits, and public acceptability.[149]

In sum, coal energy is fast becoming obsolete: uneconomic, environmentally harmful, and socially unacceptable. Renewable energy and energy conservation and efficiency, on the other hand, are making tremendous gains in cost, and are far superior in environmental and social acceptability. Large-scale deployment of

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143 Mont. Pub. Serv. Comm'n, Draft Economic Impacts of Proposed Amendments of the Montana Department of Public Service Regulation's Qualifying Facility Rules 31 (Aug. 2013).
144 Sixth Power Plan, *supra*, at 4.
145 *Id.* at 5.
146 *Id.* at AP-11.
147 *Id.* at AP-12.
148 Lovins, *Reinventing Fire*, *supra* at 213-15.
149 *Id.*; *see also* Amory B. Lovins, *A Farewell to Fossil Fuels: Answering the Energy Challenge* Foreign Affairs (Apr./Mar. 2012) (attached as Exhibit 58).

renewable energy and conservation measures are reasonable alternatives that should be considered as alternatives to continued strip-mining and coal-fired energy generation at the Rosebud strip-mine and Colstrip Generating Station and Rosebud Power Plant.

11. Managing for Community and Ecosystem Resiliency

BLM's NEPA analysis must assess how the proposed action will affect community and ecosystem resiliency. The wide-ranging effects of climate change include increased drought, flooding, heatwaves, insect and disease infections, shifts in species distribution and timing of natural events.[150] There are also potential surprises, including breaking points and abrupt changes. BLM's NEPA analysis must address measures to be taken to build resiliency in communities and ecosystems in the face of climate change.

12. National Historic Preservation Act

Section 106 of the NHPA is often described as the "stop, look, and listen" provision. *Te-Moak Tribe of Western Shoshone Nevada v. USDOI*, 608 F.3d 592, 607 (9th Cir. 2010) (citation omitted). Pursuant to section 106, BLM is required to "take into account the effect of [an] undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register." 16 U.S.C. § 470f.[151]

The process begins by defining the "area of potential effects," which in this case includes the area that could be affected by the proposed lease modification or any of the connected or cumulative actions. *See* 36 C.F.R. § 800.16 (d). BLM is then directed to review all existing information on historic properties within this area (including data on possible yet-to-be identified properties) and seek out additional information from individuals with knowledge of the area, as well as information from local Indian tribes. *See* 36 C.F.R. § 800.4(a). Based on information gathered from this first, initial step, BLM must then take additional steps "necessary to identify historic properties within the area of potential effects." 36 C.F.R. § 800.4(b). The level of effort required is articulated in the agency's regulations: BLM must make a "reasonable and good faith effort to carry out appropriate identification efforts." 36 C.F.R. § 800.4 (b)(1).

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[150] National Climate Assessment, *supra* at 15-17.
[151] An "undertaking" includes any project, activity, or program carried out, funded, or authorized by a federal agency. *See* 36 C.F.R. § 800.16 (y).

Determining what constitutes a reasonable effort "depends in part on the likelihood that such properties may be present." *Pueblo of Sandia v. Unites States*, 50 F.3d 856, 861 (10th Cir. 1995). BLM employs three different types of inventories, or levels of effort, to identify cultural and historic properties: Class I, II, and III. *See Te-Moak Tribe*, 608 F.3d at 601 n.10 (citing BLM Manual)

A Class I inventory is a professionally prepared study that includes a compilation and analysis of all reasonably available cultural resource data and literature, as well as a management-focused interpretation and synthesis of the data. *See id.* A Class II inventory is a "probabilistic field survey" or sample survey that aids in characterizing the "probable density, diversity, and distribution" of cultural properties in an area. *Id.* A Class III inventory is an intensive, on-the-ground field survey of the targeted area that is intended to locate and record all properties and provides managers with "a complete record of cultural properties." *Id.*

According to BLM, the "most frequently employed method of inventory is a class III survey carried out for specific projects to enable BLM to comply with Section 106 of the [NHPA] . . . before making decisions about proposed land and resource uses." BLM Manual 8110.21.

Here, the proposed action takes place in a location rich in historical and cultural significance. Strip mining this area will obliterate any historical objects that may exist. Accordingly, BLM must undertake a thorough inventory of the area prior to approving the lease modification.

Conclusion

Thank you for carefully considering these comments. The Citizens look forward to fully participating in the ongoing NEPA process regarding the proposed lease modification of the Rosebud strip-mine. Should you have any questions about our comments, please do not hesitate to contact me.

Sincerely,

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BY LISA KALLIO
DEPUTY

MONTANA FIRST JUDICIAL DISTRICT COURT
LEWIS AND CLARK COUNTY

MONTANA ENVIRONMENTAL INFORMATION CENTER and SIERRA CLUB, **Plaintiffs.** v. **MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY,** **Defendant,** and **WESTERN ENERGY COMPANY,** **Defendant-Intervenor.**	**Case No. CDV-2012-1075** **DEPARTMENT OF ENVIRONMENTAL QUALITY'S BRIEF IN RESPONSE TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT**

Defendant State of Montana, Department of Environmental Quality (herein "the Department"), by counsel, respectfully submits this brief in response to Plaintiffs Sierra Club and Montana Environmental Information Center (collectively, "Plaintiffs") motion for summary judgment.

I. INTRODUCTION

Plaintiffs challenge the Department's administrative decision to issue Montana Pollutant Discharge Elimination System ("MPDES") Permit Number MT0023965 to Defendant-Intervenor Western Energy Company (herein "WECo") on September 14, 2012. WECo owns and operates the Rosebud Mine, a surface coal mine located near Colstrip, Montana. Permit Number MT0023965 authorizes discharges of mine process water and storm water that is collected and held in sediment treatment ponds before it is discharged to state waters. The decision at issue is a renewal of Permit No MT0023965, effective December 1, 1999, through September 30, 2004. In accordance with Administrative Rules of Montana (ARM) 17.30.1322, WECo timely submitted an application for renewal of MPDES Permit No. MT0023965 on April 14, 2004. The terms and conditions of the 1999 permit were continued until the effective date of the renewed permit in accordance with ARM 17.30.1313. Both the 1999 and 2012 permits authorize discharges of mine process water and storm water from the Rosebud coal mine.

Plaintiffs contend that the Department issued Permit Number MT0023965 on September 14, 2012, "[i]n response to company pressure," and did so by: (1) re-classifying receiving waters without performing a use attainability analysis; (2) issuing a discharge permit that authorizes discharges to impaired waters for which there is no total maximum daily load (TMDL); and (3) exempting some of the permitted outfalls from monitoring requirements that are necessary to ensure permitted discharges are in compliance with effluent limitations and meet water quality standards. *See* Plaintiffs' Brief in Support of Motion for Summary Judgment (hereinafter "Plaintiffs' MSJ Brief") at page 1. Plaintiffs' ask this Court to: (1) declare that the Department was arbitrary, capricious and acted unlawfully in issuing Permit Number MT0023965; (2) declare that Permit Number MT0023965 is void *ab initio*; and (3) remand the Permit to the

Department for reconsideration.

Judicial review of an agency decision that does not involve a contested case is conducted under the Montana Administrative Procedure Act (MAPA) to determine whether the decision was "arbitrary, capricious, unlawful, or not supported by substantial evidence." Clark Fork Coalition, et al v. Montana Department of Environmental Quality, 347 Mont. 197, 202; 197 P.3d 482, 487 (2008) *citing* Johansen v. State, 295 Mont. 339; 983 P.2d 962 (1999). The Montana Supreme Court further provides that judicial review of agency decisions is narrow. The court does not automatically defer to the agency, but will review the record, and satisfy itself that the agency has made a reasoned decision. Clark Fork Coalition, 347 Mont. at 203; 197 P.3d at 487; *See also* concurring opinion by Justice Jim Rice in Aspen Trails Ranch, LLC v. Simmons et al, 356 Mont. 41, 63; 230 P.3d 808, 823 (2010).

The Administrative Record supporting the Department's decision to issue Permit Number MT0023965, filed herein on October 10, 2014, as Attachment A to the Affidavit of Melissa Sjolund demonstrates that the Department lawfully issued Permit No. MT0023965; that the Department exercised reasonable discretion by authorizing discharges from the Rosebud mine under the terms, limitations, and conditions set forth in Permit No. MT0023965; and that issuance of MPDES Permit Number MT0023965 was reasonable and justified. Permit No. MT0023965 must be upheld unless this Court determines that the Department acted "arbitrarily, capriciously, or unlawfully." Johansen v. State, 1998 MT 51,¶ 27, 288 Mont. 39,¶ 27, 955 P.2d 653,¶ 27; North Fork Preservation Assoc. v. DSL, 238 Mont. 451, 459, 778 P.2d 862 (1989); Langen v. Badlands Co-op State Grazing District, 125 Mont. 302, 234 P.2d 467 (1951). Plaintiffs' motion for summary judgment must be denied because Plaintiffs' have not established that they are entitled to judgment as a matter of law.

II. REGULATORY BACKGROUND

The Montana Water Quality Act, §75-5-101, MCA *et seq*. (hereinafter referred to as "the WQA."), and the federal Clean Water Act (CWA), 33 U.S.C. §§ 1251-1387, control and limit the discharge of pollutants to surface waters through issuance of discharge permits. *See* 33 U.S.C. 1342; and Title 75, Chapter 5, Part 4, MCA. Within the State of Montana, the United States Environmental Protection Agency (EPA) has delegated its authority to administer the National Pollutant Discharge Elimination System (NPDES) program to the Department. The Department issues Montana Pollutant Discharge Elimination System (MPDES) permits for "point source" discharges of "pollutants" to state surface waters. *See* Administrative Rules of Mont. (ARM) 17.30.1301, *et seq*. The Montana WQA requires point source dischargers to control pollutant discharges to surface water through limitations and conditions imposed in MPDES permits. *See* § 75-5-401(1)(a), MCA; and Bates-numbered page 920 of the Administrative Record filed in this matter on October 10, 2014, as Attachment A to the Affidavit of Melissa Sjolund (hereinafter the Administrative Record is referred to as A.R.)

Permit Number MT0023965 includes applicable technology-based effluent limit guidelines (ELGs) for coal mines found at 40 CFR Part 434, *Effluent Limitations Guidelines for the Coal Mining Point Source Category*. *See* AR at 920. The technology-based effluent limits (TBELs) for coal mines are designed to attain technology-based standards and limitations, based on current available control technologies for the industry. The following ELGs, found at 40 CFR Part 434, are potentially applicable to the Rosebud Mine discharges, and were used to establish TBELs in Permit Number MT0023965: Subpart B (for coal preparation plants and coal preparation plant associated areas including discharges that are pumped, siphoned, or drained from coal preparation plant water, coal storage, waste storage, and other areas related to cleaning or beneficiation of coal); Subpart D (alkaline mine drainage including mine drainages and discharges that regularly exhibit a pH greater than 6.0); Subpart F (miscellaneous including discharges driven by precipitation events); and Subpart H (western alkaline coal mining including drainage from reclamation, brushing and grubbing, topsoil stockpiling, and regraded areas). *See* AR at pages 920 - 929.

If EPA's technology-based limits (TBELs) are not sufficient to meet applicable water quality standards and protect beneficial uses, ". . . permit writers . . . impose, along with the technology-based limitations, any more stringent limitations on discharges necessary to meet the water quality standards." *See* Natural Resources Defense Council v. United States EPA, 915 F.2d 1314, 1317 (9th Cir. 1990), *citing* 33 U.S.C. § 1311(b)(1)(C); and *See also* AR at 929. These additional limitations are known as water quality-based effluent limits (WQBELs). Under §303(c) of the CWA, states are required to adopt water quality standards that will "protect the public health or welfare, enhance the quality of water and serve the purposes of the Act." 33 U.S.C. § 1313(c)(2)(A). Under the CWA, a state's water quality standards consist of two inter-related components: (1) the designated uses of the waters; and (2) the water quality criteria necessary to protect such uses. *See* 915 F.2d at 1317.

The receiving waters for discharges from the Rosebud Mine are within the Yellowstone River drainage between the Billings water supply intake and the North Dakota state line. These waters are broadly classified as C-3. *See* ARM 17.30.611(1)(c); AR at 80. However, waters that directly receive discharges from the Rosebud Mine, authorized by Permit Number MT0023965, are ephemeral, meaning they flow only in direct response to precipitation in the immediate watershed or in response to the melting of a cover of snow and ice and have a channel bottom that is always above the local water table. *See* ARM 17.30.602(10). *See also* Affidavit of Melissa Sjolund, attached hereto as Exhibit 1 and by this reference incorporated herein, at ¶ 9.

Ephemeral waters are subject to the alternate water quality standards in ARM 17.30.637. Permit No. MT0023965 imposes effluent limits that include numeric and narrative standards designed to protect the existing and designated beneficial uses of the receiving water based on its ephemeral nature. *See* AR at 12, 80. State surface water quality standards are composed of all rules in ARM Title 17, chapter 30, subchapter 6. *See* ARM 17.30.603(2). The provisions of ARM 17.30.637 are broad and apply to all surface waters unless in conflict with specific water quality criteria in ARM 17.30.620 through 17.30.629. *See* ARM 17.30.603(3). Under ARM 17.30.637(4) ephemeral streams are exempt from the specific water quality standards of ARM 17.30.620 through 17.30.629. Therefore, the specific water quality standards for C-3 waters found in ARM 17.30.629 do not apply to ephemeral streams pursuant to ARM 17.30.637(4).

The administrative decision to issue Permit Number MT0023965 involves a permit renewal and does not authorize a new, previously unpermitted, discharge. MPDES Permit Number MT0023965, as modified, lawfully applies numeric and narrative standards including the general standards and prohibitions in ARM 17.30.635 through 17.30.637, minimum treatment requirements, standards of operation, and general prohibitions to restore and maintain water quality and protect existing and anticipated uses of the receiving water. *See* §75-5-703(10), MCA (point source discharges may commence or continue to impaired water provided nondegradation requirements are met; the discharge will not cause a decline in water quality for parameters by which the water body is impaired; and minimum treatment requirements are met).

Permit Number MT0023965, issued by the Department on September 14, 2012, authorized the Rosebud Mine to discharge from 151 outfalls. Due to the large number of outfalls and limited accessibility of some of the outfalls during rain events, the Department reasonably authorized representative monitoring for discharges resulting from precipitation events. *See* AR at 34. *See also* Exhibit 1 at ¶ 13.

Under 40 CFR 122.41(j)(1), monitoring must be representative of the monitored activity. The Department reasonably determined that the use of representative sampling of discharges related to precipitation-driven events is justified in areas in which similar mining activities are taking place; where there are similar soil characteristics; similar runoff pollutant concentrations; similar storm water treatment and best management practices; and similar effluent limitations apply to the discharge. *See* AR at 90. Representative sampling as prescribed in Permit No. MT0023965 is representative of the monitored activity as required by state and federal law. *See* 40 CFR 122.41(j)(1) and ARM 17.30.1342(10)(a).

Permit Number MT0023965 does not authorize representative sampling for dry weather, or planned, discharges. Dry weather discharges must be sampled and monitored at each outfall from which they occur under Permit Number MT0023965. *See* AR at 1358 - 1364.

III. BACKGROUND FACTS

The Rosebud Mine includes over 25,600 acres permitted by the Department's Permitting and Compliance Division, Industrial and Energy Minerals Bureau, Coal and Uranium Section under Title 82, Chapter 4, Part 2, Montana Code Annotated and the administrative rules adopted thereunder. WECo and its predecessors have conducted surface coal mining operations at the Rosebud mine for over forty years.

Most of the outfalls permitted under MPDES Permit Number MT0023965 are associated with sediment traps or ponds that are used to collect and treat storm water runoff and water from pit de-watering activities to prevent sediment from leaving the mine site where it may impact areas downstream of the mine. These sediment ponds are designed to detain runoff from a 10-year, 24-hour storm event during active mining operations. *See* AR at 915.

The sediment ponds are designed to treat waste water from the mine by providing time for suspended solids to settle, so that waste water discharges will comply with applicable effluent limitations. Precipitation events that exceed the design capacity of the pond may periodically cause discharges from the ponds, as pond overflow. Additionally, residual storm water, or other mine drainage, in the ponds may occasionally cause the ponds to discharge at less than design storm events. *See* AR at 915.

Permit No. MT0023965 authorizes discharges of mine wastewater to East Fork Armells Creek, West Fork Armells Creek, Lee Coulee, Stocker Creek, Black Hank Creek, Donley Creek, Pony Creek, Cow Creek, and Spring Creek. West Fork Armells, Stocker Creek, Black Hank Creek, and Donley Creek are tributary to East Fork Armells Creek, which is tributary to the Yellowstone River. Lee Coulee, Spring Creek, Cow Creek, and Pony Creek are tributaries to Rosebud Creek, which is also a tributary to the Yellowstone River. *See* AR at 916.

Outfalls 10C, 128A, 128B, and 128C are new outfalls, added by Permit Number MT0023965 (issued 2012) and Modification 1 to Permit No. MT0023965 (issued 2014). *See* AR at 76 (Table 1), 79-80 and at 916; *See also* Exhibit 1 at ¶ 11. The remaining outfalls were previously covered under the 1999 MPDES Permit.

East Fork Armells Creek, from its headwaters to Colstrip, is identified as Segment MT42K002_170. At the time Permit No. MT0023965 was renewed in 2012, this segment of East Fork Armells Creek was listed on the State of Montana 2010 Integrated 303(d) List and 305(b) Water Quality Report as impaired for not fully supporting one or more beneficial uses. The probable cause of impairment of Segment MT42K002_170 of East Fork Armells Creek is listed as "alteration in stream-side or littoral vegetative covers." The source of this impairment is not pollutant-related, and a TMDL is not required to address the impairment. *See* AR at 932, 1429, and 1529. Plaintiffs contend that that the impairment of Segment MT42K002_170 is due to mining through the stream channel. *See* Plaintiffs' MSJ Brief at page 5. East Fork Armells Creek is excluded from the mine permitted area; and the Rosebud Mine permit does not allow mining operations to cut through the stream channel as alleged by Plaintiffs on page 5 of their Brief in Support of Motion for Summary Judgment. *See* Exhibit 1 at ¶ 7.

East Fork Armells Creek, from Colstrip to the mouth is identified as Segment MT42K002_ 110. Segment MT42K002_ 110 is downstream of the Rosebud Mine. At the time Permit Number MT0023965 was renewed in 2012, Segment MT42K002_ 110 was listed in the State of Montana 2010 Integrated 303(d) List and 305(b) Water Quality Report as impaired because the segment does not fully support aquatic life and warm water fisheries. The probable causes of impairment are nitrate plus nitrite, electrical conductivity (EC), total dissolved solids (TDS), and total Kjehldahl nitrogen, with agriculture, coal mining, and transfer of waters outside the basin as probable sources of impairment. *See* AR at 1511. Because Segment MT42K002_ 110 is downstream of the mine, and the mine contributes pollutants that are the cause of the impairment, Permit Number MT0023965 contains monitoring requirements or effluent limitations for EC, TDS, and nitrate plus nitrite to monitor and limit the discharge of these pollutants from the mine and protect water quality. *See* AR at 932-933.

Plaintiffs focus on an error in the Department's July 12, 2010 public notice of its tentative decision to renew Permit Number MT0023965 in their assertion that DEQ "ignored" the impaired status of East Fork Armells Creek. *See* Plaintiffs' MSJ Brief at page 10; AR at 1651-1652. The Permit Fact Sheet that was attached to the July 12, 2010 public notice was submitted by Plaintiffs with their motion for summary judgment. *See* page 8 of Exhibit 12, attached to the Affidavit of Shiloh Hernandez. Page 23 of Plaintiffs' Exhibit 12 (or Page 17 of the 2010 Permit

Fact Sheet) clearly indicates that the Department acknowledged the impaired status of East Fork Armells Creek in its 2010 tentative decision to renew Permit Number MT0023965.

IV. PERMIT, ADMINSTRATIVE AND LITIGATION HISTORY

In 1999, MPDES Permit No. MT0023965 was issued to WECo, effective December 1, 1999, through September 30, 2004, authorizing mine process and storm water discharges from the Rosebud Mine. WECo timely submitted an application for renewal of MPDES Permit No. MT0023965 on April 14, 2004, and the terms and conditions of the 1999 permit were administratively continued pursuant to ARM 17.30.1313. Plaintiffs' contend that, for purposes of the 2012 Permit renewal, "WECo lobbied DEQ to reclassify all receiving waters as ephemeral," but the administrative record clearly demonstrates that the 1999 Permit already recognized that the receiving waters for discharges from the mine were "ephemeral drainages." *See* Plaintiffs' MSJ Brief at page 7; AR at 2129 and 2135. *See also* Exhibit 1 at ¶¶8 and 9.

The Department issued a tentative determination to renew Permit Number MT0023965 on July 12, 2010, and made the draft permit available for public comment. The Department did not finalize the 2010 Permit renewal because that draft Permit did not apply water quality standards applicable to ephemeral drainages at ARM 17.30.637(4), did not address outfalls that had been reclaimed, and because the Department was considering representative monitoring of wet weather discharges at the mine. As authorized under ARM 17.30.1361 and 17.30.1365, WECo submitted revised and updated permit application materials; and the Department issued a revised tentative determination on May 11, 2012, which was subject to public notice and comment, and finalized on September 14, 2012. *See* Exhibit 1 at ¶10.

WECo appealed the 2012 Permit renewal to the Board of Environmental Review (BER) based in part on DEQ's identification of certain outfalls as "new" for purposes of nondegradation analysis that WECo contended were previously permitted. Plaintiffs intervened in the BER action. The appeal was resolved by a settlement agreement between WECo and DEQ. *See* AR at 577 through 601; *See also* Exhibit 1 at ¶11. Despite allegations to the contrary, Plaintiffs, as intervenors, were fully informed and aware of the settlement and did not oppose a motion to remand the permit to the Department and suspend the proceedings before BER. *See* Plaintiffs' MSJ Brief at page 7, AR at 581- 583. The settlement between WECo and DEQ resulted in Modification 1 of Permit Number MT0023965, effective September 8, 2014, which permits four new outfalls, Outfalls 10C, 128A, 128B, and 128C. *See* AR at 79. The Department is now aware that a recent hydrologic assessment of East Fork Armells Creek requested by the Department's Coal and Uranium Program indicates that a portion of that stream, located in Mine Area B East between outfalls 16A and 9, may be intermittent rather than ephemeral. WECo has applied for Modification 2 to Permit No. MT0023965 to address the intermittent stretch of East Fork Armells Creek. Modification 2 to Permit No. MT0023965 will apply WQBELs to outfalls discharging to intermittent receiving waters for pollutants of concern (POCs) with reasonable potential to exceed water quality standards. *See* Exhibit 1 at ¶12. Plaintiffs' allege DEQ ignored this information in its decision to finalize Modification 1 to Permit Number MT0023965, but Modification 1 was subject to an agreed upon timeline in the settlement agreement resolving WECo's BER appeal. *See* Plaintiffs' MSJ Brief at page 9; AR at 586-587. The Department proceeded to finalize Modification 1 under the terms of the Settlement Agreement, and intends to consider new information concerning the hydrologic status of East Fork Armells Creek in its determination to issue Modification 2 to Permit Number MT0023965.

Upon resolution of WECo's appeal to the BER, Plaintiffs renewed this action.

V. STANDARD OF REVIEW UPON MOTION FOR SUMMARY JUDGMENT

The undisputed facts and the administrative record supporting issuance of Permit Number MT0023965 demonstrate that the Department exercised reasonable discretion and lawfully issued MPDES Permit No. MT0023965. The Court should summarily dispose of Plaintiffs' claims and grant the Department's motion for summary judgment filed herein under Rule 56 of the Montana Rules of Civil Procedure as a matter of law.

In order to prevail on a motion for summary judgment the "movant must demonstrate that no genuine issues of material fact exist." M.R.Civ.P. 56; Bruner v. Yellowstone County, 272 Mont. 261, 264-65, 900 P.2d 901, 903 (1995). The Department's decision to issue Permit Number MT0023965 must be upheld unless, after reviewing the record, this Court determines that the Department acted "arbitrarily, capriciously, or unlawfully." Johansen v. State, 295 Mont 339; 983 P.2d 962 (1999); North Fork Preservation Assoc. v. DSL, 238 Mont. 451; 778 P.2d 862 (1989); Langen v. Badlands Co-op State Grazing District, 125 Mont. 302; 234 P.2d 467 (1951). Upon review of the administrative record supporting the Department's decision to issue MPDES Permit No. MT0023965, the Court must find that Plaintiffs have failed to state any claim upon which relief may be granted and grant summary judgment in favor of the Department as a matter of law on each and every claim presented in Plaintiffs' Verified Complaint and Application for Writ of Mandate and Declaratory Relief filed herein on December 21, 2012.

VI. RESPONSE TO PLAINTIFFS ARGUMENTS

A. Plaintiffs Have Not Established Standing to Bring This Case

Plaintiffs claim to have established standing to bring this case through the declaration of MEIC member Steve Gilbert, and Plaintiffs have identified no other witnesses or declarants to establish or support standing. *See* Plaintiffs' MSJ Brief at page 12. Mr. Gilbert asserts he began hunting and fishing in the Colstrip area after coal mining began at the Rosebud Mine; and that his recreational and aesthetic experience in pursuing outdoor interests in the area of the Rosebud Mine is negatively impacted by the Department's decision to renew Permit Number MT0023965. *See* Affidavit of Steve Gilbert attached to Plaintiffs' MSJ Brief ¶ ¶ 10, 11, 14 and 16. Plaintiffs do not explain how renewal of Permit Number MT0023965 changes the character of the area and affects Mr. Gilbert's recreational and aesthetic experience. To establish standing the complaining party must "(1) clearly allege past, present, or threatened injury to a property right or a civil right, and (2) allege an injury that is distinguishable from the injury to the public generally, though the injury need not be exclusive to the complaining party." *See* Aspen Trails Ranch LLC v. Simmons, 356 Mont. 41, 53-54; 230 P.2d 808, 817. Plaintiffs have not alleged or demonstrated a specific or threatened injury to its members arising from renewal of Permit Number MT0023965.

B. The Department did not re-classify C-3 receiving waters, and has not eliminated any designated beneficial use. Therefore, it is unnecessary to conduct a Use Attainability Analysis.

The receiving waters for discharges from the Rosebud Mine are within the Yellowstone River drainage between the Billings water supply intake and the North Dakota state line. These waters are broadly classified as C-3. *See* ARM 17.30.611(1)(c); AR at 80. However, the receiving water for discharges from the Rosebud mine are hydrologically ephemeral with the exception of an intermittent stretch of East Fork Armells Creek. *See* Exhibit 1 at ¶ 12. WECo has applied for Modification 2 to Permit No. MT0023965 to account for and identify the intermittent stretch of East Fork Armells Creek. *See* Exhibit 1 at ¶ 12. Modification 2 to Permit No. MT0023965 will apply water quality based effluent limits (WQBELs) to outfalls discharging to this intermittent stretch for pollutants of concern (POCs) with reasonable potential to exceed water quality standards. *See* Exhibit 1 at ¶ 12.

Other than the above-described intermittent segment of East Fork Armells Creek, which will be addressed in Modification 2 to Permit Number MT0023965, the receiving waters for discharges at issue in this matter are ephemeral, pursuant to ARM 17.30.602(12), and are not high quality water. Ephemeral waters are subject to the alternate standards in ARM 17.30.637. The Department developed effluent limitations, including numeric and narrative standards, to protect the existing and designated beneficial uses of the receiving water. *See* AR at 12, 80; *See* Exhibit 1 at ¶ 9. The general standards and prohibitions in ARM 17.30.635 through 17.30.637 include minimum treatment requirements, standards of operation, and general prohibitions to restore and maintain water quality based on, among other factors, the quality and nature of the flow of the receiving water. See ARM 17.30.635(1).

State surface water quality standards are composed of all rules in ARM Title 17, chapter 30, subchapter 6. *See* ARM 17.30.603(2). The provisions of ARM 17.30.637 apply to all surface waters unless in conflict with ARM 17.30.620 through 17.30.629 in which case the requirements of ARM 17.30.620 through 17.30.629 prevail. *See* ARM 17.30.603(3). ARM 17.30.637(4) is not in conflict with ARM 17.30.620 through 17.30.629 because ARM 17.30.637(4) provides "[e]phemeral streams are subject to ARM 17.30.635 through 17.30.637, 17.30.640, 17.30.641, 17.30.645, and 17.30.646 but not to the specific water quality standards of ARM 17.30.620 through 17.30.629" (emphasis added). Therefore ARM 17.30.637(4) provides the water quality standards applicable to ephemeral streams.

In 2002, the Board of Environmental Review (BER) adopted ARM 17.30.650 through 17.30.658 to provide new stream classifications for ditches and ephemeral streams. However, the BER did not modify or revoke ARM 17.30.637 when it adopted these new stream classifications. By treating the receiving waters as ephemeral and applying the standards in ARM 17.30.637, the Department is not reclassifying the streams in the "E" classes provided in

ARM 17.30.652 through 17.30.656.

Plaintiffs state that the EPA and case law support their position that streams may not be classified on a case by case basis when considering an application for discharge permit. *See* Plaintiffs' Brief in Support of MSJ at page 14. The case cited by Plaintiffs involved classification of un-named water bodies by the State of California on a case by case basis. *See* Cal. Ass'n of Sanitation Agencies v. State Water Res. Control Bd., 208 Cal. App. 4th 1438, 1457 (2012). Here, the Department is not making use classifications or de-classifications on a case by case basis, or through this permitting decision. The Department is applying a water quality standard, ARM 17.30.637(4), that was adopted in a public rulemaking process, to ephemeral receiving waters of discharges permitted by Permit Number MT0023965.

Because the receiving waters are not being reclassified, and designated beneficial uses are not being changed, the Department is not required to conduct a Use Attainability Analysis. *See* 40 CFR 131.10 incorporated in ARM 17.30.619. Montana water quality standards exempt ephemeral streams from the requirements of ARM 17.30.620 through 17.30.629. *See* ARM 17.30.637(4). The Department is not "reclassifying" receiving waters through MPDES permit decisions and is not ignoring or removing designated uses of receiving waters. By providing the alternate standards for ephemeral waters in ARM 17.30.637, the BER acknowledged the hydrologic characteristics of ephemeral receiving waters even before adoption of the "E" classification in ARM 17.30.650 through 17.30.658. This is the premise on which Permit No. MT0023965 is based. The C-3 stream classification remains for East Fork Armells Creek, and all other receiving waters at the mine, and existing uses continue to be supported, but the permitting requirements are appropriate for ephemeral streams. The general prohibitions and standards in ARM 17.30.635 through 17.30.637 apply to streams of all classifications to restore and maintain water quality and to protect beneficial uses. *See* ARM 17.30.635(1)(b). The specific water quality standards for C-3 waters found in ARM 17.30.629 do not apply to ephemeral streams pursuant to ARM 17.30.637(4).

Permit Number MT0023965 contains effluent limitations based on numeric and narrative standards to protect the existing and designated beneficial uses of the receiving water. The applicable water quality standards for discharges from the Rosebud Mine to ephemeral receiving waters include the prohibitions and treatment requirements in ARM 17.30.637 and applicable technology-based effluent limits. *See* AR at 93.

The Department's renewal of Permit No. MT0023965 (2012) and the Department's Modification 1 of Permit No. MT0023965 (2014) comply with the Montana WQA and rules adopted by the Board. The Department's decisions to issue MPDES Permit No. MT0023965 must be upheld unless this Court determines that the Department acted "arbitrarily, capriciously, or unlawfully. The record supporting the Department's permitting decision clearly demonstrates that the Department acted in full accordance with applicable law and was not arbitrary and capricious.

C. <u>The terms and conditions of MPDES Permit Number MT0023965 ensure compliance with water quality standards and protect water quality.</u>

MPDES Permit No. MT0023965, as modified, lawfully applies numeric and narrative standards including the general standards and prohibitions in ARM 17.30.635 through 17.30.637, minimum treatment requirements, standards of operation, and general prohibitions to restore and maintain water quality and protect existing and anticipated uses of the receiving water. *See* AR at 12, 80.

Plaintiffs allege that MPDES Permit Number MT0023965 unlawfully allows new or increased discharges (through new outfalls) to impaired waters for which there is no total maximum daily load (TMDL). Segment MT42K002_170 of East Fork Armells Creek, from the headwaters to Colstrip, is a receiving water for discharges from the Rosebud Mine. At the time Permit No. MT0023965 was renewed in 2012, this segment of East Fork Armells Creek was listed on the State of Montana 2010 Integrated 303(d) List and 305(b) Water Quality Report as a category 4C water body, which means the segment does not fully support one or more beneficial uses, but the source of the impairment is not pollutant-related, and a TMDL is not required. *See* AR at 932, 1429, and 1529. The State of Montana 2010 Integrated 303(d) List and 305(b) Water Quality Report also categorized Segment MT42K002_170 as 2B, meaning that, based on available data, beneficial uses are impaired or threatened because of natural conditions. *See* AR at 1529.

The probable cause of impairment of Segment MT42K002_170 of East Fork Armells Creek is listed as "alteration in stream-side or littoral vegetative covers." A TMDL would not address this impairment. *See* AR at 1529. Permit limitations including the general prohibitions and treatment requirements in ARM 17.30.637 and applicable technology-based effluent limits protect the designated beneficial uses of the receiving water. A TMDL is not necessary to address the identified water quality impairment of Segment MT42K002_170 of East Fork Armells Creek.

Segment MT42K002_ 110 of East Fork Armells Creek, from Colstrip to the mouth, is downgradient of the Rosebud Mine. At the time Permit No. MT0023965 was renewed in 2012, this segment was listed in the State of Montana 2010 Integrated 303(d) List and 305(b) Water Quality Report as a category 5 water body, indicating that one or more beneficial uses are impaired or threatened and a TMDL is required. Segment MT42K002_ 110 of East Fork Armells Creek is listed as partially supportive of aquatic life and of warm water fisheries. The probable causes of impairment are nitrate plus nitrite, electrical conductivity (EC), total dissolved solids (TDS), and total Kjehldahl nitrogen, with agriculture, coal mining, and transfer of waters outside the basin as probable sources of impairment. *See* AR at 1511. Because Segment MT42K002_ 110 is downstream of the mine, Permit Number MT0023965 contains monitoring requirements or effluent limitations for EC, TDS, and nitrate plus nitrite to monitor and limit the discharge of these pollutants from the mine. *See* AR at 932-933.

Plaintiffs assert that a State may not issue a permit to a new source that will contribute to violation of water quality standards unless the State first completes a TMDL. *See* Plaintiffs' Brief in Support of MSJ at 18 citing Friends of Pinto Creek v. United States EPA, 504 F3d 1007, 1012 (9th Cir. 2007). Friends of Pinto Creek does not impose the complete ban on new discharges that Plaintiffs suggest, but requires that discharges are subject to conditions that ensure the objectives of the Clean Water Act are met as required by 40 CFR 122.4(i)(2). *See* Id. at 1013. The prohibitions in 40 CFR 122.4(i)(2) are reflected at ARM 17.30.1311(7), which provides:

> ARM 17.30.1311 - No permit may be issued . . . (7) to a new source or a new discharger, if the discharge from its construction or operation will cause or contribute to the violation of water quality standards. The owner or operator of a new source or new discharger proposing to discharge into a water segment which does not meet applicable water quality standards or is not expected to meet those standards even after the application of the effluent limitations required by ARM 17.30.1201 and 17.30.1203, and for which the state or interstate agency has performed a pollutants load allocation for the pollutant to be discharged, shall demonstrate, before the close of the public comment period, that:
> (a) there are sufficient remaining pollutant load allocations to allow for the discharge; and
> (b) the existing dischargers into that segment are subject to compliance schedules designed to bring the segment into compliance with applicable water quality standards.

Friends of Pinto Creek and the requirements at 40 CFR 122.4(i)(2) and at ARM 17.30.1311(7) do not ban "new discharges" or "new sources" that are subject to effluent limitations and conditions that ensure water quality standards are met.

Plaintiffs further assert that the Department is prohibited by order of the U.S Federal District Court to authorize new or increased discharges to impaired waters prior to completion of a TMDL. *See* Plaintiffs' Brief in Support of MSJ at 18 citing Friends of the Wild Swan v. United States EPA, 130 F. Supp. 2d 1204, 1206-7 (D. Mont. 2000). The Order in Friends of the Wild Swan required determination of TMDLs for certain Water Quality Limited Streams (WQLSs) on Montana's 1996 §303(d) list by May 5, 2007. See Id. at 1206.

The 2012 decision to issue Permit No. MT0023965 is a permit renewal and does not authorize a new, previously unpermitted, discharge. Thus, the Department's permitting decision is not in conflict with Judge Molloy's Order in Friends of the Wild Swan. Plaintiffs contend that the discharges from the Rosebud Mine constitute a new source due to "extensive surface disruption and discharges into new drainage areas since 1984," that meet the definition of "major alteration" at 40 CFR 434.11(j)(1)(ii). *See* Plaintiffs' Brief in Support of MSJ at 19. Expansion of the Rosebud Mine is very gradual. The mine disturbs approximately 400 acres per year, and this disturbance is balanced by reclamation of the mined area. To demonstrate, the 1993 permit authorized discharges from 163 outfalls, and the 1999 permit authorized 170 outfalls. When Modification 2 of Permit Number MT0023965 is complete, there will be 143 permitted outfalls, and 69 of these will be associated with reclaimed drainages. On balance surface disruption at the Rosebud Mine does not meet the definition of "major alteration" at 40 CFR 434.11(j) because a "major alteration" has not occurred since May 4, 1984. Expansion of the mine has been gradual since 1984 and reclamation occurs concurrently with expansion.

Additionally, the same nine receiving waters have been named in discharge permits dating back to at least 1989. For these reasons the Department has determined that the Rosebud Mine is not a new source coal mine for purposes of imposing more stringent ELGs.

To clarify, previously unpermitted outfalls 10C, 128A, 128B, and 128C were considered "new or increased sources," for purposes of non-degradation analysis, as defined at ARM 17.30.702(17), and subject to nondegradation review. *See* AR at 79. Plaintiffs point to the Department's response to comments on the 2012 Permit Renewal to claim that the Department "asserted that it complied with the [Judge Molloy] . . .order [in Friends of the Wild Swan] because the permit includes effluent limits that prohibit any increase above previously authorized amounts." *See* Plaintiffs' Brief in Support of MSJ at 21, AR at 995. Plaintiffs blur the lines between permitting a "new source coal mine" for purposes of ELG imposition; authorizing a "new or increased" discharge for purposes of Judge Molloy's Order and the requirements of 40 CFR 122.4 and ARM 17.30.1311; and identifying "new or increased sources" for purposes of nondegradation review. In its Response to Comment 6 on the 2012 Permit renewal, the Department attempted to explain the different "new source" determinations and was not arbitrary and capricious. *See* AR at 995.

Plaintiffs allege that effluent limits in the 2012 Permit are significantly weaker than limits in the 1999 permit because the 1999 permit contained monthly limits for total dissolved solids, which are removed from the 2012 permit imposing only daily maximum limits. *See* Plaintiffs' Brief in Support of MSJ at 21 – 22. Establishing only daily maximum limits for pollutants is consistent with the format of applicable ELGs for precipitation-driven discharges found in 40 CFR 434.63. Precipitation-driven discharge events, by nature, are short in duration making monthly average limits impractical. *See* AR at 2020. Further, the Permittee has the burden of proving that the discharge was due to a precipitation event.

Plaintiffs also contend that the current permit imposes weaker limits by broadening the acceptable pH range from 6.5 to 9 in the 1999 permit to a range of 6 to 9 in the 2012 permit. *See*

Plaintiffs' Brief in Support of MSJ at 22. The pH range in the 2012 Permit reflects the ELGs prescribed by 40 CFR 434. Since acid mine drainage is not an issue from the Rosebud Mine, increasing the range at the lower pH limit does not significantly weaken the permit limit.

MPDES Permit Number MT0023965 does not unlawfully allow new or increased discharges to impaired waters. MPDES Permit No. MT0023965, as modified, lawfully applies numeric and narrative standards including the general standards and prohibitions in ARM 17.30.635 through 17.30.637, minimum treatment requirements, standards of operation, and general prohibitions to restore and maintain water quality and protect existing and anticipated uses of the receiving water.

Renewal of Permit No. MT0023965 (2012) and Modification 1 of Permit No. MT0023965 (2014) complies with the Montana WQA and rules adopted by the Board. The Department's permitting decisions must be upheld unless this Court determines that the Department acted "arbitrarily, capriciously, or unlawfully." The record supporting the Department's permitting decision clearly demonstrates that the Department acted in full accordance with applicable law and was not arbitrary and capricious.

D. MPDES Permit Number MT0023965 reasonably requires representative monitoring for precipitation-driven discharges that is adequate to ensure compliance with water quality standards.

Due to the large number of outfalls at the Rosebud Mine and limited accessibility of some of the outfalls during rain events, the Department reasonably authorized representative monitoring for discharges resulting from precipitation events. *See* AR at 34; See also Exhibit 1 at ¶ 13. Permit Number MT0023965 provides that discharges consisting of storm water runoff from areas classified as "Alkaline Mine Drainage" and "Coal Preparation Plants and Coal Preparation Plant Associated Areas" (40 CFR 434 Subparts B and D) may be sampled at the representative outfalls listed in Table 16. *See* AR at 35.

Under 40 CFR 122.41(j)(1), monitoring must be representative of the monitored activity. The Department reasonably determined that the use of representative sampling is justified in areas in which similar mining activities are taking place; where there are similar soil characteristics; similar runoff pollutant concentrations; similar storm water treatment and best management practices; and similar effluent limitations apply to the discharge. *See* AR at 90. In addition, automated sampling equipment must be installed at representative monitoring locations to ensure flow measurement and automatic sample collection. See AR at 49. Representative sampling as prescribed in Permit No. MT0023965 is representative of the monitored activity as required by state and federal law. *See* 40 CFR 122.41(j)(1) and ARM 17.30.1342(10)(a).

Plaintiffs also contend that the current permit imposes weaker limits by broadening the acceptable pH range from 6.5 to 9 in the 1999 permit to a range of 6 to 9 in the 2012 permit. *See* Plaintiffs' Brief in Support of MSJ at 22.

Permit Number MT0023965 does not authorize representative sampling for dry weather discharges. All dry weather discharges must be sampled and monitored at each outfall from which they occur under Permit Number MT0023965. *See* AR at 1358 - 1364.

Discharge Monitoring Reports (DMRs) submitted by the mine between January 1, 2008, and December 31, 2012, reveal that the largest volume of water discharged from outfalls at the Rosebud Mine occur during planned, dry weather discharges. Forty-five dry weather discharges with a total volume of 993 acre-feet and an average volume of 22.1 acre feet per discharge occurred during this time. During this same period, there were ninety-seven wet weather discharges, twenty-five of these could not be measured due to inaccessibility. Measured wet weather discharges totaled 358 acre-feet in volume, and the seventy-seven measured discharges averaged 5.0 acre-feet per discharge. *See* Exhibit 1 at ¶ 13. It is important to sample 100% of dry weather discharges due to the volume discharged, and the absence of water available for dilution in the ephemeral receiving streams during these discharges.

Wet weather discharges, on the other hand, are short in duration, small in volume, and water allowing dilution may be available in the ephemeral drainage at the time of the discharge. Furthermore, wet weather discharges may come from remote outfalls making collection of viable samples, meeting applicable sample holding times, difficult. *See* Exhibit 1 at ¶ 13. For all these reasons, the Department reasonably determined that installing automated sampling equipment at select outfalls to sample precipitation driven discharges was a practical and reasonable solution and will provide reliable data to assess water quality. The Department's decision to require representative sampling of precipitation-driven discharges at a large facility is not unprecedented. EPA established a similar representative sampling protocol at the Black Mesa Mine in Kayenta, Arizona. *See* Exhibit 1 at ¶ 13; and NPDES Permit 0022179. The Department's decision to require representative sampling of precipitation-driven discharges must be upheld unless this Court determines that the Department acted "arbitrarily, capriciously, or unlawfully." The record supporting the Department's permitting decision clearly demonstrates that the Department acted in full accordance with applicable law and was not arbitrary and capricious.

VII. SUMMARY AND CONCLUSIONS

Plaintiffs have failed to demonstrate that there are no material facts in dispute in this matter and that they are entitled to summary judgment as a matter of law. Therefore, this court must deny Plaintiffs' motion for summary judgment. The Department issued Permit No. MT0023965 in accordance with the Montana Water Quality Act and applicable rules adopted by the BER. The

Department acted within the bounds of its authority by authorizing discharges from the Rosebud mine under the terms, limitations, and conditions set forth in Permit No. MT0023965. The Court must defer to the Agency where it is carrying out a statutory duty assigned to it and its decision involves considerable agency expertise. *See* Johansen v. Department of Natural Resources and Conservation, 1998 MT 51 at ¶27; 955 P2d 653 (1998). The Department's decision to issue MPDES Permit No. MT0023965 complied with the WQA, and rules adopted thereunder, was reasonable and justified, and must be upheld.

WHEREFORE, the Court should deny Plaintiffs' motion for summary judgment, grant the Department's motion for summary judgment, and enter judgment in favor of the Department and against Plaintiffs on all claims, and grant such other and further relief as is just and appropriate in the premises.

Respectfully submitted this 16th day of March, 2015.

DEPARTMENT OF ENVIRONMENTAL QUALITY

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Environmental Quality

**MONTANA FIRST JUDICIAL DISTRICT COURT
LEWIS AND CLARK COUNTY**

MONTANA ENVIRONMENTAL INFORMATION CENTER and SIERRA CLUB, **Plaintiffs.** v. **MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY,** **Defendant,** and **WESTERN ENERGY COMPANY,** **Defendant-Intervenor.**	**Case No. CDV-2012-1075** **AFFIDAVIT OF MELISSA SJOLUND IN SUPPORT OF DEPARTMENT OF ENVIRONMENTAL QUALITY'S RESPONSE TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT**

STATE OF MONTANA)
ss.
Lewis and Clark County)

MELISSA SJOLUND, being first duly sworn, does hereby depose and state as follows:

EXHIBIT 1

1. I am an adult of legal age and have personal knowledge of the matters set forth below.

2. Since July 12, 2010, I have been employed by the Montana Department of Environmental Quality (herein "the Department") in Helena, Montana, as an Environmental Scientist – Technical Coordinator to write Montana Pollutant Discharge Elimination System (MPDES) discharge permits for the Coal and Uranium Section, Industrial and Energy Minerals Bureau, Permitting and Compliance Division of DEQ.

3. Prior to my employment with the Department, I worked for one year as a secondary science and math teacher and four years as an environmental consultant. I received a bachelor's degree in Environmental Science from the University of Iowa and continued my education with a Master's degree in Land Rehabilitation and teaching certification from Montana State University.

4. During my employment with DEQ, I have reviewed and written four (4) MPDES permits for surface coal mines and one (1) MPDES permit for an underground coal mine.

5. I was assigned as the permit writer for the MPDES permit issued to Western Energy Company (WECo) for coal mining and processing operations at the Rosebud Coal Mine in Colstrip, Montana on September 14, 2012, and modified on September 8, 2014. The MPDES permit issued to WECo for the Rosebud Mine is identified as Permit Number MT0023965.

6. I am generally familiar with WECo's surface coal mining permit, issued under Title 82, Chapter 4, Part 2, for its operations at the Rosebud Mine near Colstrip Montana.

7. East Fork Armells Creek is excluded from the permitted mine area; and the mine cannot and does not cut through the stream channel as alleged by Plaintiffs on page 5 of their Brief in Support of Motion for Summary Judgment.

8. In 1999, MPDES Permit No. MT0023965 was issued to WECo, effective December 1, 1999 through September 30, 2004, authorizing mine process and storm water discharges from the Rosebud Mine. In accordance with Administrative Rules of Montana (ARM) 17.30.1322, WECo timely submitted an application for renewal of MPDES Permit No. MT0023965 on April 14, 2004, and the terms and conditions of the 1999 permit were continued pursuant to ARM 17.30.1313.

9. Since at least 1992, the Department's biological assessment records that are prepared to determine water quality standards attainment classify the upper reaches of East Fork Armells Creek as ephemeral. Pursuant to the definition at ARM 17.30.602(12) an "ephemeral stream" is "a stream or part of a stream which flows only in direct response to precipitation in the immediate watershed or in response to the melting of a cover of snow and ice and whose channel bottom is always above the local water table." The conclusion that receiving waters for discharges permitted by Permit No. MT0023965 are ephemeral is based, in part, on the State of Montana Water Quality Standards Attainment Record for stream segment MT42K002_170 (East Fork Armells Creek, headwaters to Colstrip), which states: "(t)he 1992 and 2005 assessments indicated this segment is ephemeral." *See* AR at 1534. Additionally, the Statement of Basis developed in support of the 1999-issued permit states: "(t)he stream segments were (sic) discharge takes place are ephemeral. . . " *See* AR at 1859. MPDES Permit No. MT0023965, and Modification 1 to MPDES Permit No. MT0023965, establish effluent limitations and numeric and narrative standards designed to protect the existing and designated beneficial uses of the receiving water. The treatment requirements and general prohibitions in ARM 17.30.637(4) specifically apply to ephemeral streams of all classifications and prescribe the standards applicable to protect the uses of hydrologically ephemeral streams.

10. Before I was assigned as the permit writer for the Coal and Uranium Section, the Department issued a tentative determination to renew Permit Number MT0023965, which was made available for public comment, on July 12, 2010. The Department did not finalize the 2010 Permit renewal because the 2010 permit ignored water quality standards applicable to ephemeral drainages at ARM 17.30.637(4), did not address outfalls that had been reclaimed, and the Department was considering representative monitoring of wet weather discharges at the mine. WECo submitted revised and updated application materials; and the Department issued a second tentative determination on May 11, 2012, which was subject to public notice and comment.

11. Outfalls 10C, 030, 127, 128, 128A, 128B, 128C, 128D, 129, 136, 137, and 139 were identified as new outfalls in MPDES Permit No. MT0023965 issued on September 14, 2012. The 2012 permit identified all twelve outfalls as "new source or increased sources," as that term is defined by ARM 17.30.702(17) for purposes of nondegradation analysis. WECo later provided documentation indicating that eight of the twelve outfalls were previously permitted under the 1999 permit and had been misidentified by WECo in its renewal application. Of the twelve outfalls identified as new source outfalls by the 2012 permit, only outfalls 10C, 128A, 128B, and 128C were new source outfalls not previously permitted by the 1999 permit. Modification 1 of MPDES Permit No. MT0023965 correctly identified the four new outfalls, and the eight existing outfalls previously permitted by the 1999 MPDES permit.

12. The Department is now aware that a recent hydrologic assessment of East Fork Armells Creek indicates that a portion of that stream, located in Mine Area B East between outfalls 16A and 9, may be intermittent. WECo has applied for Modification 2 to Permit No. MT0023965 to address the intermittent stretch of East Fork Armells Creek. Modification 2 to Permit No. MT0023965 will apply water quality based effluent limits (WQBELs) to outfalls

discharging to intermittent receiving waters for pollutants of concern (POCs) with reasonable potential to exceed water quality standards.

13. In recent history, discharges that result in the largest volume of water discharged from outfalls at the Rosebud Mine occur during dry weather, or planned discharges. Upon review of Discharge Monitoring Reports (DMRs) submitted by the mine between January 1, 2008, and December 31, 2012, I noted forty-five dry weather discharges with a total volume of 993 acre-feet and an average volume of 22.1 acre feet per discharge. During this same period, there were ninety-seven wet weather discharges, twenty-five of these could not be measured due to inaccessibility. Measured wet weather discharges totaled 358 acre-feet in volume, and the seventy-seven measured discharges averaged 5.0 acre-feet per discharge. It is important to sample 100% of dry weather discharges due to the volume discharged during dry weather, and the absence of water in the ephemeral receiving streams during these discharges. Wet weather discharges, on the other hand, are short in duration, small in volume, and may come from remote outfalls making collection of viable samples difficult. For all these reasons it was determined that installing automated sampling equipment at select outfalls was a practical and reasonable solution.

14. Representative sampling protocols at large coal mines are not unprecedented. EPA established a representative monitoring program for wet weather discharges at the Black Mesa Mine in Kayenta, Arizona (NPDES Permit 0022179).

FURTHER AFFIANT SAYETH NOT.

Melissa Sjolund

Melissa Sjolund

State of Montana)
) ss
County of Lewis & Clark)

Subscribed and sworn to before me this 16th day of March, 2015, by Melissa Sjolund.

Notary Public for the State of Montana

CERTIFICATE OF SERVICE

I hereby certify that on the 16th day of March, 2015, I sent a true and correct copy of the foregoing BRIEF IN RESPONSE TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT AND SUPPORTING AFFIDAVIT OF MELISSA SJOLUND, by first class mail, postage prepaid to the following:

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TECHNICAL REFERENCE FOR THE
MID-CONTINENT REGION:

HYDROLOGIC CONSIDERATIONS FOR PERMITTING AND LIABILITY RELEASE

PROBABLE HYDROLOGIC CONSEQUENCES (PHC) DETERMINATION
HYDROLOGIC RECLAMATION PLAN (HRP)
CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA)
POSTMINING HYDROLOGIC ASSESSMENT (PHA)

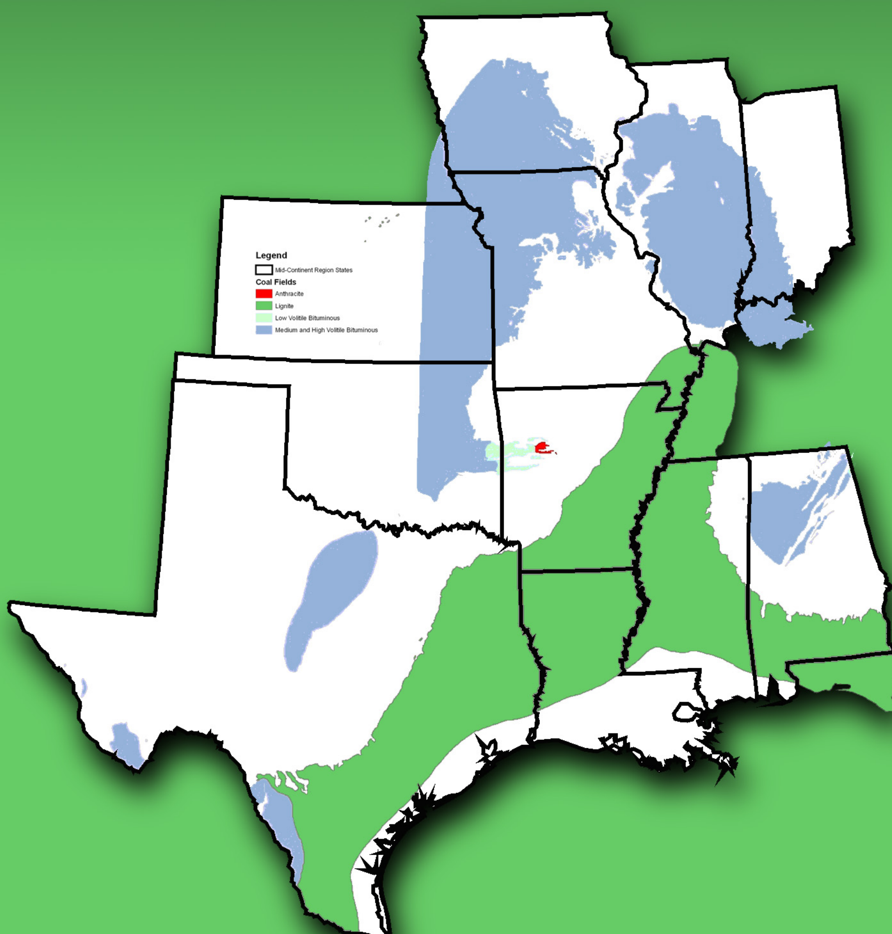

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TABLE OF CONTENTS

LIST OF ACRONYMS AND INITIALISMS

AMD	Acid Mine Drainage
BTCA	Best Technology Currently Available
CBM	Coal Bed Methane
CCB	Coal Combustion By-Product
CFR	Code of Federal Regulations
CHIA	Cumulative Hydrologic Impact Assessment
CIA	Cumulative Impact Area
CWA	Clean Water Act
HRP	Hydrologic Reclamation Plan
NNP	Net Neutralization Potential
NPDES	National Pollutant Discharge Elimination System
OSM	Office of Surface Mining Reclamation and Enforcement
PHA	Postmining Hydrologic Assessment
PHC	Probable Hydrologic Consequence
SMCRA	Surface Mining Control and Reclamation Act
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load

INTRODUCTION

Coal mining, like any other activity that significantly disturbs earth materials, has the potential to adversely affect the quality and quantity of surface and ground water within the vicinity of the mining operations. Adverse impacts may include decreased water availability, increased mineralization and changes in stream loading. Proper planning of the mining operations, along with contemporaneous reclamation, can greatly decrease or prevent unwanted effects and restore or enhance premining hydrologic conditions.

Public Law 95-87, the Surface Mining Control and Reclamation Act of 1977 (SMCRA), requires coal mining and reclamation activities be conducted in a manner that minimizes disturbance to the existing hydrologic balance and prevents long-term adverse impacts to areas both on and off the permitted site (30 CFR 780.21(h)). The term "hydrologic balance" refers to the relationship between the quality and quantity of water flowing into, stored within, and flowing out of a hydrologic unit. A hydrologic unit may be a surface-water drainage basin or subsurface soil or rock layers that store and transmit water. Regulations also require the mining operation be designed in a way that will prevent material damage to the hydrologic balance outside the permit area (30 CFR 780.21(h)). The definition of material damage has not been standardized since it is specific to each mine site. In general, material damage implies some functional impairment of surface lands, features, structures, facilities, or water resources that results in the land's inability to support current or reasonably foreseeable uses. The consequences of material damage may include a significant loss in productive capability or loss of income from the land. Hydrologic balance and material damage are central concepts for all hydrologic considerations for permitting and liability release.

A probable hydrologic consequences (PHC) determination is a discussion with explicit findings of how a proposed operation might affect the quality and quantity of surface- and ground-water systems within, and adjacent to, the proposed permit area (30 CFR 780.21(f)). This determination is written by the permit applicant for inclusion in the permit application package and is based on existing hydrologic, geologic and other pertinent information relative to the site. A hydrologic reclamation plan (HRP) is also part of the permit application package. It describes how disturbance to the hydrologic balance within the permit and adjacent areas will be minimized during the period of mining and reclamation until final reclamation liability release (30 CFR 780.21(h)). A cumulative hydrologic impact assessment (CHIA) is a consideration of how effects on surface- and ground-water systems by a proposed mining operation might combine with similar effects from any existing operation still under reclamation liability within a specified cumulative impact area. The assessment is based on the probable hydrologic consequences determination, hydrologic reclamation plan and other pertinent data and is prepared by the regulatory authority (30 CRF 780.21(g)). Finally, a postmining hydrologic assessment (PHA) is a conception that follows from 30 CFR 800.40(b)(1) and (c)(3). This evaluation, conducted at the time the permittee requests final release from reclamation liability, is the regulatory authority's last opportunity to examine whether pollution of surface and subsurface water is occurring. More generally, it is a determination whether the permittee has successfully completed mining and reclamation operations with regard to having adequately protected the hydrologic balance.

In May of 2002, the Office of Surface Mining distributed *Permitting Hydrology, A Technical Reference Document for Determination of Probable Hydrologic Consequences (PHC) and Cumulative Hydrologic Impact Assessments (CHIA), Baseline Data*. The 2002 document outlined approaches on a national level for obtaining geologic and hydrologic information to be used in the review and preparation of coal mine permit applications. This publication, *Technical Reference for the Mid-Continent Region: Hydrologic Considerations for Permitting and Liability Release* provides a systematic approach to the analysis of existing site conditions and offers various tools that can be used to predict possible hydrologic impacts due to a proposed mining operation. Although most of the information in this document is applicable to coal mining throughout the nation, the focus is on relevant issues within the Mid-Continent Region.

Each of the four major hydrologic considerations for permitting and liability release that is discussed in this document has its own abbreviation (i.e. PHC, HRP, CHIA, PHA); however, not every state in the region will necessarily use these specific designations. For example, it is common practice in some states to incorporate the hydrologic reclamation information into the PHC rather than having a separate section specifically titled the HRP. Also, a state's review of a bond-release request might not produce a report titled a PHA even though the evaluation process could have proceeded in much the same way as outlined in this technical reference document. It should not be inferred that a state's nonuse of any of these abbreviations means the state did not adequately appraise the associated hydrologic issue.

It is important to note the use of this technical reference document is not mandated by any state or federal agency. Material presented here is based on sound approaches intended to aid in the development of an adequate PHC, HRP, CHIA, and PHA. While a great deal of thought went into the identification of topics in the Mid-Continent Region that require consideration in these hydrologic discussions, plans, and assessments, there are, undoubtedly, additional issues that have not been addressed. Furthermore, every state in the region has an approved program that meets the requirement of SMCRA and may have developed additional permitting systems and processes for assuring effective hydrologic evaluations. Therefore, this technical reference document should be utilized as a framework—adding, removing, or modifying topics as necessary.

PROBABLE HYDROLOGIC CONSEQUENCES (PHC)

The PHC determination addresses the anticipated effects of the planned mining operation and subsequent reclamation on the quality and quantity of surface- and ground-water systems within, and adjacent to, the proposed permit area. It is prepared by the applicant and is based on the existing geologic and hydrogeologic settings of the site. The applicant is required to make specific findings in the PHC regarding the proposed operation.

A comprehensive PHC includes, at a minimum, discussions concerning: overburden properties; disposal/storage operations for coal processing waste, non-coal waste, coal combustion byproducts, etc.; erosion and sediment control measures; mining methods; coal-bed methane recovery; subsidence; and mine pools. Generally, the PHC also gives information about alternate water supplies and describes the water-monitoring plan (sample stations, sampling methods and frequencies, field measurements and laboratory analyses, and reporting schedule) that will be used to document both the short-term and long-term effects on local water resources. Both the PHC and the hydrologic reclamation plan may present similar information about some of these topics. Therefore, to limit repetition in this document, only the hydrologic reclamation plan presented in the following section will discuss monitoring plans and alternate water sources.

An outline of suggested minimal requirements for PHC determinations can be found in Appendix B.

Overburden Properties

As part of the permitting process, the applicant must include sufficient geologic information to not only describe and characterize the subsurface strata but also to determine if potentially acid- or other toxic-forming materials exist within the proposed permit area down to and including the stratum immediately below the lowest coal seam to be mined (30 CFR 780.22(a)(2)). The Code of Federal Regulations at 30 CFR 701.5 defines *acid-forming materials* as "…earth materials that contain sulfide minerals or other materials which, if exposed to air, water or weathering processes, form acids that may create acid drainage." This same regulation defines *toxic-forming materials* as "…earth materials or wastes which, if acted upon by air, water, weathering or microbiological processes, are likely to produce chemical or physical conditions in soils or water that are detrimental to biota or uses of water." While the PHC should be comprehensive with regard to the properties of the overburden materials, the focus of the discussion must be on the possible effects of the materials on surface and ground water.

Coal-mining states throughout the nation commonly delineate potentially acid- or toxic-forming materials as those containing a net potential deficiency in calcium carbonate (neutralization potential) of five tons or more per 1,000 tons of material (T/KT). This deficiency represents the difference between the maximum potential acidity (based on total sulfur) and the neutralization potential. Although this method is widely used, caution should be exercised since delineation of potentially problematic strata is generally more complex than simply computing the net neutralization potential (NNP). For example, a calculated NNP more positive than -5 T/KT but with an accompanying fizz rating of "0" may indicate the presence of the iron carbonate siderite which ultimately is not a source of alkalinity. Fizz rating is an important qualitative ranking of how the material reacts to a weak acid and should be an integral part of any laboratory overburden analysis (Sobek et al., 1978).

Besides NNP values, some states within the Mid-Continent Region recognize geologic units with pH values of <4 or >8.5 standard units and/or a total sulfur content of >2% as potentially problematic. Furthermore, electrical conductivity measurements >8 millimhos per centimeter or a sodium adsorption ratio >12 often denote materials that would be unacceptable for placement in the vegetation root zone.

The PHC should not only identify which materials may be acid- or otherwise toxic-forming, but also give the percentages of these materials present across the proposed permit area. The discussion should state the volume of suspect materials that may be disturbed and present any planned special handling plans to mitigate their effects. Special handling measures include isolation of the toxic materials in the spoil profile (above the water table – "high and dry"; below the water table – "down and deep"), disposal at an approved off-site facility, and mixing suspect materials with innocuous or neutralizing matter. The PHC should identify the percentage of overburden strata that contain excess alkalinity that may aid in counteracting adverse effects of acid-producing strata when the two materials are backfilled together in the mine pits.

For more information concerning overburden analyses, please refer to the reference document *Permitting Hydrology, A Technical Reference Document for Determination of Probable Hydrologic Consequences (PHC) and Cumulative Hydrologic Impact Assessments (CHIA), Baseline Data (2002*) previously distributed by the Office of Surface Mining. In addition, *Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania* (1998) is an excellent resource on acid-base accounting and other topics.

Disposal/Storage Operations

Spoil

The PHC should include a discussion of disposal and storage operations with emphasis on possible effects on surface and ground water. During surface mining, spoiled strata from the active pit are placed within the previously mined area and reclaimed according to the approved reclamation plan. The primary issue with spoil deposition in terms of surface and ground water is the potential for acid generation and drainage. Proper placement and quick burial of potentially acid-forming materials can dramatically reduce or prevent acidic conditions (Infanger and Hood, 1980). The PHC should address the type, thickness, and mode of emplacement of topsoil/capping material. A discussion of the storage/disposal of development waste should be part of the PHC completed for underground mining operations.

Coal Processing Waste

Coal processing and its waste disposal is another mine activity that potentially can affect water resources. This type of waste is generated by the crushing, screening, and washing raw coal and may consist of both coarse and fine particles. During surface mining, coarse coal refuse is generally disposed of in the active pit simultaneously with spoil material or placed in a designated area (refuse pile) within the permitted area.

Coal processing waste hauled back to the surface mine pits may generate acid. Proper placement and relatively quick covering of refuse with nontoxic spoil, along with the addition of alkaline-rich matter, can greatly reduce the likelihood of acid mine drainage. As with spoil placement, care must be taken to ensure the construction of a generous, nontoxic rooting zone. Refuse should be placed either high in the pit profile (above the water table) or deep within the pit to ensure the material remains saturated and oxygen free. Refuse should not be deposited at a depth where periodic wet/dry conditions occur because this situation is optimum for acid generation. If the refuse is placed shallow in the pit, a competent cap must be used to prevent or reduce infiltration of precipitation. While awaiting deposition, the refuse should not be stored in a location where it can contact surface water (i.e. near a stream channel or drainage way).

If coarse coal refuse is planned for disposal in refuse piles (common in underground mining operations), the characteristics of the material that will form the base of the pile, as well as the underlying geologic material, should be investigated. Materials with low permeabilities will restrict the downward movement of drainage from the refuse, thus protecting underlying aquifers. Refuse piles may require a system of underdrains to channel seepage to approved sediment basins. While drains may be successful during active mining, thought must be given as to how treatment of the drainage will be maintained when performance bond has been released. Again, the use of low-permeability capping material will inhibit infiltration of precipitation.

Fine coal refuse is often disposed of in surface impoundments (slurry ponds) transported through overland pipelines. When siting the location of these ponds, it is crucial that a thorough characterization of the geologic material(s) underlying the proposed slurry ponds be obtained prior to construction. Likewise, characterization of earth materials adjacent to a proposed slurry pond is needed when placement will occur near unmined strata (e.g. in final-cut impoundments). Low-permeability materials restrict migration of mineralized water from the slurry into surface and ground water. Although manufactured liners can prevent leakage, liners are expensive and care must be taken during installation to avoid puncture or tearing. Generally, coal companies will choose to use in situ material (or material brought in from a nearby "borrow area") to form a natural liner if the material contains sufficient clay that can be compacted to the desired permeability. In addition to discussing potential problems associated with the planned disposal, the PHC should explore the possibility of leaks or breakage along pipelines conveying slurry to the deposition site.

Along with the underlying geologic material, the PHC should discuss the proposed design of the surface impoundments. Proper design and maintenance are crucial in preventing failure that could result in the discharge of coal slurry into adjacent waterways and ground water. Slurry spills can also occur due to a subsidence event; therefore, it is important to know whether there are underground workings in the vicinity of the planned impoundments.

Coal processing waste deposited in underground mine workings may affect the future use of the water that eventually fills the mine voids and may impact the quality of ground water in aquifers that are hydrologically connected to the mine workings. The PHC should address the expected water quality of the mine pool following coal processing waste disposal and project its possible impact on nearby aquifers. The expected volume of the mine pool is also important as underground works that are fully inundated inhibit acid generation; however, mine pools under sufficient hydraulic pressure can blow out. Finally, the PHC should discuss the location of the mine voids planned for coal processing waste disposal with regard to their surface-discharge potential. Mine workings located below drainage have less potential to discharge to surface waters than mines located above drainage.

Noncoal Waste
The disposal of noncoal wastes such as grease, lubricants, solvents, and paints is addressed in the PHC. At a minimum, the applicant should identify the type of wastes, disposal locations and options, temporary storage sites, compaction standards, setback requirements, and reclamation plans. Disposal, whether temporary or permanent, should not occur where the waste, or leachate from the waste, can contaminate surface or ground water.

Coal Combustion Byproducts
As with any activity with the potential to impact water resources, the PHC must address the disposal or beneficial use of coal combustion byproducts (CCBs). The discussion should include the following topics: (1) physical and chemical characteristics of ash material; (2) the proposed locations and disposal methods (backfill, monofill, etc.); (3) reclamation of disposal area; and (4) monitoring requirements and other pertinent information. The applicant must discuss the potential for CCBs to affect surface and ground water as well as specify mitigation efforts should such a condition occur.

Erosion and Sediment Control
The PHC should address the effects of the proposed operation on sediment yield from disturbed areas during mining/reclamation activities and after final bond release. Activities associated with surface mining, as well as activities in the surface effects area of underground mines, must be planned and executed in a manner to prevent erosion and control the amount of sediment entering waterways. Failure to do so can result in increased sediment loads in receiving streams that can have a detrimental effect on aquatic organisms, affect stream velocities and alter existing stream geometries. As with all pertinent parameters, the average concentration of total suspended solids in all applicable stream channels and water bodies must be established prior to mining to allow comparisons of these levels with those detected once activities at the site have begun.

Operational activities used to minimize erosion and control excess sediment yield to receiving streams include stabilization of disturbed areas through land shaping, runoff diversions, temporary and permanent vegetative methods, mulching, regulating stream channel velocities, adequate siltation structures and chemical treatment. The PHC should identify the proposed methods of erosion and sediment controls that will be used during active operations and the anticipated results of these measures.

Mining Methods
Surface Mining
Coal producers in the Mid-Continent Region use both surface (area, thin-seam/auger) and underground (room and pillar, longwall) mining methods. Currently, surface mining is the most common method; however, some states are witnessing an increase in underground operations as shallow coal reserves are depleted. Both types of mining methods have the potential to adversely affect local water resources. The PHC should identify and discuss the proposed mining method.

Surface mining disrupts large volumes of earth materials resulting in possible impacts to surface water bodies and aquifers. Waterways may receive increased sediment load from disturbed areas or from effluent discharging from inadequately designed or poorly maintained sediment basins. Mine operations may also temporarily or permanently relocate waterways resulting in temporal changes in water quality and/or volume.

During mining, both gaining streams (effluent streams) and losing streams (influent streams) near the mine site may decrease in volume as ground water is redirected into the active pit. This occurrence is generally temporary with premining flow conditions reestablished once mining and recharge in the backfilled mine pits is complete and final-cut lakes fill. In addition to overland flow from the mine site, water quality in streams may be degraded by mineralized water within the spoil seeping through channel beds of effluent waterways.

Aquifers within, and adjacent to, a surface coal mine can be adversely impacted by mining operations. Those within the coal extraction zone are destroyed possibly diminishing the volume of water available to wells both upgradient and downgradient of the mine pit. Water loss may be temporary with volume returning (or increasing) once mining activities are complete and the spoil material has recharged. However, since the water within the recharged mine pit may be more mineralized as compared to pre-mining aquifer quality, the water available to surrounding aquifers may be of lesser quality.

Aquifers underlying surface mines are generally not impacted due to the presence of low-permeability material (i.e. underclay, shale) located beneath the lowest coal seam extracted. When present in sufficient thickness, these strata inhibit the migration of water from within the pit into underlying aquifers. If more permeable material is present beneath the coal seam, and the hydraulic head difference between the water within the pit and the underlying aquifer is sufficient to initiate downward movement, mineralized water from within the mine pit can infiltrate lower aquifers possibly degrading water quality. If the target coal seam is underlain by a confined aquifer of significant aerial extent, and hydraulic head conditions are favorable, it is possible for water to enter the pit floor from the underlying aquifer either directly or through cracks/fissures necessitating the need for the pit to be pumped. Ground water may also flow into the pit through improperly sealed boreholes or wells.

Blasting of the consolidated strata during active mining operations may induce fractures or increase the aperture of existing fractures in bedrock located near the blast zone. Blast-induced fractures that occur in an aquifer or that connect previously separate water-bearing formations can have a major effect on ground-water availability and quality. The PHC should consider the possibility of impact to water-bearing units as a result of blasting within the mine site.

The PHC must identify and discuss existing mine workings within and adjacent to the proposed permit area. Prospective mine areas may have flooded underground workings which, if encountered during mining, could result in large quantities of water entering the surface pit or underground mine tunnels. Such an influx of water is not only a safety issue but also an operational challenge due to disposal or treatment needs.

The lowering of water levels in abandoned underground mines may result in subsidence due to the loss of hydrostatic pressure exerted on the roof and overlying strata. When possible, the hydraulic head in nearby abandoned workings should be measured prior to mining and then monitored during mining and reclamation activities. The PHC should address the existing hydrologic conditions of the abandoned workings and discuss the potential impacts to the proposed operation and surrounding area should the underground workings be breached.

Underground Mining

While underground mining operations generally disturb less ground surface and generate less waste rock than surface mines, both types of mining can have similar adverse affects on the hydrologic balance. The PHC should discuss those activities that require sediment control measures and water management plans such as topsoil removal, sediment basin construction, diversion ditch layout, and support facilities and processing plant siting. Development of the shaft necessitates the need to consider overburden characteristics, temporary and permanent disposal of development waste and possible diminution in water quality/quantity servicing nearby domestic wells. A proposal to process coal calls for a discussion of gob and slurry disposal (including waste transportation methods) and consideration of the water source for the processing operation. In addition to the preceding topics, PHCs completed for underground mining operations should discuss subsidence and the quality and quantity of mine-pool water.

Subsidence events can be either unexpected or designed as part of the mining operation. In longwall mining, surface subsidence is planned and occurs shortly after coal extraction along a panel. Conversely, mines using the room-and-pillar method are designed to prevent subsidence by leaving sufficient coal pillars to support the overlying strata. However, the pillars may deteriorate over time resulting in subsidence decades after the mine closed. Regardless of mining technique, subsidence near surface impoundments or waterways can partially or fully drain these features as water moves down through cracks and fissures into the mine void. Ground-water availability at wells located in or near subsided ground can be similarly diminished as fractures emanating from the subsidence zone intersect and drain water-bearing units.

Once underground mining is complete, the resulting mine voids may fill with water. The volume of water entering the subsurface workings is dependant on various factors including local climate, depth of the workings, and hydrologic setting. Geochemistry of the coal seam, roof and floor determines whether pooled water will be acidic and have excess amounts of iron, sulfate and manganese that may restrict or limit its use. The PHC should pay particular attention to those situations where mine workings are liable to flood. Water within flooded mine workings may discharge to the land surface as seeps, or if sufficient hydraulic pressure develops, pooled water may erupt forcefully.

Coal-Bed Methane Recovery

SMCRA does not contain regulations specifically addressing the recovery of coal-bed methane (CBM) nor does the recovery of this gas facilitate coal mining. However, SMCRA regulations do require that mining activities be conducted to minimize disturbances of the hydrologic balance within the permit and adjacent areas and to prevent material damage to the hydrologic balance outside the permit area. Therefore, if CBM recovery activities are to be carried out within a SMCRA permitted area, or if such operations are occurring in proximity to the SMCRA site, the PHC should address any possible cumulative effect of the coal extraction and CBM recovery on local water resources.

CBM recovery can affect surface and ground water in various ways. To produce CBM, the hydrostatic pressure within a water-saturated coal seam must be reduced by pumping the formation water. The bound water is often saline and may contain elevated concentrations of fluoride, ammonia, sulfate or other constituents; therefore, disposal options for the water may be limited. Although the quantity of ground water that must be pumped from the coal will diminish over time, initial quantities can be quite large. Ground water conveyed to the surface during methane recovery may be injected into porous strata not hydrologically connected to the coal bed, discharged into surface drains, or pumped into holding ponds.

Injection of CBM-produced saline or otherwise low-quality water into aquifers or other geologic strata is relatively expensive and can cause subsurface pollution. The applicant and regulatory authority should collect data concerning existing water quantity and quality in the receiving porous strata and identify the aerial extent of those zones before infection begins. In addition, if the receiving unit is an aquifer, the applicant should measure its hydraulic characteristics (permeability, porosity, etc.) and identify customary or potential use of its water.

Discharging CBM water to surface drains and holding ponds is more economical than injecting it underground. However, saline water pumped into surface waterways can contaminate that resource and harm aquatic life. Furthermore, waterways and impoundments can lose water to underlying aquifers, and an influx of mineralized water into a subsurface receiving unit may limit or prevent the usage of that formation as a water supply.

Findings

Federal regulations at 30 CFR 780.21(f) enumerate the minimum PHC findings required of a coal permit applicant. The applicant must find:

- Whether adverse impacts may occur to the hydrologic balance.
- Whether acid- or other toxic-forming materials are present in amounts that could contaminate surface and ground water.
- Whether the planned operation may, in the near term, contaminate, diminish, or interrupt a water resource in legitimate use within or adjacent to the proposed permit area.
- What effect the proposed operation will have on:
    - Sediment yield from the disturbed area.
    - Acidity, total suspended solids, dissolved solids, and other water-quality characteristics of local importance.
    - Flooding or stream-flow alteration.
    - Ground- and surface-water availability.
    - Other characteristics as required by the regulatory authority.

HYDROLOGIC RECLAMATION PLAN (HRP)

All permit applications for surface and underground coal mining must include an HRP. The HRP is a detailed description of the measures to be taken during and after mining (until release of the performance bond) to meet two standards: (1) minimization of all surface- and ground-water hydrologic impacts within and adjacent to the permit area; and (2) prevention of material damage outside the permit area. Material damage is assessed on the basis of permanent or long-term impacts to useable ground- and surface-water resources. Preventive measures proposed in the design and implementation of a HRP must generally employ the best technology currently available (BTCA) for both standards and must include contingency plans for mitigation of hydrologic impacts, should they occur.

An outline of suggested minimal requirements for the HRP can be found in Appendix C.

HRP Elements

Coal mining can potentially affect the hydrologic balance within and adjacent to the permitted area in various ways. For example, without proper sediment control measures in place, mining can cause increased sediment loads in waterways. In addition, mining operations expose additional rock and mineral surfaces to weathering which may result in the generation of acidic or other toxic conditions. Mining may also intercept ground-water systems causing drastic changes from premine flow patterns and rates (OSM, 1991; 1997).

The HRP must describe specific activities (or reference such activities committed to in the operation plan) that will minimize impacts to ground- and surface-water resources and prevent material damage to the hydrologic balance outside the permit area. The applicant must address any potential adverse deviations from baseline conditions. This may be done in part by considering the following specific elements known to be associated with surface and underground coal mining.

Acid Mine Drainage (AMD)

Prevention of surface- and ground-water degradation by acidic mine discharge is paramount. The HRP must discuss the potential for generating acidic water and identify measures to minimize that contaminant. Two general approaches are used during mining to inhibit the development of AMD—controlled placement of overburden materials and careful management of water. Special handling of troublesome strata (pyritic, or in some cases, alkaline materials) limits the exposure of these materials to oxidizing conditions.

Under the proper setting, acid generation can be controlled by flooding potentially problematic materials. Oxygen diffuses very slowly and has limited solubility in water. Stagnant, no-flow conditions within a saturated zone several tens of feet thick inhibits oxygen diffusion and produces an anoxic (oxygen free) state. Submergence or flooding is most successful at mines in flat terrain where ground-water gradients are low, the zone of saturated spoil is thick, and subsurface water discharging into the spoil travels a long way from the aquifer recharge area. Submergence should not be used in hilly terrain where gradients and flow velocities are too great to achieve stagnant, anoxic conditions. In these situations, submergence may actually promote acid generation.

Acid-forming materials can be inundated in a permanent impoundment or segregated and placed under a non-toxic layer that will preclude oxidation and the subsequent development of AMD seeps. Keep in mind, impounding structures constructed of coal mine waste (i.e., coal processing waste and underground development waste) or intended to impound such waste cannot be retained permanently as part of the approved postmining land use (30 CRF 816.84 (b)(1)). Also, permanent impoundments are not allowed on completed refuse piles (30 CRF 816.83 (c)(3)). When considering inundation, projecting reliable postmining water table levels is essential. The applicant and the regulatory authority should be cognizant of those scenarios where resaturation can occur from the surface.

Submergence or flooding is also used to prevent AMD from underground mines. Key considerations to keep in mind when contemplating submergence or flooding for underground mines are whether the mine is located above or below drainage and the ability of mine seals and outcrop barriers to prevent both significant seepage and catastrophic failure under hydrostatic pressure. Flooding to prevent AMD may be more successful in below-drainage mines. Nevertheless, flooding above-drainage mines is typically practiced through the use of "wet" seals that allow water to drain but exclude air entry. Sealing and flooding above-drainage mines does reduce acid loading but can be technically difficult to achieve a long-term effective, stable system. There are no guidelines addressing specific criteria to be used in determining outcrop barrier thickness with regard to flooding underground workings. Likewise, a consensus for a "standard" engineering design approach is lacking for outcrop barriers and seals.

Another method of controlled placement is the isolation of potentially acid- or toxic-forming materials above the water table: This technique attempts to prevent the reactive material from coming into contact with water. Infiltration can be greatly reduced by compacting pyrite-bearing spoil and capping it with clay or other low-permeability materials. The capping approach can be extended to complete encapsulation on top, bottom and sides as a further effort to isolate the material from water contact. Complete isolation from water, however, is difficult to achieve. Clay caps and other barriers are prone to leakage, and the sporadic infiltration of rain or snowmelt may periodically leach the spoil.

Water management strategies, both during and after mining, are another option for reducing acid generation. This type of strategy can include the following:

- Proper placement and rough grading of spoil material to prevent ponding and subsequent infiltration
- Prompt removal of pit water during surface mining
- Isolation of affected pit water from non-contaminated sources (no commingling)
- Construction of underdrain systems to route water away from acid-forming materials
- Diversion of surface-water drainage away from pyrite-bearing spoil or through alkaline material.

Alkaline substances can be added to potentially acid-toxic earth materials to minimize or prevent AMD. This addition can be accomplished by mixing alkaline earth materials with the acid-or toxic-forming substances to obtain a net alkalinity, or by adding the alkaline materials in concentrated placements. A third variant of the alkaline placement technique is encapsulation with alkaline material above and below the acid-producing zone.

"Alkaline recharge" employs trenches loaded with alkaline material (usually a combination of soluble sodium carbonate and crushed limestone) to charge infiltrating waters with high doses of alkalinity sufficient to overwhelm any acid produced within the backfill. This approach is highly dependent on proper location of the alkaline trenches in order to provide maximum inflow of high-alkaline water to the acid-producing zones. Although this method may be useful under certain conditions, some field investigations suggest the distribution of the alkalinity from trenches may be limited (Dale, unpublished field study, 2004).

Although AMD may not be anticipated, this phenomenon may occur regardless of preventive measures implemented during mining. Consequently, the HRP must contain plans for timely mitigation of any such event. The plan may be general, but it should provide for an evaluation period, mitigation work, and follow-up monitoring with periodic re-evaluation. Detailed mitigation plans must be developed on a site-specific basis for each occurrence.

Active treatment methods of acidic waters (chemical additions, pump and treat systems, etc.) are not viable long-term mitigation solutions; however, passive treatment systems may provide a suitable option for the mitigation of AMD. Passive treatment technology has been studied since 1978, and the research and development is voluminous and ongoing. It is important to remember, passive treatment systems may require periodic maintenance that extends beyond the point of final bond release.

Limestone has been one of the more commonly used materials in passive treatment systems. Although it is relatively inexpensive and easy to obtain, limestone-based systems can fail due to armoring of the rock. Metals precipitated from the AMD coat the limestone, reducing its ability to dissolve and provide alkalinity. Precipitated metals also fill pore spaces restricting flow through the gravel body. All alkaline substances used to treat AMD will have a finite useful life; therefore, a key design consideration must be the length of time the material will provide alkalinity.

Low-volume treatment of acidic waters by a passive treatment system (e.g., permanent wetlands) may be satisfactory; however, success is dependent on the geometry and stability of the system and the magnitude of the acidity problem. Constructed wetlands utilize soil and water-borne microbes associated with wetland plants to remove dissolved metals from mine drainage. Initial design and construction costs may be significant; however, unlike chemical treatments, permanent wetlands have low maintenance requirements.

Regardless of the mitigation method chosen, close coordination with, and approval by, the regulatory authority is necessary since findings must be made at the time of final bond release that the hydrologic balance has been protected and that material damage outside the permit area has not occurred. For areas where mitigation is deemed not feasible, the operation plan must be designed to avoid such areas during mining.

Non-Acidic Mine Drainage

Acidity problems may not be the only effects to the hydrologic balance from coal mining. Mining may also lead to poor ground- and surface-water quality exhibited as high total dissolved solids (TDS)(i.e. sulfates and chlorides). Areas of mining that have low precipitation coupled with high evaporation rates (e.g. south Texas) are particularly susceptible to these problems. Problems are exacerbated by the creation of a spoil aquifer system with low-quality water in an area where little ground water existed prior to mining. Again, the HRP must discuss possible adverse impacts to surface- and ground-water resources from the planned mining operation and address mitigation plans for conditions that arise from failure of the HRP.

Sediment Control Measures
Sediment production is a function of runoff rates and the susceptibility of earth materials to erosion (OSM, 1991). When preparing the HRP, the applicant must consider prevention of additional contributions of suspended solids to stream flow using the BTCA. Three strategies to reduce erosion and transport of sediment are: (1) expose the smallest possible area of bare soil for the shortest possible time; (2) minimize sheet erosion by stabilizing reclaimed soils with scarification and mulch; and (3) prevent sediment from leaving the permit area. Limiting the area or time of exposure and minimizing sheet erosion are generally accomplished through efficient planning and execution of clearing, grubbing, mining, backfilling, grading, replacement of topsoil, and revegetation. Preventing sediment from leaving the permit area is generally achieved through the proper construction and maintenance of diversions, sedimentation ponds, and other siltation structures.

Recharge Capacity
Regulations require the permittee to restore the approximate premining recharge capacity in the postmine area. Even though aquifers within the coal-extraction zone will be destroyed, the ability of the backfill to absorb and transmit water necessary to support the intended postmine land use (as measured relative to the premining land use) must be preserved. In addition, protection measures are required to prevent diminution of springs and the destruction of wetlands in areas adjacent to mining. Jurisdictional wetland mitigation and restoration require consultation with the U.S. Army Corps of Engineers.

Disposal Activities
The HRP must address disposal activities involving coal processing waste, coal combustion by-products, and noncoal waste. In addition to federal requirements, disposal of these materials are usually subject to state laws and regulations that may be described in the mining permit. The water-monitoring plan should be designed to detect solutes from wastes and by-products.

Water Monitoring
A water-monitoring program is necessary for assessing compliance with regulatory requirements. It also provides a useful opportunity for tracking trends that may indicate a future problem. Trend analysis may prompt mitigation action that prevents damage from occurring.

<u>Surface Water</u>
Minimum permit applications requirements for baseline surface-water information can be found in 30 CFR 780.21(b) and 784.14(b). Baseline surface-water data are essential since both surface and underground mining have the potential to disrupt and permanently alter surface-water systems. Mining-related effects on baseflow and storm hydrograph peaks may result from: pumping discharges to adjacent watersheds; altering runoff characteristics by changing groundcover; disrupting drainage patterns by modifying the size of drainage areas; and storing overland flow in temporary detention structures or permanent impoundments.

An applicant must identify all surface-water bodies that could be measurably affected by the proposed operation. These resources include waterways, streams, rivers, ponds (“tanks” in

Texas), and lakes. The surface-water description must also delineate the watersheds affiliated with the permit area. By rule, surface-water sampling plans (baseline and compliance monitoring) must be designed to detect seasonal variations in both water quantity and quality. The applicant should explain why each monitoring station is placed where it is and describe how data from these sites will be used to track mining effects on the hydrologic balance and surface-water users. Typically, both upstream and downstream monitoring stations are needed to effectively evaluate any impacts. For maximum continuity, the monitoring plan should incorporate as many baseline stations as possible.

Very large mine areas may encompass many watersheds of similar size, topography, and erosional characteristics. In this case, a permittee may be able to monitor representative disturbed and undisturbed watersheds (termed "paired" watersheds) in lieu of total-mine monitoring. Preapplication consultation with the regulatory authority is advisable for those contemplating this option.

Regulations dictate that each station in the surface-water monitoring plan established to monitor water quality effects be sampled and reported at least every three months. Based on a state's monitoring criteria and the specific site conditions, the regulatory authority may require more frequent monitoring. Monitoring parameters must be useful for demonstrating whether the hydrologic balance is protected from the effects of regulated coal mining. At a minimum, measurements are required for TDS or specific conductivity corrected to 25 °C, total suspended solids, pH, total iron, total manganese, and flow rate. The applicant must give a detailed description of the sampling protocol.

The regulatory authority may approve changes in the surface-water sampling plan if the applicant demonstrates with monitoring data that continued monitoring of certain parameters or specific monitoring stations is no longer needed to protect the hydrologic balance. In general, point-source monitoring under the National Pollutant Discharge Elimination System (NPDES) cannot be modified except by the agency responsible for issuing and administering the NPDES permit. The permit-issuing agency, however, may grant limited NPDES administrative responsibilities to the coal regulatory authority.

<u>Ground Water</u>

In developing an effective ground-water monitoring plan, the permittee must be cognizant of the established ground-water flow directions, both for overburden and underburden aquifers, and must design a plan that incorporates monitoring of both upgradient and downgradient areas. As with surface-water monitoring, the incorporation of baseline monitoring wells and other baseline sampling locations (e.g., springs or seeps) into the plan will maximize the continuity of the data for their intended purpose. In addition to monitoring changes to the quantity and quality of the ground-water resources, the plan should also be designed to detect any changes in flow direction during the course of mining and confirm the re-establishment of the ground-water system after mining is completed prior to final bond release.

Regulations dictate that each well or other sampling location in the ground-water monitoring plan established to monitor water quality effects be sampled and reported at least every three months for TDS or specific conductance, pH, total iron, total manganese, and water level. The regulatory authority may add other constituents of local importance as identified from baseline monitoring or overburden analyses. Additional constituents would be those that might be at concentrations high enough to jeopardize current or postmining ground-water uses. A preapplication meeting would be the time for consultation between the prospective permittee and regulatory authority on suitable monitoring locations and parameters.

The applicant must justify each component of the proposed ground-water monitoring plan including any variations among monitoring stations. For example, when large-area dewatering is proposed, the monitoring plan may incorporate piezometers for measuring the water table or potentiometric surface. Piezometers are not intended for the collection of water samples and may be located within the area of affect but at some distance from the permit area. The monitoring plan must also discuss the fate of monitoring wells and piezometers once mining and reclamation activities are complete.

The regulatory authority may approve modifications to ground-water monitoring requirements provided the applicant, through an analysis of baseline and subsequent monitoring data, demonstrates the proposed change will not hinder the detection of adverse impacts to the hydrologic balance. Conversely, the regulatory authority may require additional monitoring stations and/or parameters if the monitoring record indicates that such a change is necessary to meet statutory objectives.

Replacement of Water Supply

Regulations require that users of ground and surface water be protected from the effects of surface and underground coal mining activities. The permittee must provide a suitable replacement for a water supply in use that is contaminated, diminished, interrupted, or destroyed by the permittee's mining activities. Replacement water shall be available until such time when the adverse effect is no longer occurring. The HRP must describe plans for such eventualities and contingencies in sufficient detail to allow the regulatory authority to assess their viability. Also, the regulatory authority may require a special, targeted monitoring program in addition to the overall long-term water-monitoring plan when water supplies are likely to be threatened.

Plans for water-supply replacement must be based on a thorough survey of water users within the area of potential impact. This premining survey generally includes the locations of all domestic wells or surface-water sources along with water-quality and quantity data sufficient to show seasonal variations. When available, well completion information (i.e., depth, drilling method, and construction) is also included in the premining survey. Assessments of actual effects during and after mining may be conducted by the permittee and/or the RA with the existing water data measured against the baseline information submitted in the permit application. Lacking that detailed level of information, general water-quality criteria may be used to assess impacts. Useful criteria may be found in the Clean Water Act and Drinking Water Act as administered by the state; NPDES permit(s); established total maximum daily loads (TMDLs); and university extension service publications dealing with livestock watering and irrigation.

CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA)

The Surface Mining Control and Reclamation Act (SMCRA) requires the regulatory authority to assess the probable cumulative impacts of all anticipated mining in a given area to assure that the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area. Hydrologic balance is the relationship between the quantity and quality of water flowing into, stored within, and discharging from a unit such as a drainage basin, aquifer, soil zone, lake, or reservoir. The regulatory authority must complete this assessment before issuing a permit to conduct surface coal mining and reclamation operations. The Office of Surface Mining Reclamation and Enforcement (OSM) has termed this evaluation a *cumulative hydrologic impact assessment.* What follows is a suggested process by which regulatory authorities in the Mid-Continent Region might prepare a reasonable and technically sound CHIA.

This technical reference document is written primarily in the context of the regulatory authority having to write a CHIA upon receipt of a permit application package for a new mine. The term *permit application package* refers to the document (often a set of three-ring binders) containing all information required by the regulatory authority for a business entity to obtain and hold a valid coal mining permit throughout the resource recovery and reclamation phases.

After a permit is issued, certain administrative actions will require the regulatory authority to reevaluate an existing CHIA. The regulatory authority must decide whether a CHIA needs to be modified in light of some proposed revision to an approved permit application package. As a practical matter, to trigger a reevaluation of the CHIA, a permit revision would have to involve activity that could potentially affect the hydrologic balance.

Prior to starting the CHIA process, the regulatory authority should review the permit application and determine whether the hydrologic information, data analyses and PHC statement in the application are acceptable. Do these items provide a complete and adequate description of the hydrologic systems that will be affected by the proposed operation? Does the application specify the magnitude of those effects? If these questions have not been answered or if the regulatory authority has not made such a determination, the CHIA process should not begin until these issues are resolved.

The CHIA is distinct from the PHC, although elements of the PHC are used to support and develop the CHIA. The CHIA is the responsibility of the regulatory authority, whereas the applicant must provide the PHC in the permit application package. The PHC focuses on how the proposed mining operation might affect hydrologic conditions within the permit and adjacent areas; the scope of the CHIA is much broader. A CHIA examines how the hydrologic affects of the proposed operation might add to those effects from other anticipated mining operations.

Anticipated mining is that set of SMCRA-regulated work sites, distributed across a landscape, over which hydrologic impacts from coal removal and reclamation could potentially combine to a measurable extent. A cumulative impact area (CIA) is uniquely associated with anticipated mining.

The term *anticipated mining* is from SMCRA, sections 507(b) and 510(b). In common parlance, *anticipated* connotes something that is expected to occur. However, federal coal regulations at 30 CFR 701.5, under the definition of cumulative impact area, assign a more expansive meaning to the term *anticipated mining*.

Anticipated mining includes prospective mining operations and all existing operations. A prospective mining operation primarily would be the proposed operation for which a permit application package has been submitted to the regulatory authority, but it also could possibly be a future operation for which there is adequate baseline and mine-development information. A future operation may be identified as such in the permit application under review or may have been discussed in some other permit application package that was subsequently approved to be a permit. Mine development information for leased federal coal could qualify as a future operation. In all cases, one could reasonably expect the regulatory authority would approve these operations some time in the future when formal application is made to bring them under permit.

An existing operation may be in the coal-production phase, may involve only reclamation activity, or may have been idled by temporary cessation or permit-revocation action. The defining characteristic of this class of existing operations is that the permittee still has reclamation liability for at least some portion of the acres that had been included in a permit issued under an approved, SMCRA-compliant permanent program. Another class of existing operations would be those mining activities for which a permit was not required under SMCRA (for example, coal recovery incidental to the extraction of other minerals).

Hydrologic impacts of individual mining operations will be minimized, though not eliminated, by adherence to mining regulations. Remaining or residual impacts, however small and individually insignificant, may, with the development of additional mines, accumulate to magnitudes that are significant and potentially damaging to the hydrologic balance. The CHIA is necessary to assure that such aggregate impacts will not be overlooked in the routine processing of individual permit applications. A CHIA could result in the denial or delay of a mining permit should the regulatory authority find that the proposed operation has credible potential for significantly damaging the hydrologic balance.

One might ask whether a CHIA is required if the proposed mine would be the first in some broad area. After all, the operative word in the CHIA concept is *cumulative* which seemingly necessitates the potential interaction of two or more anticipated mining operations. This issue was addressed in a preamble to OSM rules and regulations (OSM, 1983a). A commenter wanted OSM to state that when a proposed mine would be the first in an area, there would be no cumulative impacts and, therefore, no need for a CHIA. The OSM response was as follows:

> *While it may be possible that for a single hydrologically isolated mine the probable hydrologic consequences determination made by the operator would be adopted by the regulatory authority as the CHIA, nevertheless such a conclusion must be reached by the regulatory authority on a case-by-case basis.*

Hydrologic impact assessment is not a precise process. Because of the many uncertainties associated with hydrologic estimation, predictions made under the process proposed here, or under any similar process, must be considered as probable in nature rather than exact. Therefore, the regulatory authority must have the option of using professional judgment to make the final material damage determination. This should not detract from the significance of the process if the determination is based on the facts produced by a comprehensive analysis. Likewise, use of qualitative methods and techniques for the analysis is an acceptable option if the regulatory authority can show these to be adequate for the specific site situation.

Often, a permitting action that requires a CHIA will be for an operation in an area that had already been assessed for hydrologic impacts. As much as possible, the previously prepared CHIA should be reused in the new assessment. Not only does this save time for the regulatory authority, but it ensures some degree of continuity in how potential environmental effects of mining operations are evaluated in a given area. In particular, once material damage criteria have been established for a specific area, they would be applicable, with little modification, to all future CHIAs in that area.

Elements of the CHIA

CHIA development is a documented process that proceeds in a logical manner through a set of elements. It involves the analysis of critical aspects of the hydrologic system within a defined area. The purpose of the analysis is to predict the type and magnitude of impacts to the hydrologic system attributable to the proposed operation in conjunction with other anticipated mining. Thus, during the CHIA process, the regulatory authority should:

1. Provide general information about the situation and conditions dealt with in the CHIA by noting:
    - Why the CHIA is necessary (new mine application or significant permit revision).
    - Who is proposing the action that requires a CHIA.
    - Where the new regulated activity will occur.
    - What sort of mining activity is proposed for the site.
    - Whether any previously prepared CHIAs are incorporated into, or are related to, the present CHIA effort.
2. Specify all anticipated mining operations.
3. Delineate the cumulative impact area.
4. Give baseline hydrologic conditions.
5. Identify hydrologic resources likely to be affected by the proposed operation.
6. Establish material damage criteria.
7. Make a material-damage determination from estimated impacts of mining on hydrologic resources.
8. Prepare a statement of findings.

Some of the procedures and hydrologic concerns discussed in this technical reference document may not apply to every CHIA. Within the constraints of good hydrologic practice and those imposed by statutory and regulatory requirements, the regulatory authority has wide latitude to determine the exact manner in which individual elements will be evaluated. An assessment may be based on professional judgment or determined using rigorous analytical techniques. Professionals conducting the assessment should justify their specific assumptions and decisions. This justification is an important aspect of the CHIA process.

Cumulative Impact Area (CIA)
A CHIA is required by SMCRA for each application for a new mine permit or request to significantly revise an existing permitted operation. It is an integral part of the permit decision package. However, a CHIA is not unique to a specific minesite or permit area, but rather it applies to a CIA. The CIA is that region, including the proposed permit area, within which impacts on surface- and ground-water systems resulting from the proposed operations may interact with hydrologic impacts from all other anticipated mining.

The term *impact* does not necessarily indicate a severe or adverse condition. As used in this document, an impact is a measurable change in some characteristic which defines the quality or quantity of a water resource. The occurrence of an impact is distinct from the severity of the impact. Determination of the potential seriousness of impacts is considered a separate and distinct issue in the CHIA process.

A mining impact area is that zone where measurable changes to the hydrologic system have occurred or are likely to occur due to coal recovery and reclamation activities. The only way to delineate the true impact area is by monitoring representative hydrologic parameters at numerous sites over the total time period during which the impacts occur (from before mining until after hydrologic equilibrium is restored after mining). Since the impact area will not be known until after mining and reclamation are completed, it is not useful in preparing the CHIA. Therefore, the CHIA includes an estimation of the size, shape and location of the impact area which becomes the working CIA.

Qualitative Delineation of the Working CIA
The first step in delineating the CIA is to identify anticipated mining. This may be done by first locating the proposed operation in the landscape. Next, seek other mining operations, existing or prospective, whose hydrologic effects could combine with those of the proposed operation. Mining effects on both surface- and ground-water systems must be considered. The surface-water CIA is the geographic region that drains or impounds water that has a measurable chemical signature acquired through contact with anticipated mining and/or has discharge characteristics that can be attributed to activity at anticipated mining operations. The ground-water CIA is the geographic region overlying a three-dimensional body of porous, permeable earth material saturated with water that could be measurably affected in terms of quantity and quality by anticipated mining. A surface-water impact area may have a different size and shape compared to those of the associated ground-water system. The analysis procedures should take into account the interrelationships between the surface- and ground-water systems. The composite of these surface- and ground-water impact areas is the CIA.

The process for identifying anticipated mining at this initial phase is purely qualitative and founded on professional judgment. Consider the surface-water system. Runoff from the site of the proposed operation will eventually commingle with runoff from all other mine sites within a major river basin. However, it is unlikely that Congress intended anticipated mining to routinely include operations within whole river systems, as might be required if the preceding rationale were strictly followed. The downstream extent of a CIA that is environmentally comprehensive and also satisfies the intent of SMCRA probably lies somewhere between the downstream boundaries of the proposed permit area and the farthest downstream mine in the river basin. The additive effects between the proposed mining area and each other site within the basin must be measurable. Spatially remote sites may be eliminated for that reason.

The process of delineating the CIA focuses on the proposed mine site and runs through a series of pair-wise considerations. From the proposed mine, go out to the nearest potential anticipated mine site. Find the closest point on the common receiving stream below these two sites. How does the combined area of the two mine sites compare to the drainage area above the evaluation point on the receiving stream? One could reasonably expect that the cumulative effect of runoff from two mines could have a measurable impact on a small common watershed. That impact may not be measurable if the watershed above the evaluation point is orders of magnitude larger than the combined mine area. Increasingly distant mine sites are subjected to this qualitative, pair-wise evaluation process. Those sites that would likely have measurable cumulative effect on the common receiving stream qualify as anticipated mining. Nearness to the proposed operation alone may not be a valid criterion for identifying anticipated mining. The closest site may be in a different drainage basin, and the shared receiving stream may be quite remote.

A first approximation of the surface-water CIA is made by locating the furthest point upstream on the common receiving stream through which passes runoff from anticipated mining operations. Trace the watershed for that point. That watershed will contain the anticipated mining plus, most likely, a great deal of area that could not have contact with mine runoff, because it is at a higher altitude than anticipated mining operations. The regulatory authority must decide to either delineate the surface-water CIA as a watershed or restrict it to only that portion of the land surface that truly conveys mine runoff. The latter would begin as zones of overland flow across anticipated mine sites. From these zones, runoff would eventually be conducted through a system of merging stream channels and floodplains. The scale at which the surface-water CIA is mapped may determine which of these two alternatives would be more appropriate. Anticipated mining distributed over a large area would have to be displayed on a small-scale map. Here, a surface-water CIA would be better depicted as a watershed; otherwise the downstream true area of contact with mine-affected runoff would simply appear as a network of fine lines.

The process for approximating the ground-water CIA follows that for the surface-water CIA. Again, the first step is to identify anticipated mining. Anticipated mining in terms of ground-water effects may not be the same set of sites that comprises anticipated mining for surface-water impacts. Should the proposed operation potentially jeopardize one or more aquifers, then every other operation that might also measurably affect these same aquifers would qualify as anticipated mining. Hydrologic impacts in this context might include solute plumes from mine workings or draw-down cones from mine dewatering wells.

A conceptual model of the sub-surface flow system is essential for predicting possible movement of solute plumes. The model must identify the aquifer or aquifers that might be affected by mining and identify their areas of recharge and discharge. Hydrogeologic information needed to develop the model should be provided in the PHC determinations for the proposed operation and other anticipated mine operations.

Having identified anticipated mining, the next step is to trace the boundary of the ground-water CIA. For each at-risk aquifer, choose a series of conceptualized flow lines along which pollutants from a given anticipated mine operation might travel. These flow lines would be deduced from the potentiometric surface as revealed by water-level monitoring data. Pick a location along each of these lines that mark the furthest estimated advance of a measurable concentration of some mine pollutant. Connect the points and extend the boundary upgradient around the anticipated mine. Adjust the boundary to include areas that are expected to experience significant lowering of water levels as a result of pit or aquifer dewatering

An aquifer affected by mining may discharge to the surface. The zone along which this occurs is the line of transition from potential ground-water impacts to surface-water impacts, and, as such, locally establishes the downgradient border of the ground-water CIA. The discharge areas of some aquifers may be so far from anticipated mining that migration of degraded water to these points would require decades or centuries. A boundary of the CIA could be set along some line upgradient from the discharge zone to mark the estimated extent of a hypothetical degraded water plume after a specified travel time. The regulatory authority should discuss the rationale for choosing the travel time used in this determination. Given the right hydrogeologic setting, hydrodynamic dispersion—the process by which ground water containing a solute is diluted with uncontaminated ground water as it moves through an aquifer—ensures that the solute concentration will eventually drop to a level too small to be environmentally significant. Ground-water modeling may be used to estimate where a hypothetical contaminant plume fades into insignificance.

The zone of impacted ground water around the proposed operation may merge with affected ground water from one or more anticipated mine operation resulting in a cumulative effect on the water resource. On the other hand, geology, geomorphology and past mining activity may create highly localized flow systems in a coal field such that the proposed mine operation, in terms of ground water, may be hydrologically isolated from all other operations. Suppose, for example, the target coal seam is the primary water storage and transporting stratum. Further suppose, a previous operation had long ago mined the more accessible portions of the coal along the contour. This left a ring of abandoned surface-water impoundments around what had once been economically unrecoverable coal. The remnant coal bed aquifer is recharged by infiltration through the overburden and it discharges into the abandoned mine pits.

If the regulatory authority finds that a scenario such as described above applies to the proposed mine operation for which the CHIA is being written, there is no cumulative ground-water impact area. Otherwise, an impact area would be delineated for each affected aquifer. The ground-water CIA is the composite area of the individual aquifer impact area. The working CIA is the composite of the surface- and ground-water CIAs. The regulatory authority is responsible for delineating a CIA that makes environmental sense. By strictly “following the water,” the regulatory authority should be blind to administrative boundaries. A CIA can extend across state lines.

Figures 1 through 5 illustrate the process for defining the CIA. The two ground-water impact areas do not intersect (Fig. 4); therefore, there is no cumulative effect of mining on the groundwater system. However, impacted ground water would discharge to the receiving stream shared by the two anticipated mining operations. The surface-water system ties the two ground-water impact area together within the working CIA.

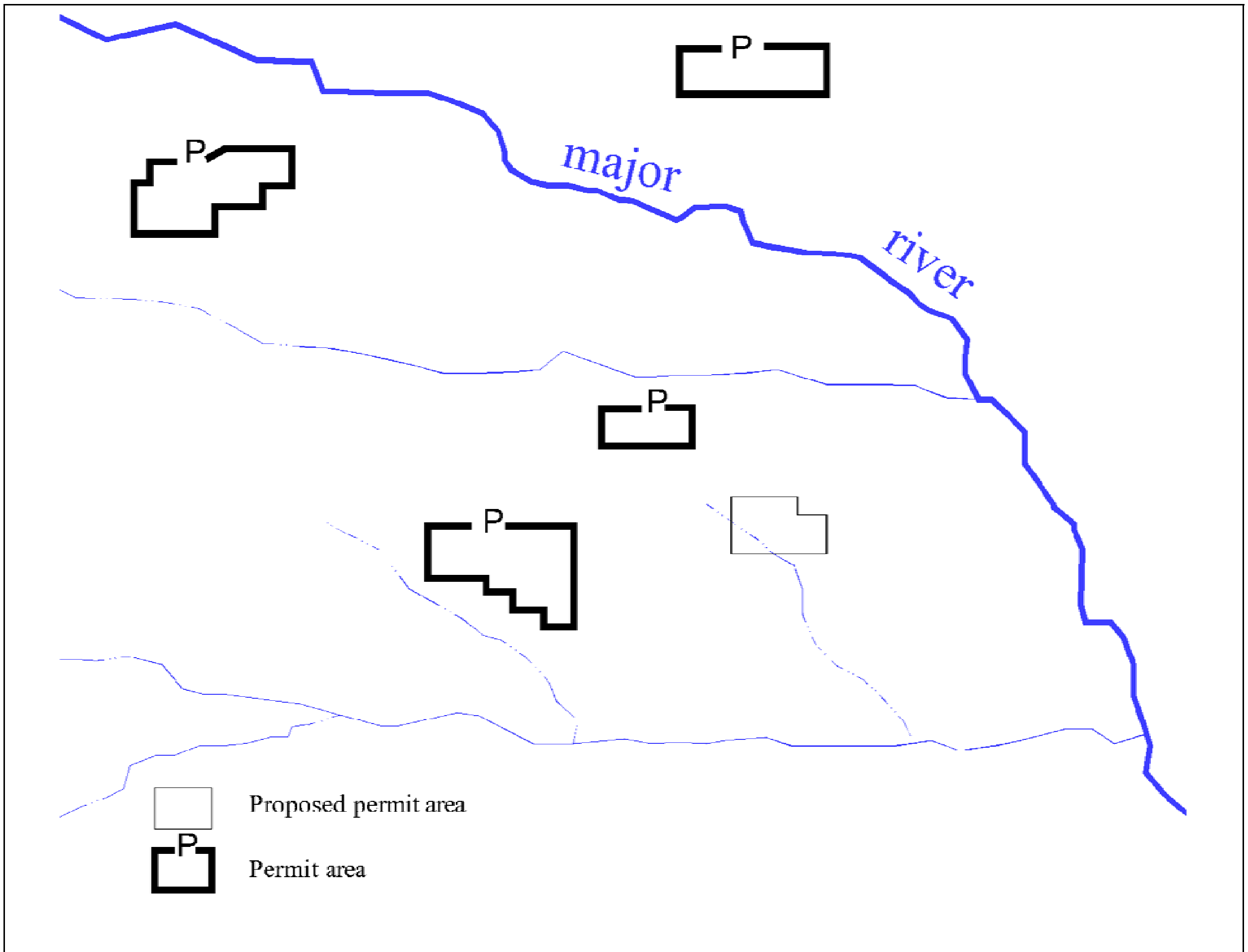

Figure 1 Proposed and existing mine permit areas.

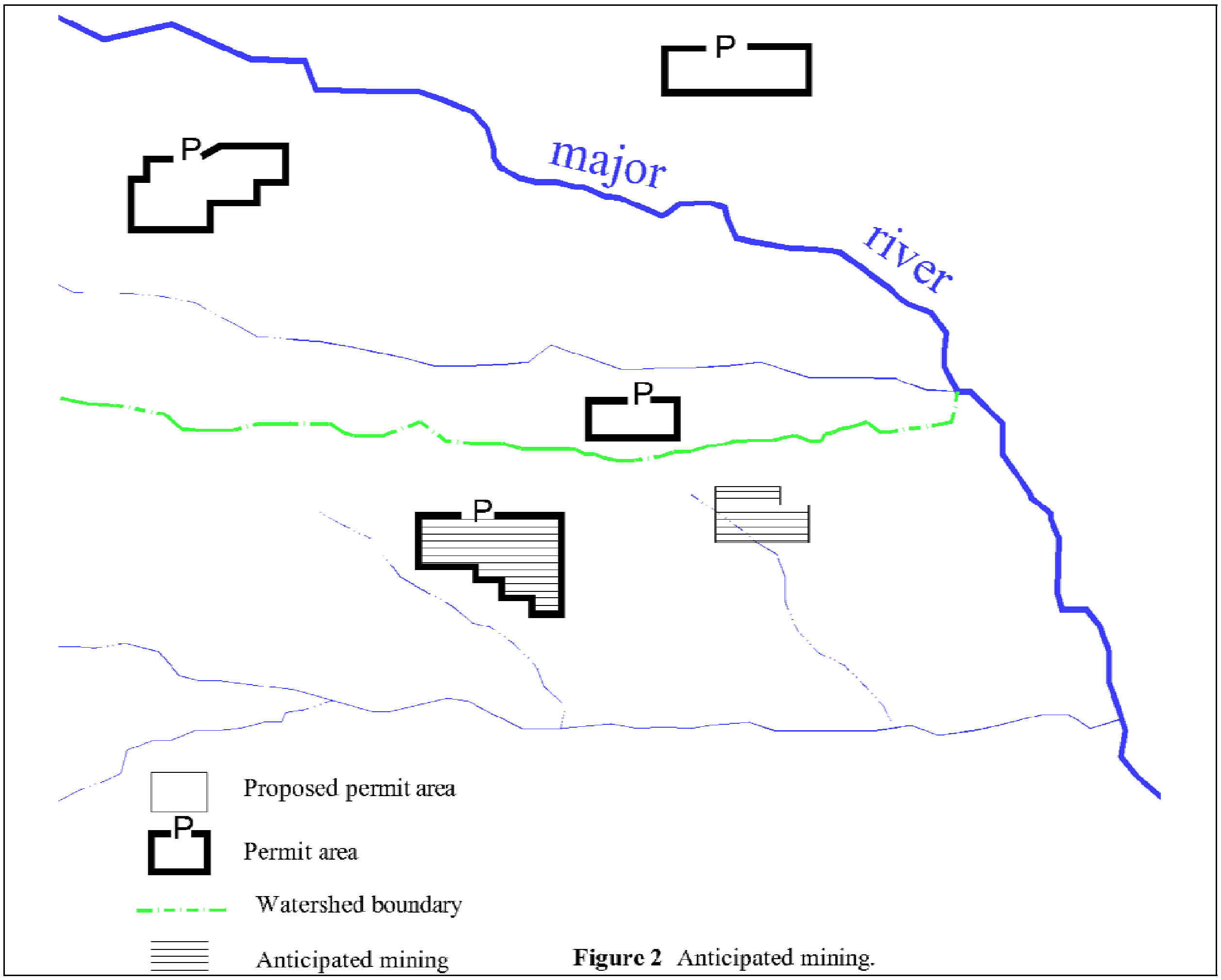

Figure 2 Anticipated mining.

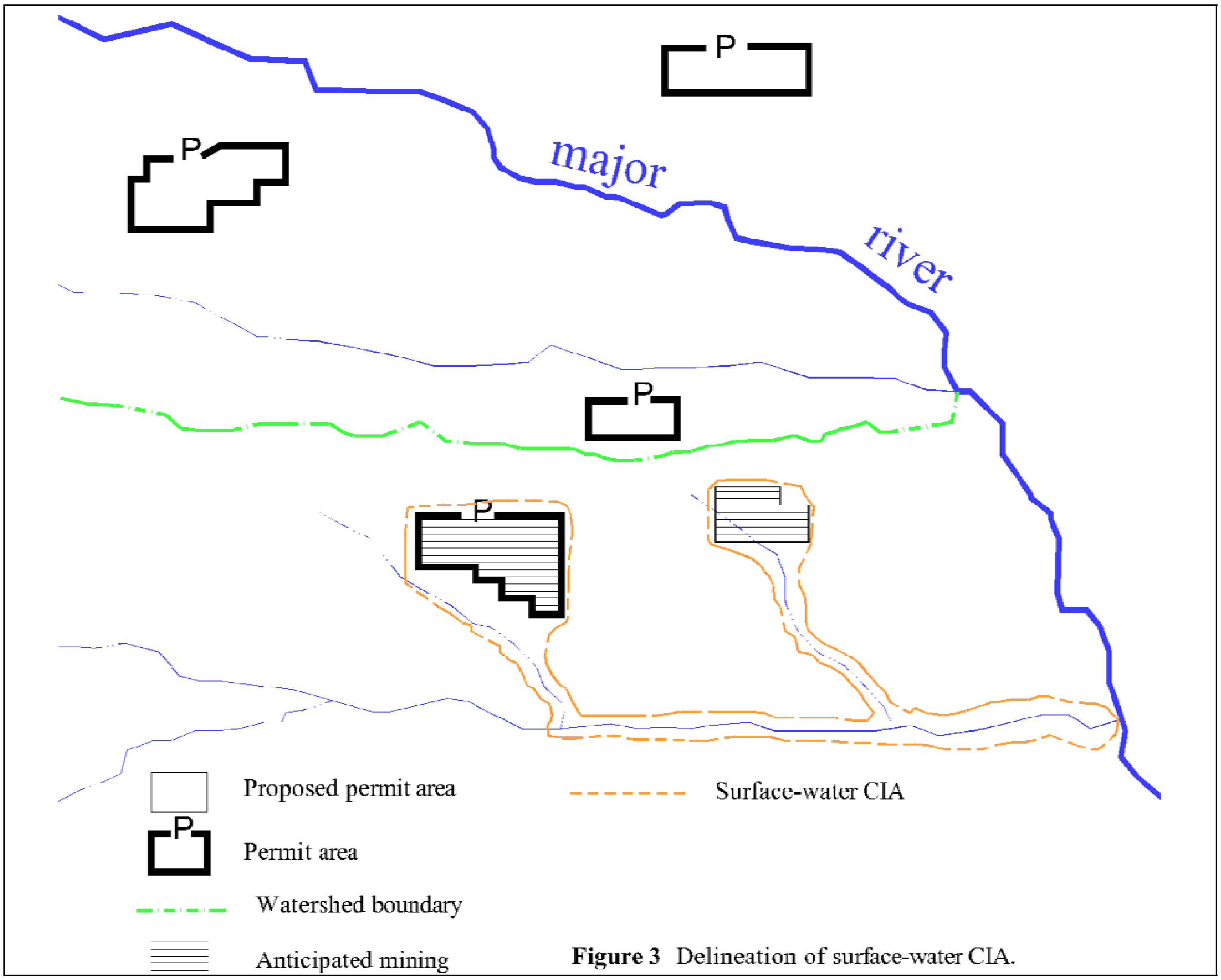

Figure 3 Delineation of surface-water CIA.

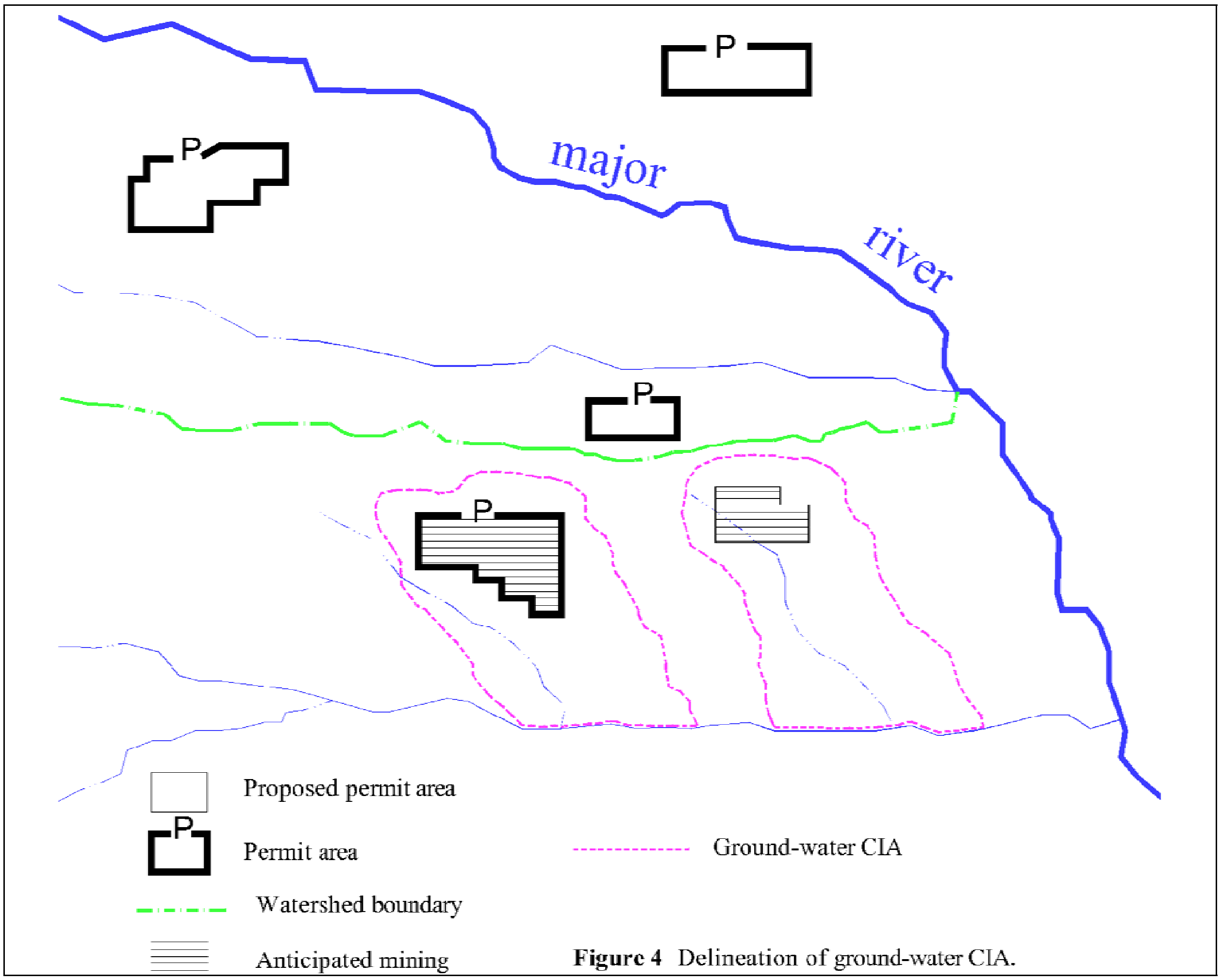

Figure 4 Delineation of ground-water CIA.

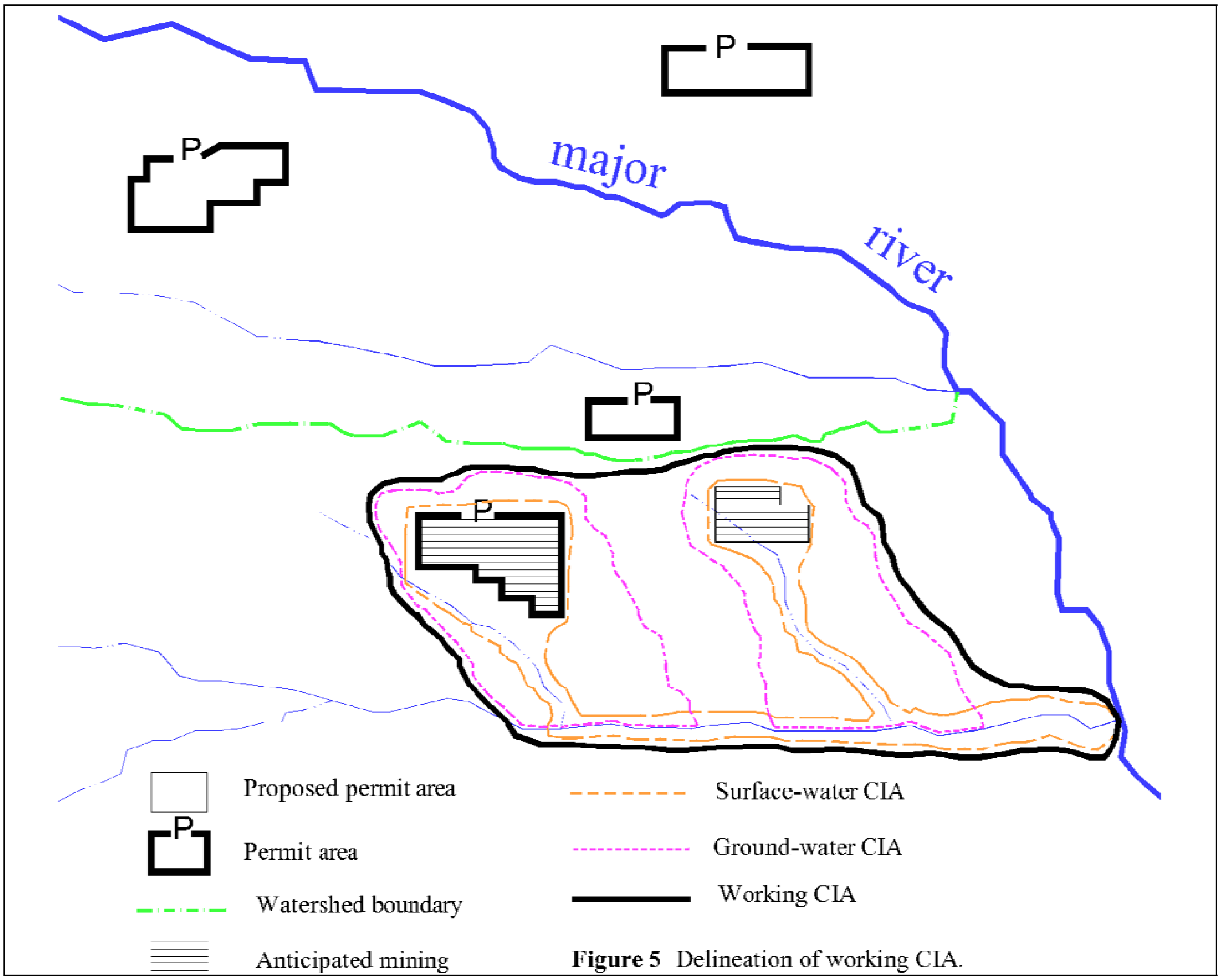

Figure 5 Delineation of working CIA.

Should the CIA of a mining operation cross into an adjoining state, it may be prudent for the regulatory authority writing the CHIA to provide notice of the CIA and impending permit action to relevant authorities in the adjoining state   Notification may result in a cooperative effort to ensure the mining activities do not have a cumulative adverse effect on water resources of each state's respective territory. Cooperation between the states may result in an exchange of experience and experts, as well as exchanges in information on water management regulations and guidelines. Communication may result in joint participation in scientific and specialist meetings and may lessen the possibility of future legal proceedings involving the coal-mine operation.

In those situations where there is a potential for a transborder hydrologic impact as a result of the proposed mining operation, the state regulatory authorities may want to consider committing themselves to the development of early detection schemes and relevant action plans. By working together, the states may be able to prevent or lessen the effect of the proposed operation on common water resources.

Quantitative Check of the Working CIA

A simplistic, qualitative consideration of dilution effect in the downstream direction could be a basis for identifying anticipated mining and estimating the surface-water CIA. The next step in the CHIA process would be to develop criteria for checking the validity of that estimate. By definition, a hydrologic impact is a *measurable* change. Quantitative criteria should specify the parameters to be evaluated and the associated ranges of measurement error.

Once developed, the criteria can be applied along receiving streams common to the proposed operation and other presumptive anticipated mining operations in its vicinity. Several points may be tested where more than one common stream originates in or flows through the working CIA. When appropriate, upstream as well as downstream evaluation points should be located. The downstream limit of the working CIA should be a point in the flow system below which impacts from designated anticipated mining, when added to those from mine operations outside the working CIA, would be less than the inherent error of the measurement techniques used.

Lumb (1982) gives a formula for estimating the concentration of an aqueous constituent at a given critical point in a drainage basin. Constituents that might be used in this mass-balance technique—for example, chloride, sulfate and TDS—would be treated as conservative solutes. Conservative solutes do not precipitate, react with sediments, or undergo biological decay. A mass-balance analysis requires some measured concentrations, and that may limit the choice of the solute. Chloride is a true conservative solute that is widely used in tracer studies, but it may not be as routinely measured in mid-continent coal-producing areas as sulfate or TDS. Sulfate is a quasi-conservative solute. It can exist at high concentration in stream water before it begins to be removed from solution by the precipitation of gypsum, a quite-soluble hydrous calcium-sulfate mineral. Barium sulfate and strontium sulfate are much less soluble than gypsum, but neither barium nor strontium is found in much abundance in natural waters (Fetter, 1993). Sulfate is derived from the oxidation of sulfide minerals and is a primary chemical constituent indicating coal-mine drainage. Consequently, coal regulations may require permittees to routinely monitor sulfate in streams and ground water. In addition, the NPDES permit may mandate regular measurement of sulfate in water running off the mine site.

Strictly speaking, TDS is not a solute, because it is the sum of all dissolved species. Some components of TDS such as heavy metals are themselves not conservative solutes, because they readily adsorb on sediment particles that may settle and not reach the downstream critical evaluation point. Nevertheless, because sulfate is probably the major component of TDS from coal field runoff, TDS may be considered a quasi-conservative solute.

Baseline Conditions

Baseline information characterizes the state of the hydrologic system before the proposed mine operation imposes any changes to that system. Much of the needed hydrologic and geologic information should be available in the permit application package. If anticipated mining includes existing operations, then the water–monitoring record for those operations becomes part of the baseline data set for the CHIA.

Minimum baseline surface-water information is an inventory of streams, lakes and impoundments in the proposed permit and adjacent areas with a description of the seasonal variability in flow rates, quality and usage of those water resources. Water quality is to be characterized by measurement of at least total suspended solids, TDS (or electrical conductivity corrected to 25ºC), pH, total iron, and total manganese. Baseline acidity and alkalinity information should be provided if there is a potential for acid drainage from the proposed mining operation.

At a minimum, baseline ground-water information should include a water-user survey which identifies the location and ownership of wells and springs within and adjacent to the proposed permit area and the approximate rates of usage or discharge of those ground-water resources. Minimum requirements also include seasonal measurements of depth-to-water in the coal seam and each water-bearing stratum above and potentially affected stratum below the coal seam. The permit application package is to contain data on the seasonal quality of water produced from these strata with that quality characterized by measurement of at least TDS (or electrical conductivity corrected to 25ºC) pH, total iron, and total manganese.

In the context of the CHIA, the term *adjacent area* means a zone extending out from the permit boundary where water resources are, or reasonably could be, expected to be adversely affected by mining operations (surface or underground) associated with that permit. The boundary of the water-user survey area coincides with the outside edge of the specified adjacent area (Fig. 6).

Some regulatory authorities may establish a single, fixed zone for all water-user surveys. That zone might coincide with the preblasting survey area which is located within one-half mile of any part of the permit boundary. Furthermore, a regulatory authority may choose to require a permit applicant to establish the baseline quality of impounded water or private well water within the survey zone and measure the productive capacity of those private wells. Water-user inventory information would be used to determine whether mining has adversely affected individual water supplies.

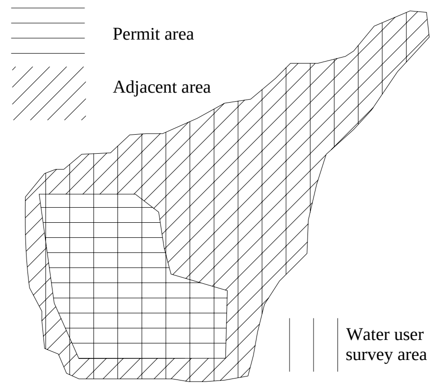

Figure 6 Relationship between permit area, adjacent area, and water-user survey area.

In-depth information about collecting, evaluating and using baseline water data in the permitting process can be found in *Permitting Hydrology, A Technical Reference Document for Determination of Probable Hydrologic Consequences (PHC) and Cumulative Hydrologic Assessment (CHIA)—Baseline Data* (OSM, 2002). This document covers a wide range of topics such as: geology, overburden analysis, quality assurance/quality control procedures, data management and analysis software, national data bases and it includes a mid-continent (Texas) site among its regional examples of baseline information.

Identification of Hydrologic Concerns
The regulatory authority must identify changes to hydrologic resources that could result from the proposed operation in conjunction with other anticipated mining operations and estimate the importance and likelihood of those changes. Hydrologic concerns are an expression of potential impacts related to water use, hydrologic balance and geomorphology. In order to judge the severity of potential problems, it is necessary to select measurable physical or chemical characteristics that relate to the specified problems. The regulatory authority will establish material damage criteria from among the hydrologic concerns.

Most concerns will be specified in the PHC portion of the permit application package. Others may be inferred from hydrologic characteristics of the permit and adjacent areas. Concerns grow out of a consideration for: (1) the location of the source of supply for all surface-water and ground-water uses, (2) the quantity and quality of water required to meet demands of the different uses, and (3) the susceptibility of land to erosion or burial under excess sediment. Publications of state agencies may provide information related to local or regional problems that could be applicable to specific concerns in the cumulative impact area. The regulatory authority should check for the presence of officially designated impaired streams (those qualifying under Section 303(d) of the Clean Water Act).

Section 303(d) of the Federal Clean Water Act (Title 33 Chapter 26 Subtitle III §1313(d)) requires states to identify waters that do not meet water quality standards after applying certain required technology-based effluent limits (*impaired* water bodies). States must compile this information in a list and submit the list to EPA for review and approval. As part of this listing process, states are required to rate waters/watersheds in order of priority for future development of total maximum daily loads (TMDLs). States have ongoing efforts to monitor and assess water quality, to prepare the Section 303(d) list and to subsequently develop TMDLs. A state's most recent 303(d) list can be found through www.epa.gov/OWOW/tmdl/.

Table 1 shows interrelationships between water use, hydrologic balance and geomorphic conditions. Hydrologic concerns may relate to more than one of the three factors. For example, flow rate applies to water availability, seasonal variation and channel erosion. Each factor should be considered separately. The regulatory authority's objective is to identify quantity and quality criteria that will protect water use, the hydrologic balance and maintain geomorphic stability.

Table 1 Potential hydrologic concerns as related to the cumulative impact area

WATER USE

1. Domestic
2. Agricultural
   a. Irrigation
   b. Livestock
3. Industrial
   a. Boiler/process
   b. Cooling
   c. Hydro power
4. Instream
   a. Aquatic life
   b. Recreation

CUMULATIVE IMPACT AREA HYDROLOGIC BALANCE

1. Base flow
2. Surface-water quantity
3. Surface-water quality
4. Ground-water quantity
5. Ground-water quality

GEOMORPHIC CONDITIONS

1. Upland erosion
2. Channel erosion
3. Excess sedimentation

HYDROLOGIC CONCERNS

1. **Quality** (both surface and ground water)
   a. pH, acidity/alkalinity
   b. Dissolved solids
   c. Sediment
   d. Temperature
   e. Toxic constituents
   f. Sodium adsorption ratio
   g. Odor, color, staining
2. **Quantity**
   a. Surface water
      1) Flow rate
      2) Volume
      3) Distribution
      4) Seasonal variation
   b. Ground water
      1) Transmissivity/hydraulic conductivity
      2) Potentiometric/water-table surface
      3) Direction of flow
      4) Recharge/discharge
3. **Geomorphology**
   a. Slope instability due to excess pore-water pressure
   b. Stream channelization—loss of meander pattern
   c. Pool-riffle ratio

Baseline data should identify water use in the permit and adjacent areas of each operation that qualifies as anticipated mining. Ideally, this should cover all land within the CIA where water resources are, or reasonably might be, adversely affected by surface- or underground-mining activity. As illustrated in Table 1, water use can be sorted into a number of categories. Agricultural water might be used for irrigation or livestock watering. Demand for irrigation water should peak about the same time throughout the CIA. If the balance between water supply and demand is tenuous under baseline conditions, then the regulatory authority should be concerned that any reduction in water availability that might result from the proposed operation could harm water users. Quality parameters for irrigation are usually TDS, sodium-adsorption ratio and concentration of potentially toxic constituents such as boron. The regulatory authority might find that crops typically grown in the CIA have particular sensitivity to other parameters. A high level of suspended solids and an objectionable taste, odor, or color can cause farm animals to drink less than they should. A state's university extension service should have guidance documents on water-quality criteria for livestock drinking. The U.S. EPA has set national drinking water standards for domestic water.

Primary standards are enforceable for public water systems; secondary standards are non-enforceable guidelines regarding contaminates that may cause cosmetic effects (skin or tooth discoloration) or aesthetic effects (taste, odor, or color). Constituents of concern in domestic water include: TDS, sulfates, nitrites, radioactivity, hardness, sediment, pH, Fe, Mn and bacterial quality. Usually mid-continent coal mining will not affect bacterial or radiological characteristics of water. Different water-quality criteria apply to different industrial uses for that water. An industrial use may be as process water in a manufacturing or food preparation operation, cooling or boiler-feed water, or hydro power. Quality criteria for industrial water are not necessarily less restrictive than those for drinking water. Instream use usually requires a certain minimum flow before adverse impacts occur. Temperature, pH, sediment load and solute concentrations may limit a stream's use for fish propagation. Suitable ranges of values are species dependent. Unique situations, such as the protection of endangered or threatened species and their habitats, may require other considerations as determined by the U.S. Fish and Wildlife Service. Boating and swimming are examples of recreational use. These activities could be restricted by water quantity changes and they require certain water chemistry for safe whole-body contact.

Hydrologic concerns vary across the eleven states of the Mid-Continent Region because of differences in precipitation amounts, temperature, water uses, geomorphic conditions and geology. Typical hydrologic concerns are listed below and include only some of the possibilities. At each specific site and CIA, the hydrologic concerns must be determined on the basis of water usage in the area, established water-quality standards and local hydrologic conditions.

1. Reductions in the quantity of available surface water and ground water may be critical, because existing supplies in the region are relatively scarce. Available supplies may be reduced as a result of changes in surface runoff conditions or lowering of ground-water levels.
2. Increases in TDS or sodium adsorption ratios in surface water or ground water may cause critical crop production losses where supplies are used for irrigation.
3. Increases in the concentration of total suspended solids may cause destruction of aquatic habitat or the loss of reservoir storage capacity due to siltation.
4. Changes in flow rates or suspended-solids load of a stream can change the erosional balance (down cutting of channels, silting up of pools and riffles or altering channel sinuosity).

5. Mine spoil or coal processing waste may release excessive concentrations of some chemical constituents into water supplies rendering the water unsuitable for industrial processes or harming aquatic organisms.
6. Changes in conditions affecting surface-water runoff may add to the flood hazard of a watershed.

Things other than regulated coal mining can stress the hydrologic system. Existing or potential sources of impacts within the CIA may include logging, agriculture, reservoir releases, oil and gas production activity, effluent from public or private sewage systems, landfills and non-coal mining operations (sand and gravel workings, rock quarries, etc.).

Establishing Material Damage Criteria

Section 510(b)(3) of SMCRA requires the regulatory authority to determine whether the proposed operation has been designed so that its impact on water resources, when combined with impacts from all other anticipated mining, will prevent material damage to the hydrologic balance outside the permit area. Neither SMCRA nor its enabling federal regulations define the term *material damage to the hydrologic balance.* Federal regulations at 30 CFR 701.5 define material damage in the context of subsidence, and these regulations go on to specifically tie the meaning of the expression *materially damage the quantity and quality of water* to alluvial valley floors. These definitions contain a key concept—material damage occurs when some customary or reasonably foreseeable use is denied or significantly degraded by the mining operation. Each Mid-Continent Region state may define the term *material damage to the hydrologic balance* as appropriate to that state. Nevertheless, one might declare the expression to mean any long-term or permanent change in the quantity or quality of surface or subsurface water caused by coal mining and reclamation operations that precludes customary or designated use for those affected water resources (as recognized by the regulatory authority) or that results in property damage, and such change can not be satisfactorily mitigated.

Mining may not only degrade the environment in terms of water use by people or fauna, but it may cause property damage by altering stream channel stability or peak-flow discharges. Material damage is too expensive to mitigate. Material damage implies that mining cannot proceed because the impact is deemed too severe. Examples of material damage are permanent destruction of a major regional aquifer and long-term contamination of an aquifer in use for which there is no suitable replacement water supply.

A measure of the severity of a mine’s affect on the environment might be the extent to which a given aspect of the hydrologic balance deviates from baseline conditions. This approach could rely on the calculation of a prediction interval; the width of the interval is a function of the variability and size of the baseline data set. The prediction interval estimates bounds on some future parameter, specifically the next k measurements from a given monitoring station. The number of future values, k, may be as small as one. Values measured after the baseline study period that fall outside the prediction interval indicate the baseline and post-baseline populations are statistically different at some specified level of confidence (often 95%) and that some activity in the CIA has affected the hydrologic balance. For water contaminants, comparison is usually made to the upper prediction limit. A future value above the upper prediction limit is taken to be statistically significant evidence of contamination. As few as four (eight or more is preferred) baseline values are needed to calculate the prediction interval. Baseline data must be normally distributed or able to be transformed into a normal distribution (e.g. taking the natural logarithm of each value). Non-parametric prediction intervals can be calculated for non-normally distributed data or data that includes a high proportion of nondetects, but more baseline values are needed than with the parametric method. See EPA, 1992 for a discussion of prediction intervals.

Statistically valid evidence of contamination does not prove material damage. Surface coal mining will likely add pollutants to local water resources, at least for the short term. The regulatory authority should establish material damage in terms of specified water uses. Material damage criteria based on water use should consider both in-stream and out-of-stream requirements. This means that water-contact recreation, fish habitat and the needs of aquatic organisms must receive equal consideration with industrial, domestic and agricultural uses.

The Clean Water Act (common name for the 1977 amendment to the Federal Water Pollution Control Act Amendments of 1972) established the basic structure for regulating the discharge of pollutants into waters of the United Sates. The Act also required states to set water quality standards for contaminants in surface water and, through implemented regulations, mandated that states develop an anti-degradation policy. The Federal Register, Vol. 48, No. 217, Tuesday, November 8, 1983, explains the anti-degradation policy and presents a three-tiered approach to maintaining and protecting various levels of water quality and uses. At its base (40 CFR 131.12(a)(1)) regulations require that existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected. The second level (§131.12(a)(2)) provides protection of actual water quality in areas where the quality of the water exceeds levels necessary to support propagation of fish, shellfish/wildlife and recreation in and on the water. Some limited water-quality degradation is allowed after extensive public involvement as long as the water quality remains adequate to fully protect existing uses. Finally, §131.23(a)(3) provides special protection of *outstanding National resource waters* for which ordinary use classification and water-quality criteria do not suffice. These include the highest quality waters of the United States, and those that are important, unique or sensitive ecologically but with existing water quality that may not be particularly high.

The anti-degradation policy <u>does not</u> prohibit any activity that would reduce water quality. Rather, the policy is directed against those activities that would partially or completely eliminate an existing water use. An existing use can be established by demonstrating that a use has actually occurred since November 28, 1975, or that the water quality is suitable to allow that use to occur.

Lumb (1982) recognized that the regulatory authority must determine material damage to the hydrologic balance by identifying water uses and the acceptable level of impact. He further recognized that numeric stream standards indirectly or directly relate to material damage, and one can compare these numbers to estimate conditions that might result from the proposed mine operation. The regulatory authority should include a rationale for each limit placed on a water quantity or quality characteristic beyond which, material damage may occur. This technical reference document makes no distinction among the terms *limit*, *criterion*, *standard*, and *threshold*.

Material damage criteria provide standards against which the regulatory authority compares predicted hydrologic impacts from anticipated mining. The comparison is made at some evaluation point that is sufficiently remote from the proposed operation so that it can also be measurably affected by all other anticipated mining but not so remote that effects from the proposed mine would be too slight to measure.

Multiple agencies within a state may have standards for attainment of specified-use water quality. EPA (1986) provides information on the toxic levels of many water-polluting substances relative to specific uses which is often mirrored in state standards. Counties and cities (especially the larger metropolitan areas) may also have their own water standards. Should a CIA cross a state line, the regulatory authority must set material damage thresholds that protect water uses in that neighboring state.

Specified water uses may include: aquatic life, human health for drinking water or fish consumption, recreation, industrial, livestock watering, and irrigation. Damage to the specified use occurs when a pollutant or condition has excessive concentration or magnitude, the duration of the harmful event is too long, and the frequency of the harmful event is too high. The regulatory authority may quantify possible mine-related changes in water characteristics in the CIA and compare those changes to established standards. But, the regulatory authority must always be mindful that a predicted exceedence in a criterion would not be considered material damage to the hydrologic balance unless the duration and frequency of the event will likely cause long-term denial or impairment of a specified or customary water use.

The regulatory authority should assemble existing standards that apply to the hydrologic resources of the CIA and determine which, if any, of the hydrologic concerns of the CHIA are not covered by those standards. Although material damage criteria may not be established for all the constituents of concern, water quality issues can generally be addressed with established standards. Indeed, the regulatory authority is more likely to confront a situation where standards are much more comprehensive than would apply to coal mines. For example, published standards typically include markers for biological contamination (fecal and coliform bacteria) and many organic compounds (pesticides, herbicides, solvents) plus a host of inorganic compounds for which there would neither be baseline data nor a requirement by the regulatory authority for coal permittees to systematically measure these solutes in the waters of the CIA. Should the proposed operation include a plan to deposit coal combustion by-products at the mine, however, the regulatory authority might have to set material damage criteria for a large suite of constituents.

Hydrologic concerns that are most likely to lack standards relate to ground water. In situations where the aquifer discharges into the surface stream system, the effects of this discharge on the quality of surface flows should be considered in developing material damage criteria for ground-water quality. Major concerns about the cumulative impacts of the mining on ground-water availability, on the other hand, tend to focus on pumping requirements and maintenance of baseflow to streams. Mining may draw down the potentiometric surface of aquifers near active workings. One may express material damage criteria for ground-water quantity in terms of changes in these water levels. Deleterious changes can also be in the opposite direction. High water tables can damage fields and pastures, flood basements or cause landslides when pore water pressure within slopes becomes excessive. Material damage criteria may need to address both increases and decreases in hydraulic head. The development of these criteria then becomes a matter of determining how much change in head can be sustained without rendering a water supply unusable or causing other environmental problems.

Geomorphic concerns are another area where the regulatory authority may find it difficult to set material damage criteria. Soil conservation agencies may have soil-loss guidelines the regulatory authority might cautiously adopt as material damage criteria. Upland erosion, per se, is not a hydrologic issue; the fouling of surface water with sediment from those areas is. Mines can alter stream flow which can affect streambed morphology by the loss, gain or displacement of pools and riffles. Sinuosity of the channel may also change to accommodate mine-related disturbance in the watershed. These disturbances can affect aquatic life which is an instream water use. One might be able to place a threshold on geomorphic changes above which material damage occurs, but the regulatory authority will have to predict the magnitude of a geomorphic response to some specified change in the hydrologic regime in order to test whether the proposed operation will cause material damage.

Analysis of Cumulative Hydrologic Impacts
The regulatory authority's task is to estimate the magnitude of change in indicator parameters that can be expected as a result of mining. Indicator parameters are those water-quality, water-quantity and perhaps geomorphic measures that have been assigned material damage criteria. Estimating future values of hydrologic parameters is uncertain at best, as is the task of clearly defining what constitutes material damage and what does not. One cannot be certain of the correctness of answers provided by hydrologic-estimating procedures. Also, different procedures may result in a range of values that straddle critical levels. Damage levels may cover ranges rather than be single, precise values. To make material damage determinations solely by comparing estimated values to single-value criteria ignores the natural variability of hydrologic processes.

Methods for predicting cumulative impacts may be either qualitative or based on empirical equations and statistical analyses. Qualitative methods rely heavily on the experience/training of the user and minimize the need for numerical calculations. A qualitatively defined material damage threshold requires a qualitative analysis of cumulative hydrologic impacts. Results are more general than those achieved through quantitative methods which require more data. Quantitative techniques may vary from fairly simple analyses to more intricate methods utilizing complex calculations or modeling. The regulatory authority should consider the accuracy needed for a particular impact analysis, the information available for the CIA and the time and resources available to do the analysis. Ultimately, only long-term monitoring is the test for the accuracy of any CHIA prediction.

Analysis of cumulative hydrologic impacts could be a three-step process: (1) selection of an analytical approach; (2) selection of the specific techniques and methodologies to be used; and (3) analysis. Two basic analytical approaches might apply to the CHIA. One approach is to combine estimated values of indicator parameters presented in the PHC portions of individual mine plans into composite impact values for the CIA. Use of this approach requires the regulatory authority to develop a PHC for any anticipated mining operation for which a PHC is not available. The other approach is to make an independent hydrologic analysis of the CIA using raw data provided in the permit application packages for anticipated mine operations, as well as pertinent data from post-baseline water monitoring reports for stations throughout the CIA. Among anticipated mining operations, different analysts perhaps using different sets of analytical techniques may have prepared the PHCs. Under the combinational approach, the actual summing of these PHC results to obtain the cumulative impacts would involve yet another set of techniques and another analyst (that is, the regulatory authority). Each analyst is likely to make assumptions about the hydrologic system. On the other hand, the independent analytical approach ensures the same evaluation techniques would be applied over the entire CIA by the same analyst.

After choosing an analytical approach, the regulatory authority selects suitable hydrologic estimation techniques in step two of the analysis process. The combination approach for some hydrologic parameters requires a procedure for compiling individual estimated values that goes beyond simple addition. For example, a discharge-weighted technique is needed to find the concentrations of solutes at different locations in the stream system.

Lumb(1982) provides guidance and examples for determining mining impacts. His mass-balance estimate is appropriate for solutes that are not likely to precipitate. Baseline or background concentrations of these solutes are needed for the general area—the surface- and ground-water basins potentially affected by the proposed operation. An estimate of solute concentrations is also needed for the proposed permit area. Estimates may be those given in the PHC or those independently made by the regulatory authority. The new concentration at some evaluation point (the critical point) is:

$$C_{nc} = \frac{Q_a C_a + Q_c[(A_c - A_a)/ A_c] C_g}{Q_a + Q_c[(A_c - A_a)/ A_c]}$$

Where:
C_{nc} = new concentration at the critical point,
C_g = concentration from the general area,
C_a = concentration from the anticipated mine area,
A_c = drainage area above the critical point
A_a = anticipated mine area in the drainage basin,
Q_a= average flow from the anticipated mining area in the drainage basin, and
Q_c = average flow at the critical point

Each state or larger subdivision of the Mid-Continent Region will have published equations for determining low, average and peak stream flows. For example, the U.S. Geological Survey has a series of open-file reports of water-resources investigations for the western interior coal province covering areas in Iowa, Kansas, Missouri, Oklahoma and Arkansas. See Appendix C of OSM (2002) for more information on these national coal area hydrology reports.

Under an independent analysis approach, the selected technique should adequately account for the dominant hydrologic processes occurring in the CIA. These processes define a real system and constitute the all-important conceptual hydrologic model. A step beyond the conceptual model is one that uses mathematical equations to simulate water flow or solute concentrations. The mass-balance estimate above is a simple model of that type. Other analytical models may be solved to find the area of drawdown from pit pumping. Equations governing the system processes in all but the simplest hydrologic systems are either too numerous or too complicated to be solved directly. Therefore, computers are needed to solve numerical models - those models that address complex boundary conditions or where the values of parameters vary within the area of interest. However, as the capability of the model increases, the required input data also increases. The regulatory authority may find the type of hydrologic information available or the distribution/density of the data sets is not appropriate for numerical modeling.

Every analytical or numerical model has a set of assumptions. Meeting those assumptions is extremely important to the validity of the output. A model can provide excellent results when assumptions are met and data sets are extensive enough to allow adequate calibration and verification of the model. Whatever techniques or combinations of techniques are selected, the analytical process should have the capability of predicting water quantity and quality changes under seasonal conditions. It should also have the capability of determining magnitudes of changes and of routing those changes through the system to the downgradient boundary of the CIA. The time span for the analysis period should cover the mining, reclamation and post-reclamation phases in order to determine the magnitude and timing of maximum impacts and the rates of recession from the maximum values.

The third step in the analysis of hydrologic impacts is to estimate the mine impacts using the chosen technique and comparing the results for each indicator parameter to the corresponding material-damage threshold. Any condition for comparison should be given as part of the identification of hydrologic concerns. For instance, the flow state under which the concentration of dissolved solids is to be evaluated should be part of the information that characterizes the concern for salt loading. The specific wording of these criteria becomes especially important when, with each additional mine, cumulative impact magnitudes approach critical levels. Material damage criteria and the estimated values for the indicator parameters should be stated in similar terms and units.

If an estimate indicates that material damage thresholds may be exceeded, the regulatory authority might re-evaluate the impact prediction procedures and make appropriate changes. For example, the regulatory authority may have initially assumed worst-case scenarios in which maximum impacts from all anticipated mining occur simultaneously. While this very conservative approach simplifies the estimation process and is a good way to begin, it would probably not be realistic. The regulatory authority could rerun the analysis to only estimate impacts from prospective mining operations (the proposed operation and any qualifying future operations). The balance of anticipated mining would be existing operations and the hydrologic impacts from these operations already accounted for in the background or baseline CIA conditions. A further refinement in the analysis would be to estimate impacts in light of the planned timing and sequence of land disturbance at the proposed mine. Such adjustments are acceptable and proper. However, it would be difficult for the regulatory authority to justify re-evaluations in which individual input parameter values are adjusted to obtain favorable output magnitudes.

If the impact estimate is positive (material damage to the hydrologic balance is probable), and the regulatory authority determines no further evaluation of the estimate is warranted, the positive finding is reported, granting of the permit is delayed and the CHIA process is finished for the time being. Mitigating actions by the company to further minimize impacts of the proposed mine would be handled outside the CHIA process as part of the overall permit processing procedure.

Statement of Findings

A regulatory authority's final act in the preparation of a CHIA is to write the statement of findings. The purpose of the CHIA is to determine whether the effects of the proposed operation, when added to those of existing or other anticipated mining operations, may cause material damage to the hydrologic balance outside the proposed permit area. Up to this point of preparing a statement of findings, the regulatory authority will have presented all pertinent information and will have qualitatively and quantitatively evaluated the information in a valid, defensible manner. The regulatory authority will have (1) provided information of a general nature that adds to the understanding of the situation and conditions dealt with in the CHIA such as why the CHIA is necessary; (2) specified anticipated mining; (3) delineated the cumulative impact area; (4) examined baseline water-monitoring data and PHC determination and found them adequate; (5) identified hydrologic concerns; (6) established material damage criteria; and (7) predicted cumulative hydrologic impacts and compared them to the material damage criteria. The regulatory authority will have provided supporting evidence and rationale for choices made along the process leading to the finding. The findings should explicitly affirm or negate that the proposed mining has been designed to prevent material damage to the hydrologic balance outside the permit area. Any special condition or stipulation that qualifies the finding must be stated as well.

An outline of suggested minimal requirements for CHIAs can be found in Appendix D.

POSTMINING HYDROLOGIC ASSESSMENT (PHA)

The term *postmining hydrologic assessment (PHA)* is not listed as an explicit heading in 30 CFR 780.21. Rather, the concept of the PHA can be inferred from the requirements found in 30 CFR 800.40(b)(1). These requirements specify that the regulatory authority must determine whether pollution of surface and subsurface water is occurring (or whether the probability of such occurrence exists) prior to release of the reclamation performance bond. An operator must have successfully completed coal mining and reclamation activities before the regulatory authority releases Phase III bond. One measure of this success is the mine's effect on the hydrologic balance - the relationship between the quantity and quality of water flowing into, stored within, and discharging from a hydrologic unit.

When considering a request for bond release (particularly a request for final bond release), the regulatory authority must conduct a PHA. The PHA is fundamentally a process of analyzing the water-monitoring record from the permit and surrounding area to determine if the mining operation affected the hydrologic balance of the area or caused material damage off the permitted site. Like the PHC and the CHIA, the PHA requires a clear understanding of the intended postmining water use. Ideally, the regulatory authority will have been regularly evaluating water data throughout the course of mining and reclamation operations. Disturbing hydrologic trends should have been addressed long before a permittee applies for final liability release. The occasion of writing a PHA is not the time for surprises!

Hydrologic Balance, Postreclamation

The permittee and regulatory authority must understand those elements of the mining environment that can adversely affect the hydrologic balance and, subsequently, impede the release of a reclamation bond. It is generally more cost effective and less complicated to address potential problems while actively mining rather than waiting until the reclamation or post-reclamation phase. Upfront preventive measures will pay enormous dividends once an area has been reclaimed and requested for liability release. It is not profitable for a permittee to have repeated enforcement actions or costly corrective maintenance work. Correspondingly, a regulatory authority would like to avoid seemingly endless inspections and associated paperwork or expensive litigation on what is, and should be, an essentially reclaimed site.

The regulatory authority should consider a number of questions about the hydrologic balance when determining whether bond should be released:

- Has the recharge capacity of the mine site been restored?
- Are post-reclamation water qualities, quantity, and flow rates significantly different from premining?
- Are there any trends in the water-monitoring record?
- Have there been any problems or complaints from water users?
- Have drainage issues been raised?
- Have any seeps developed?
- Is AMD present at the site?
- Have all monitoring wells (those installed by the operator and not transferred for domestic use) been properly plugged and abandoned?

As required by 30 CFR 816.41(b)(2), mining and reclamation activities for both surface and underground coal mines must be conducted so that the premining recharge capacity of the reclaimed area is restored. Restoration of recharge capacity does not mean that spoil has to be fully recharged before the permittee can be released from final reclamation liability. Minesite conditions, both at the surface and in the subsurface, must be conducive to establishing some underground water-bearing potential provided that condition existed prior to mining. Runoff from the postreclamation site is often managed in such a way as to aid in ground-water recharge provided the HRP does not require the recharge to be limited or restricted (i.e. because of potentially acid- or toxic-forming materials). The regulatory authority may evaluate whether recharge capacity has been restored by tracking water level changes in spoil wells and/or monitoring wells and private wells adjacent to the reclaimed area.

The water-monitoring record consists of two temporal phases: baseline and everything after baseline until final liability release (the latter could be referred to as the operations phase). The regulatory authority might subdivide the postbaseline phase into the period of active coal removal/reclamation and the post-reclamation time when mine activity is limited to maintenance work. Data review should include the records for upstream/upgradient and downstream/downgradient monitoring stations to evaluate the quality and quantity of water entering as well as exiting the site.

As illustrated in Figure 7, a regulatory authority must consider whether water currently on or leaving the mine site is of acceptable quality prior to releasing bond. One can consider current water quality as that characterized by the most recently analyzed samples. For example, the set might be the last eight samples. Monitoring frequency will then define the word *current* in terms of a specific time period. The regulatory authority should avoid choosing only the most recent sample to represent current conditions because of naturally variable water chemistry.

For a given monitoring station, the regulatory authority may statistically compare some measure of central tendency (the mean or median) of baseline data to that of data collected during mining and reclamation. In addition, the data should also be evaluated for trends. The water-monitoring record also lends itself to statistical analysis that looks for changes with distance. Comparisons of central tendency can be made between upstream and downstream stations or upgradient and downgradient wells. The regulatory authority could use nonparametric statistical tests (Mann-Whitney W for comparison of medians and Kendall Tau for trend tests). When permanent impoundments are in the proposed release area, the regulatory authority should review the NPDES monitoring record for that water body, assuming the principal spillway is an NPDES outfall.

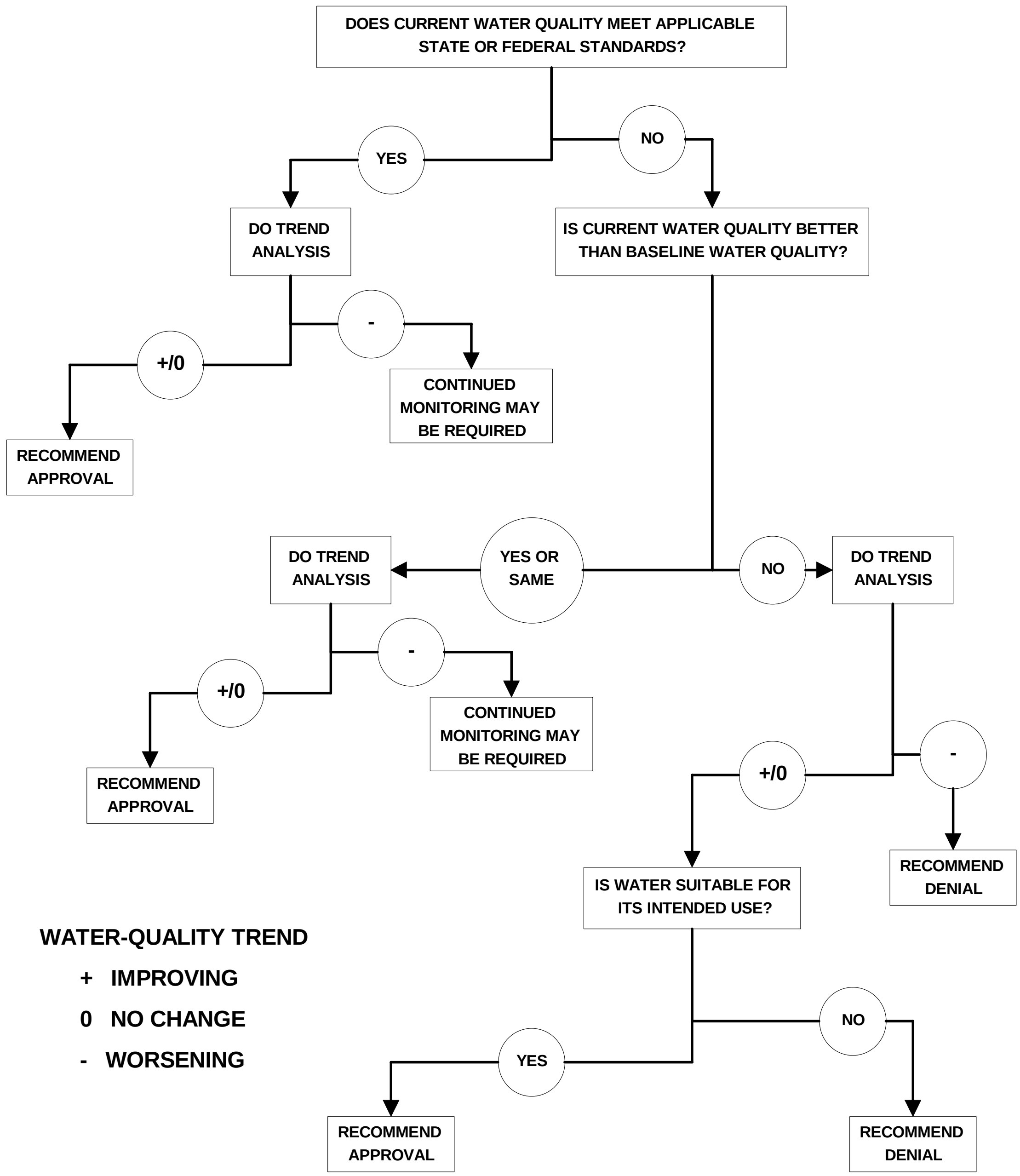

Figure 7 Decision flow chart for water-quality consideration of the postmining hydrologic assessment.

The regulatory authority should be mindful of a potential bond-release scenario in which the permittee divides a large area into small parcels which, in turn, are submitted for liability release one by one. An individual parcel targeted for release might not be hydrologically related to a monitoring well and only remotely associated with established stream stations. How then would the regulatory authority avoid having to assert in a PHA for each such small parcel that there is simply insufficient data to determine whether the permittee's operations on that particular tract had affected water resources as monitored over a much larger area? Pursuing bond release in a piecemeal fashion, a permittee could seemingly whittle reclamation liability down to nothing even though the water record indicates mining-related problems.

An outline of suggested minimal requirements for the PHA can be found in Appendix E.

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Appendix A

GLOSSARY OF WATER-RELATED WORDS*

A–Horizon — The uppermost zone in the *Soil Profile*, from which soluble *Salts* and *Colloids* are leached, and in which organic matter has accumulated. Generally this represents the most fertile soil layer and constitutes part of the *Zone of Eluviation*.

Abandoned Well — A well which is no longer used or a well removed from service; a well whose use has been permanently discontinued or which is in a state of such disrepair that it cannot be used for its intended purpose. Generally, abandoned wells will be filled with concrete or cement grout to protect underground water from waste and contamination.

Abatement — Reducing the degree or intensity of, or eliminating, pollution, as a water pollution abatement program.

Abrasion — Removal of stream-bank soil as a result of sediment-laden water, ice, or debris rubbing against the bank.

Absolute Humidity — The actual weight of water vapor contained in a unit volume of the atmosphere, usually expressed in grams of water per kilogram of air. Compare to *Relative Humidity*.

Absorption — (1) The entrance of water into the soil or rocks by all natural processes, including the infiltration of precipitation or snowmelt, gravity flow of streams into the valley alluvium into sinkholes or other large openings, and the movement of atmospheric moisture. (2) The uptake of water or dissolved chemicals by a cell or an organism (as tree roots absorb dissolved nutrients in soil). (3) More generally, the process by which substances in gaseous, liquid, or solid form dissolve or mix with other substances. Not to be confused with *Adsorption*.

Absorption Loss — The loss of water by *Infiltration* or *Seepage* into the soil during the process of priming, i.e., during the initial irrigation of a field; generally expressed as flow volume per unit of time.

Accretion — The slow addition to land by deposition of water-borne sediment. An increase in land along the shores of a body of water, as by *alluvial* deposit.

Acid — (1) Chemicals that release hydrogen ions (H^+) in solution and produce hydronium ions ($H3O^+$). Such solutions have a sour taste, neutralize bases, and conduct electricity. (2) Term applied to water with a pH of less than 7.0 on a pH scale of 0 to 14.

Acid-Forming Material — Material containing sulfide minerals or other materials, which if exposed to air, water, or weathering processes will form sulfuric acid that may create *Acid Mine Drainage*.

Acid Mine Drainage (AMD) — Acidic water that flows into streams from abandoned mines or piles of mining waste or tailings. The acid arises from the oxidation of iron sulfide compounds in the mines by air, dissolved oxygen in the water, and chemoautotrophs, which are bacteria that can use the iron sulfide as an energy source. Iron sulfide oxidation products include sulfuric acid, the presence of which has reduced or eliminated aquatic life in many streams in mining regions. Also see *Open-Pit Mining* and *Yellowboy*. Also referred to as *Acid Mine Waste*.

Acid Neutralizing Capacity (ANC) — (1) A measure of the ability of water or soil to resist changes in pH. (2) The equivalent sum of all bases or base-producing materials, solutes plus particulates, in an aqueous system that can be titrated with acid to an equivalence point. The term designates titration of an *unfiltered* sample (formerly reported as alkalinity).

Acid Rain — Rainfall with a pH of less than 7.0. One of the principle sources is the combining of rain (H2O) and sulfur dioxide (SO2), nitrous oxides (NOx), and carbon dioxide (CO2) emissions which are byproducts of the combustion of fossil fuels. These oxides react with the water to form sulfuric (H2SO4), nitric (HNO3), and carbonic acids (H2CO3). Long-term deposition of these acids is linked to adverse effects on aquatic organisms and plant life in areas with poor neutralizing (buffering) capacity. Also see *Acid Deposition*.

Acid Soil (Alkaline Soil, Neutral Soil) — A description of one aspect of a soil's chemical composition. Many plants will grow best within a range of pH rating from slightly acid to slightly alkaline. A pH rating of 7 means that the soil is neutral; a pH below 7 indicates acidity; a pH above 7 indicates alkalinity.

Acidic — The condition of water or soil that contains a sufficient amount of acid substances to lower the pH below 7.0.

Acidity — A measure of how acid a solution may be. A solution with a pH of less than 7.0 is considered acidic. Solutions with a pH of less than 4.5 contain mineral acidity (due to strong inorganic acids), while a solution having a pH greater than 8.3 contains no acidity.

Active Fault — A fault that has undergone movement in recent geologic time (the last 10,000 years) and may be subject to future movement. Also see *Fault*.

Active Storage Capacity — (1) The total amount of usable reservoir capacity available for seasonal or cyclic water storage. It is gross reservoir capacity minus inactive storage capacity. (2) More specifically, the volume of water in a reservoir below the maximum controllable level and above the minimum controllable level that can be released under gravity. In general, it is the volume of water between the outlet works and the spillway crest. In some instances, *Minimum Pool* operating constraints may prevent lowering the reservoir to the level of the outlet works, and the water below the minimum pool level is not considered to be in active storage.

Adhesion — Molecular attraction that holds the surfaces of two substances in contact, such as water and rock particles. Also, the attraction of water molecules to other materials as a result of hydrogen bonding.

Adiabatic — Applies to a thermodynamic process during which no heat is added to or withdrawn from the body or system concerned. In the atmosphere, adiabatic changes of temperature occur only in consequence of compression or expansion accompanying an increase or decrease of atmospheric pressure. Thus, a descending body of air undergoes compression and adiabatic cooling.

Adiabatic Lapse Rate — The theoretical rate at which the temperature of the air changes with altitude. The temperature change is due to the pressure drop and gas expansion only, and no heat is considered to be exchanged with the surrounding air through convection or mixing. The *Dry Adiabatic Lapse Rate* for air not saturated with water vapor is 0.98EC per 100 meters (5.4EF per 1,000 feet). The *Wet Adiabatic Lapse Rate* for air saturated with water vapor is about 0.60EC per 100 meters (3.3EF per 1,000 feet).

Adit — A horizontal or nearly horizontal passage, driven from the surface, for the working or dewatering of a mine. Also referred to as *Drift*, *Shaft*, or *Portal*.

Adjudication — (1) Refers to a judicial process whereby water rights are determined or decreed by a court of law. (2) A court proceeding to determine all rights to the use of water on a particular stream system or within a specific ground water basin.

Adsorption — (1) The adherence of ions or molecules in solution to the surface of solids. (2) The adherence of a gas, liquid, or dissolved material on the surface of a solid. (3) The attraction and adhesion of a layer of ions from an aqueous solution to the solid mineral surfaces with which it is in contact. An example is the adsorption of organic materials by activated carbon. Not to be confused with *Absorption*.

Adsorption Isotherm - the graphical representation of the relationship between the solute concentration and the mass of the solute species adsorbed on the aquifer sediment or rock.

Advection — (1) The process by which solutes are transported by the bulk of flowing fluid such as the flowing ground water. (2) The horizontal transfer of heat energy by large-scale motions of the atmosphere.

Aeolian Soil — Soil transported from one area to another by the wind.

Aeration (Unsaturated) Zone — The zone between the land surface and the water table which characteristically contains liquid water under less than atmospheric pressure and water vapor and air or other gases at atmospheric pressure. The term *Unsaturated Zone* is now generally applied.

Aerobic — Characterizing organisms able to live only in the presence of air or free oxygen, and conditions that exist only in the presence of air or free oxygen. Contrast with *Anaerobic*.

Aerobic Bacteria — Single-celled, microscopic organisms that require oxygen to live and are partly responsible for the *Aerobic Decomposition* of organic wastes.

Aerobic Decomposition — The biodegradation of materials by aerobic microorganisms resulting in the production of carbon dioxide, water, and other mineral products. Generally a faster process than *Anaerobic Decomposition*. Also see *Aerobic Bacteria*.

Aerobic Treatment — The process by which microbes decompose complex organic compounds in the presence of oxygen and use the liberated energy for reproduction and growth. Such processes may include extended aeration, trickling filtration, and rotating biological contactors.

Affected Environment — (1) Existing biological, physical, social and economic conditions of an area subject to change, both directly and indirectly, as the result of a proposed human action. (2) The chapter in an Environmental Impact Statement (EIS) describing current environmental conditions.

Affluent (Stream) — A stream or river that flows into a larger one; a *Tributary*.
Age (of Ground water) — An approximation of the time between the water's penetration of the land surface at one location and its later presence at another location.

Agglomeration — (Water Quality) The grouping of small suspended particles into larger particles that are more easily removed through filtration, skimming, or settling. Also see *Coagulation*.

Aggradation — (1) The raising of stream beds or flood plains by deposition of sediment eroded and transported from upstream. (2) The build-up of sediments at the headwaters of a lake or reservoir or at a point where stream flow slows to the point that it will drop part or its entire sediment load. (3) The building of a floodplain by sediment deposition; the filling of a depression or drainage way with sediment; the building of a fan by deposition of an alluvial mantle. (4) Modification of the earth's surface in the direction of uniformity of grade or slope, by *Deposition*, as in a river bed. Opposite of *Degradation*.

Aggrade — The raising of a stream-channel bed with time due to the *Deposition* of sediment that was eroded and transported from the upstream watershed or the channel.

Aggrading — The building up of a stream channel which is flowing too slowly to carry its sediment load.

Air Injection — In ground water management, the pumping of compressed air into the soil to move water in the *Unsaturated Zone* (*Vadose Zone*) down to the *Saturated Zone* (*Phreatic Zone*), or *Water Table*.

Algae — Simple single-celled, colonial, or multi-celled, mostly aquatic plants, containing chlorophyll and lacking roots, stems and leaves. Aquatic algae are microscopic plants that grow in sunlit water that contains phosphates, nitrates, and other nutrients. Algae, like all aquatic plants, add oxygen to the water and are important in the fish food chain.

Algal Bloom — (1) Rapid growth of algae on the surface of lakes, streams, or ponds; stimulated by nutrient enrichment. (2) A heavy growth of algae in and on a body of water as a result of high phosphate concentration such as from farm fertilizers and detergents. It is associated with *Eutrophication* and results in a deterioration in water quality. Also spelled *Algae Bloom*.

Algorithm — A series of well-defined steps used in carrying out a specific process. May be in the form of a word description, an explanatory note, a diagram or labeled flow chart, or a series of mathematical equations.

Alkali — Any strongly basic (high pH) substance capable of neutralizing an acid, such as soda, potash, etc., that is soluble in water and increases the pH of a solution greater than 7.0. Also refers to soluble salts in soil, surface water, or ground water.

Alkaline — Sometimes water or soils contain an amount of *Alkali* substances sufficient to raise the pH value above 7.0 and be harmful to the growth of crops. Generally, the term alkaline is applied to water with a pH greater than 7.4.

Alkalinity — (1) Refers to the extent to which water or soils contain soluble mineral salts. Waters with a pH greater than 7.4 are considered alkaline. (2) The capacity of water for neutralizing an acid solution. Alkalinity of natural waters is due primarily to the presence of hydroxides, bicarbonates, carbonates and occasionally borates, silicates and phosphates. It is expressed in units of milligrams per liter (mg/l) of $CaCO_3$ (calcium carbonate). A solution having a pH below 4.5 contains no alkalinity.

Allochthonous Material — Organic material that falls into a stream from the surrounding land. Compare to *Autochthonous Material*.

Alluvial — (1) Pertaining to processes or materials associated with transportation or deposition by running water. (2) Pertaining to or composed of *alluvium*, or deposited by a stream or running water. (3) An adjective referring to soil or earth material which has been deposited by running water, as in a riverbed, flood plain, or delta.

Alluvion — (1) The flow of water against a shore or bank. Inundation by water; flood. (2) (Legal) The increasing of land area along a shore by deposited *Alluvium* or by the recession of water.

Alluvium — (1) A general term for deposits of clay, silt, sand, gravel, or other particulate material that has been deposited by a stream or other body of running water in a streambed, on a flood plain, on a delta, or at the base of a mountain. (2) A general term for such unconsolidated detrital material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or its flood plain or delta, or as a cone or fan at the base of a mountain slope; especially such a deposit of fine-grained texture (silt or silty clay) deposited during time of flood. Also see *Alluvion*.

Alternatives — Courses of action which may meet the objectives of a proposal at varying levels of accomplishment, including the most likely future conditions without the project or action.

Altitude — The vertical distance of a level, a point, or an object considered as a point, measured from *Mean Sea Level (MSL)*.

Ambient Water Quality Standards — The allowable amount of materials, as a concentration of pollutants, in water. The standard is set to protect against anticipated adverse effects on human health or welfare, wildlife, or the environment, with a margin of safety in the case of human health.

Amictic Lake — A lake that does not experience mixing or turnover on a seasonal basis. Also see *Dimictic Lake*.

Anabranch — A diverging branch of a river which re-enters the main stream.

Anaerobe — An organism that does not require oxygen to maintain its life processes.

Anaerobic — Characterizing organisms able to live and grow only where there is no air or free oxygen, and conditions that exist only in the absence of air or free oxygen.

Anaerobic Decomposition — The degradation of materials by *Anaerobic* microorganisms living beneath the ground or in oxygen-depleted water to form reduced compounds such as methane or hydrogen sulfide. Generally a slower process than *Aerobic Decomposition*.

Analog — A continuously variable electrical signal representing a measured quantity. For example, electrical signals such as current, voltage, frequency, or phase used to represent physical quantities such as water level, flow, and gate position.

Analytical Model — A model that provides approximate or exact solutions to simplified forms of the differential equations for water movement and solute transport. Such models generally require the use of complex calculations and the use of computers.

Anastomosing — The branching and rejoining of channels to form a netlike pattern.

Anhydride — A chemical compound formed from another, often an acid, by the removal of water.

Anhydrous — Without water, especially water of crystallization; not hydrated (*Dehydrated*).

Anion — In an electrolyzed solution, the negatively charged particle, or ion, which travels to the anode and is therefore discharged, evolved, or deposited. Also, by extension, any negative ion.

Anisotropy — (1) The condition of having different properties in different directions. (2) The condition under which one or more of the hydraulic properties of an aquifer vary according to the direction of the flow.

Annular Space — The space between two cylindrical objects, one of which surrounds the other, such as the space between the wall of the drilled hole and the casing, or between a permanent casing and the borehole.

Annulus — For a well, the space between the pipe and the outer wall (casing) of the borehole, which may be a pipe also (the well casing).

Anoxia — (1) Absence of oxygen. (2) The total deprivation of oxygen, as in bodies of water, lake sediments, or sewage.

Anoxic — (1) Denotes the absence of oxygen, as in a body of water. (2) Of, relating to, or affected with anoxia; greatly deficient in oxygen; oxygenless as with water.

Antecedent Streams — Antecedent streams are those in place before the rising of mountain chains. As the mountains rise, the streams cut through at the same rate and so maintain their positions.

Antidegradation Policy (or Clause) — Rules or guidelines that are required of each state by federal regulations implementing the *Clean Water Act (CWA),* stating that existing water quality be maintained even if the current water quality in an area is higher than the minimum permitted as defined by federal ambient water quality standards. Some controlled degradation is permitted in support of economic development.

Approximate Original Contour — The surface configuration achieved by backfilling and grading of mined areas so that the reclaimed area, including any terracing or access roads, closely resembles the general surface configuration of the land prior to strip mining and blends into and complements the drainage pattern of the surrounding terrain.

Aquatic — (1) Consisting of, relating to, or being in water; living or growing in, on, or near the water. (2) Taking place in or on the water. (3) An organism that lives in, on, or near the water.

Aquatic Life — All forms of living things found in water, ranging from bacteria to fish and rooted plants. Insect larva and zooplankton are also included.

Aqueous — (1) Relating to, similar to, containing, or dissolved in water; watery. (2) (Geology) Formed from matter deposited by water, as certain sedimentary rocks.

Aquiclude (Confining Bed) — A formation which, although porous and capable of absorbing water slowly, will not transmit water fast enough to furnish an appreciable supply for a well or spring. Aquicludes are characterized by very low values of *leakage* (the ratio of vertical *Hydraulic Conductivity* to thickness), so that they transmit only minor inter-aquifer flow and also have very low rates of yield from compressible storage. Therefore, they constitute boundaries of aquifer flow systems.

Aquifer — (1) A geologic formation, a group of formations, or a part of a formation that is water bearing. (2) A geological formation or structure that stores or transmits water, or both, such as to wells and springs. (3) An underground layer of porous rock, sand, or gravel containing large amounts of water. Use of the term is usually restricted to those water-bearing structures capable of yielding water in sufficient quantity to constitute a usable supply. (4) A sand, gravel, or rock formation capable of storing or conveying water below the surface of the land. (5) A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Aquifer, Basin-Fill — An aquifer located in a basin surrounded by mountains and composed of sediments and debris shed from those mountains. Sediments are typically sand and gravel with some clay.

Aquifer Compaction — Term used to describe the effects of emptying or overdrawing an aquifer; overdrafts tend to collapse the structure of the aquifer such that the original volume cannot be restored. May also be associated with a general *Land Subsidence* in the surrounding ground level as the result of such compaction.

Aquifer, Confined — An aquifer which is bounded above and below by formations of impermeable or relatively impermeable material. An aquifer in which ground water is under pressure significantly greater than atmospheric and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the aquifer itself. See *Artesian Aquifer*.

Aquifer, Fractured Bedrock — An aquifer composed of solid rock, but where most water flows through cracks and fractures in the rock instead of through pore spaces. Flow through fractured rock is typically relatively fast.

Aquifer, Leaky (Semi-Confined) — An aquifer overlaid and/or underlain by a thin semipervious layer through which flow into or out of the aquifer can take place.

Aquifer, Perched — A ground water unit, generally of moderate dimensions, that occurs whenever a ground water body is separated from the main ground water supply by a relatively impermeable stratum and by the *Zone of Aeration* above the main water body.

Aquifer, Saline/Poor Quality — An aquifer containing water that is high in total dissolved solids, and is unacceptable for use as drinking water.

Aquifer, Sandstone — The type of aquifer supplying ground water to large parts of the United States upper Middle West, Appalachia, and Texas. The water-bearing formation is often contained by shale strata, and the water has high levels of iron and magnesium.

Aquifer System — A body of permeable and relatively impermeable materials that functions regionally as a water-yielding unit. It comprises two or more permeable units separated at least locally by confining units (*Aquitards*) that impede ground-water movement but do not greatly affect the regional hydraulic continuity of the system. The permeable materials can include both saturated and unsaturated sections.

Aquifer Test — A test to determine hydrologic properties of an aquifer, involving the withdrawal of measured quantities of water from, or the addition of water to, a well and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition (recharge).

Aquifer, Unconfined — An *Aquifer* made up of loose material, such as sand or gravel, that has not undergone lithification (settling). In an unconfined aquifer the upper boundary is the top of the *Zone of Saturation* (water table).

Aquifuse — A formation that has no interconnected openings and hence cannot absorb or transmit water.

Aquitard — A saturated, but poorly permeable bed that impedes ground-water movement and does not yield water freely to wells, but which may transmit appreciable water to or from adjacent aquifers and, where sufficiently thick, may constitute an important ground-water storage unit. Aquitards are characterized by values of leakance that may range from relatively low to relatively high. Areally extensive aquitards of relatively low leakance may function regionally as boundaries of aquifer flow systems.

Area of Influence of a Well - the area surrounding a well over which the potentiometric surface has changed as the result of pumping ground water from or recharging ground water to an aquifer. Same as Zone of Influence. This is not to be confused with the Capture area of a well.

Argillic Alteration (Argillization) — A form of *Hydrothermal* alteration in which certain minerals of rock are converted to clay minerals.

Armor — To protect fill slopes, such as the sides of a levee, by covering them with erosion-resistant materials such as rock or concrete.

Armoring — (1) Formation of a layer of rocks on the surface of a streambed that resists erosion by water flows. The rocks can be naturally occurring, caused by the scour of smaller particles from high discharges, or placed by humans to stop channel erosion. (2) A facing layer (protective cover), or *Rip Rap*, consisting of very large stones placed to prevent erosion or the sloughing off of a structure or embankment. Also, a layer of large stones, broken rocks or boulders, or precast blocks placed in random fashion on the upstream slope of an *Embankment Dam*, on a reservoir shore, or on the sides of a channel as a protection against waves, ice action, and flowing water. The term armoring generally refers only to very large rip rap. (3) Armoring of limestone is a common cause of failure in limestone-based systems for treatment of acid mine drainage. Armoring occurs when acid mine drainage sludge or 'yellowboy' coats rocks and fills in the pore spaces in streambeds. For flow-through passive treatment systems, iron hydrolysis and precipitation reactions coat the limestone resulting in less surface area available for limestone dissolution.

(United States) Army Corps of Engineers (Corps or COE) — Originally formed in 1775 during the Revolutionary War by General George Washington as the engineering and construction arm of the Continental Army. Initially, the Corps of Engineers built fortifications and coastal batteries to strengthen the country's defenses and went on to found the Military Academy at West Point, help open the West, and to develop the nation's water resources. In its military role, the COE plans, designs, and supervises the construction of facilities to insure the combat readiness of the U.S. Army and Air Forces. In its civilian role, the COE has planned and executed national programs for navigation and commerce, flood control, water supply, hydroelectric power generation, recreation, conservation, and preservation of the environment. In a very general sense, the U.S. Army Corps of Engineers has a primary responsibility for water projects which protect property from potential flood damage, whereas the (U.S. Department of the Interior) *Bureau of Reclamation (USBR)* is responsible for primarily western water projects with respect to developing water sources for agriculture and commerce. In reality, however, quite often these federal agencies' project goals overlap with USBR's dams and reservoirs providing important flood protection and the COE's water projects — dams, locks, and canals — providing important water transportation linkages and benefits to commerce. [See Appendix E–2 for the U.S. Army Corps of Engineers' organizational structure and primary missions and objectives.]

Artesian — A commonly used expression, generally synonymous with *Confined* and referring to subsurface (ground) bodies of water which, due to underground drainage from higher elevations and confining layers of soil material above and below the water body (referred to as an *Artesian Aquifer*), result in underground water at pressures greater than atmospheric.

Artesian Aquifer — A commonly used expression, generally synonymous with (but a generally less favored term than) *Confined Aquifer*. An artesian aquifer is an aquifer which is bounded above and below by formations of impermeable or relatively impermeable material. An aquifer in which ground water is under pressure significantly greater than atmospheric and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the aquifer itself.

Artesian Pressure — The pressure under which *Artesian Water* in an *Artesian Aquifer* is subjected, generally significantly greater than atmospheric

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Artesian Water — Ground water that is under pressure when tapped by a well and is able to rise above the level at which it is first encountered. It may or may not flow out at ground level. The pressure in such an aquifer commonly is called *Artesian Pressure,* and the formation containing artesian water is an *Artesian Aquifer* or *Confined Aquifer*.

Artesian Well — (1) A well bored down to the point, usually at great depth, at which the water pressure is so great that the water is forced out at the surface. The name is derived from the French region of Artois, where the oldest well in Europe was bored in 1126. (2) A well tapping a *Confined* or *Artesian Aquifer* in which the static water level stands above the top of the aquifer. The term is sometimes used to include all wells tapping confined water. Wells with water levels above the unconfined water table are said to have positive artesian head (pressure) and those with water level below the unconfined water table, negative artesian head. If the water level in an artesian well stands above the land surface, the well is a *Flowing Artesian Well*. If the water level in the well stands above the water table, it indicates that the artesian water can and probably does discharge to the unconfined water body.

Artesian Zone — A zone where water is confined in an aquifer under pressure so that the water will rise in the well casing or drilled hole above the bottom of the confining layer overlying the aquifer.

Artificial Recharge — (1) The addition of surface water to a ground water reservoir by human activity, such as putting surface water into a *Spreading Basin*. (2) The designed (as per man's activities as opposed to the natural or incidental) replenishment of ground water storage from surface water supplies such as irrigation or induced infiltration from streams or wells. There exist five (5) common techniques to effect artificial recharge of a ground water basin:

- [1] ***Water Spreading*** consisting of the basin method, stream-channel method, ditch method, and flooding method, all of which tend to divert surface water supplies to effect underground infiltration;
- [2] ***Recharge Pits*** designed to take advantage of permeable soil or rock formations;
- [3] ***Recharge Wells*** which work directly opposite of pumping wells, although they generally have limited scope and are better used for deep, confined aquifers;
- [4] ***Induced Recharge*** which results from pumping wells near surface supplies, thereby inducing higher discharge towards the well; and
- [5] ***Wastewater Disposal*** which includes the use of secondary treatment wastewater in combination with spreading techniques, recharge pits, and recharge wells to reintroduce the water into deep aquifers thereby both increasing the available ground water supply and also further improving the quality of the wastewater.

Also referred to as *Induced Recharge*.

Attached Ground Water — The portion or amount of alkali substances in the ground sufficient to raise the pH value above 7.0 or to be harmful to the growth of crops, a condition called alkaline.
Attenuation — (1) Generally, a term used to describe the slowing, modification, or diversion of the flow of water as with *Detention* and *Retention*. (2) (Water Quality) The process of diminishing contaminant concentrations in ground water, due to filtration, biodegradation, dilution, sorption, volatilization, and other processes.

Atterberg Limits — The transition points between various states of soil consistency. The Atterberg Limits consist of: (1) the liquid limit (water content at which the soil passes from the liquid to the plastic state); (2) the plastic limit (water content at which the soil passes from the plastic to the semi-solid state); and (3) the shrinkage limit (water content at which the soil passes from the semi-solid to the solid state).

Autochthonous Material — (1) Pertaining to substances, materials, or organisms originating within a particular waterway and remaining in that waterway. (2) Organic material produced in the stream usually through primary production. Compare to *Allochthonous Material*.

Available Water — The portion of water in a soil that can be absorbed by plant roots, usually considered to be that water held in the soil against a tension of up to approximately 15 atmospheres.

Available Water Holding Capacity — The capacity of a soil to hold water in a form available to plants. Also, the amount of moisture held in the soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension.

Average Annual Recharge — The amount of water entering an aquifer on an average annual basis. In many, if not most, hydrologic conditions, “average” has little significance for planning purposes as there may exist so few “average” years in fact.

Avulsion — (1) The sudden movement of soil from one property to another as a result of a flood or a shift in the course of a boundary stream. (2) A forcible separation or detachment; a sudden cutting off of land by flood, currents, or change in course of a body of water; especially one separating land from one person’s property and joining it to another’s. (3) A sudden cutting off or separation of land by a flood or by an abrupt change in the course of a stream, as by a stream breaking through a meander or by a sudden change in current, whereby the stream deserts its old path for a new one. (4) A sudden loss or gain of land as the result of action of water or a shift in a bed of a river which has been used as a boundary by property owners. If land is lost as a result of avulsion the riparian owner does not lose title to the land that has been lost; the boundary lines remain the same. This is not true when land is lost by erosion.

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B–Horizon — (1) The lower soil zone which is enriched by the deposition or precipitation of material from the overlying zone, or *A–Horizon*. (2) A mineral horizon of a soil, below the A-horizon, sometimes called the *Zone of Accumulation* and characterized by one or more of the following conditions: an illuvial accumulation of humus or silicate clay, iron, or aluminum; a residual accumulation of sesquioxides or silicate clays; darker, stronger, or redder coloring due to the presence of sesquioxides; a blocky or prismatic structure. Along with the A–horizon soil zone, these two zones constitute part of the *Zone of Eluviation*.

Backbar Channel — A channel formed behind a bar connected to the main channel but usually at a higher bed elevation than the man channel. Backbar channels may or may not contain flowing or standing water.

Backfill, or Backfilling — process of filling the notches carved in the earth from strip mining in order to restore the original slope. This is intended to reduce soil erosion and allow for the reestablishment of vegetation.

Baffle — A flat board or plate, deflector, guide, or similar device constructed or placed in flowing water or slurry systems to cause more uniform flow velocities to absorb energy and to divert, guide, or agitate liquids.

Bailer — An instrument such as a long pipe with a valve at the lower end used to extract a water sample from a ground water well. Also used to remove slurry from the bottom or side of a well as it is being drilled.

Bank, and Banks — The slope of land adjoining a body of water, especially adjoining a river, lake, or a channel. With respect to flowing waters, banks are either right or left as viewed facing in the direction of the flow. As *Banks,* a large elevated area of a sea floor.

Bank and Channel Stabilization — Implementation of structural features along a streambank to prevent or reduce bank erosion and channel degradation.

Bankfull Channel — The stream channel that is formed by the dominant discharge, also referred to as the active channel, which meanders across the floodplain as it forms pools, riffles, and point bars.

Bankfull Stage — The stage at which a stream first begins overflows its natural banks. More precisely, an established river stage at a given location along a river which is intended to represent the maximum safe water level that will not overflow the river banks or cause any significant damage within the river reach. Bankfull stage is a hydraulic term, whereas *Flood Stage* implies resultant damage.

Bank Storage — The water absorbed into the banks of a stream, lake, or reservoir, when the stage rises above the water table in the bank formations, then returns to the channel as effluent seepage when the stage falls below the water table. Bank storage may be returned in whole or in part as seepage back to the water body when the level of the surface water returns to a lower level.

Bar — (1) A sand or gravel deposit found on the bed of a stream that is often exposed during low-water periods. (2) An elongated landform generated by waves and currents, usually running parallel to the shore, composed predominantly of unconsolidated sand, gravel, stones, cobbles, or rubble and with water on two sides. (3) A component landform comprised of elongate, commonly curving, low ridges of well sorted sand and gravel that stand above the general level of a *Bolson* floor and were built by the wave action of a Pleistocene lake. (4) A unit of pressure equal to 10^6 dynes per cm^2, 100 kilopascals, or 29.53 inches of mercury.

Base — (1) Any of various typically water-soluble and bitter tasting compounds that in solution have a pH greater than 7, are capable of reacting with an acid to form a salt, and are molecules or ions able to take up a proton from an acid or able to give up an unshared pair of electrons to an acid. (2) Chemicals that release hydroxide ions (OH^-) in solution. Such solutions have a soapy feel, neutralize acids, and conduct electricity.

Base Flow — (1) The flow that a perennially flowing stream reduces to during the dry season. It is supported by ground water seepage into the channel. (2) The fair-weather or sustained flow of streams; that part of stream discharge not attributable to direct runoff from precipitation, snowmelt, or a spring. Discharge entering streams channels as effluent from the ground water reservoir. (3) The volume of flow in a stream channel that is not derived from surface run-off. Base flow is characterized by los flow regime (frequency, magnitude, and duration daily, seasonally, and yearly), by minimum low flow events and in context of the size and complexity of the stream and its channel.

Base Level — (1) The elevation to which a stream-channel profile has developed. (2) The lowest level to which a land surface can be reduced by the action of running water.

Base Runoff — Sustained or fair weather runoff. In most streams, base runoff is composed largely of ground-water effluent. The term base flow is often used in the same sense as base runoff. However, the distinction is the same as that between streamflow and runoff. When the concept in the terms base flow and base runoff is that of the natural flow in a stream, base runoff is the more appropriate term.

Base Width — (1) The time interval between the beginning and end of the direct runoff produced by a storm. (2) The time period covered by a *Unit Hydrograph*.

Baseline — The condition that would prevail if no action were taken.

Baseline (Data) — A quantitative level or value from which other data and observations of a comparable nature are referenced. Information accumulated concerning the state of a system, process, or activity before the initiation of actions that may result in changes.

Basic Hydrologic Data — Includes inventories of features of land and water that vary only from place to place (e.g., topographic and geologic maps), and records of processes that vary with both place and time (e.g., records of precipitation, streamflow, ground-water, and quality-of-water analyses). *Basic Hydrologic Information* is a broader term that includes surveys of the water resources of particular areas and a study of their physical and related economic processes, interrelations and mechanisms.

Basin — (1) (Hydrology) A geographic area drained by a single major stream; consists of a drainage system comprised of streams and often natural or man-made lakes. Also referred to as *Drainage Basin*, *Watershed*, or *Hydrographic Region*. (2) (Irrigation) A level plot or field, surrounded by dikes, which may be flood irrigated. (3) (Erosion Control) A catchment constructed to contain and slow runoff to permit the settling and collection of soil materials transported by overland and rill runoff flows. (4) (Nautical) A naturally or artificially enclosed harbor for small craft, such as a yacht basin.

Basin Fill — Unconsolidated material such as sand, gravel, and silt eroded from surrounding mountains and deposited in a valley.

Basin-Floor Remnant — A flattish topped, erosional remnant of any former landform of a basin floor that has been dissected following the incision of an axial stream.

Basin Lag — (1) The time from the centroid (centermost point in time based on total period rainfall) of rainfall to the hydrograph peak. (2) The time from the centroid of rainfall to the centroid of the *Unit Hydrograph*.

Basin of Origin — The area (hydrographic region or area) from in surface waters naturally occur or from which ground water is removed.

Bathometer — An instrument used to measure the depth of water.

Bathymetric Map — A map showing the depth of water in lakes, streams, or oceans.

Bathymetry — (1) The measurement of the depth of large bodies of water. (2) The measurement of water depth at various places in a body of water. Also the information derived from such measurements.

Bathythermograph — An instrument designed to record water temperature as a function of depth.

Baumé — Being, calibrated in accordance with, or according to either of two arbitrary hydrometer scales for liquids lighter than water or for liquids heavier than water that indicate specific gravity in degrees.

Bayou — In general, a creek, secondary watercourse, or minor river, tributary to another river or other body of water. A term regularly used in the lower Mississippi River basin and in the Gulf-coast region of the United States to denote a large stream or creek, or small river, characterized by a slow or imperceptible current through alluvial lowlands or swamps. May also refer to an estuarial creek or inlet on the Gulf coast; a small bay, open cove, or harbor; also, a lagoon, lake or bay, as in a sea marsh or among salt-marsh islands.

Bed — (1) The bottom of a body of water, such as a stream. (2) An underwater or intertidal area in which a particular organism is established in large numbers. (3) (Geology) A rock mass of large horizontal extent bounded, especially above, by physically different material (as in *Bedrock*).

Bed Load — (1) Sediment particles up to rock, which slide and roll along the bottom of the streambed. (2) Material in movement along a stream bottom, or, if wind is the moving agent, along the surface. (3) The sediment that is transported in a stream by rolling, sliding, or skipping along or very close to the bed. In USGS reports, bed load is considered to consist of particles in transit from the bed to an elevation equal to the top of the bed-load sample nozzle (usually within 0.25 feet of the streambed). Contrast with material carried in *Suspension* or *Solution*.

Bed Load Discharge — The quantity of sediment, typically measured in tons per day, that is moving as bed load, reported as dry weight, that passes a cross section in a given time.

Bed Material — The sediment mixture of which a streambed, lake, pond, reservoir, or estuary bottom is composed.

Bedrock — (Geology) The solid rock beneath the soil (*Zone of Aeration* or *Zone of Saturation*) and superficial rock. A general term for solid rock that lies beneath soil, loose sediments, or other unconsolidated material.

Bedscarp (Nick Point) — An abrupt change in grade in the bottom of a stream channel that moves progressively upstream; the change in grade forms a waterfall. Also, the location where a streambed is actively eroding downward to a new base level.

Beheaded Stream — The lower section of a stream that has lost its upper portion through diversion or *Stream Piracy*.

Beneficial Use (of Water) — (1) The amount of water necessary when reasonable intelligence and diligence are used for a stated purpose. (2) A use of water resulting in appreciable gain or benefit to the user, consistent with state law, which varies from one state to another. Most states recognize the following uses as beneficial:

- [1] domestic and municipal uses;
- [2] industrial uses;
- [3] irrigation;
- [4] mining;
- [5] hydroelectric power;
- [6] navigation;
- [7] recreation;
- [8] stock raising;

[9] public parks;
[10] wildlife and game preserves.

(3) The cardinal principle of the *(Prior) Appropriation Doctrine*. A use of water that is, in general, productive of public benefit, and which promotes the peace, health, safety and welfare of the people of the State. A certificated water right is obtained by putting water to a beneficial use. The right may be lost if beneficial use is discontinued. A beneficial use of water is a use which is of benefit to the appropriator and to society as well. The term encompasses considerations of social and economic value and efficiency of use. In the past, most reasonably efficient uses of water for economic purposes have been considered beneficial. Usually, challenges have only been raised to wasteful use or use for some non-economic purpose, such as preserving instream values. Recent statutes in some states have expressly made the use of water for recreation, fish and wildlife purposes, or preservation of the environment a beneficial use.

Benefit-Cost Ratio — (1) The relationship of the economic benefits of an action to its total costs. (2) An economic indicator of the efficiency of a proposed project, computed by dividing benefits by costs; usually, both the benefits and the cost are discounted, so that the ratio reflects efficiency in terms of the present value of future benefits and costs.

Benthic — (1) The bottom of lakes or oceans. See *Benthic Region*. (2) Referring to organisms that live on the bottom of water bodies. See *Benthic Invertebrates* and *Benthic Organisms*.

Benthic Region — The bottom of a body of water, supporting the *Benthos*.

Bentonite — A clay material that swells as it dries, filling gaps and sealing itself against a well casing. It is commonly used to seal abandoned dewatering wells at mines. Concrete, by contrast, shrinks as it cures, and can therefore leave gaps around a wellhead casing that can allow contaminated water from the surface to penetrated into the well.

Bernoulli Effect — The phenomenon of internal pressure reduction with increased stream velocity in a fluid.

Bernoulli's Equation — Under conditions of steady flow of water, the sum of the velocity head, the pressure head, and the head due to elevation at any given point is equal to the sum of these heads at any other point plus or minus the head losses between the points due to friction or other causes.

Berm — (1) A narrow ledge or path as at the top or bottom of a slope, stream bank, or along a beach. (2) (Dam) A horizontal step or bench in the upstream or downstream face of an *Embankment Dam*.

Best Available Demonstrated Technology (BADT) — The level of effluent limitation technology required by the 1972 *Clean Water Act (CWA)* to be used in setting new source performance standards for new industrial direct dischargers of water pollutants.

Best Available Technology Economically Achievable (BAT) — A national goal under the *Water Pollution Control Act* of 1972 (*Public Law 92–500*, commonly referred to as the *Clean Water Act*) which provides that industry shall use the best treatment technically and economically achievable for a category or class of point sources. Under this concept, pollution control will consider such factors as the age of the facilities and equipment involved, processes employed, engineering aspects of the control techniques, process changes, cost of the reductions, and environmental impacts other than water quality, including energy requirements.

Best Conventional Control Technology (BCT) — The level of water pollution control technology required of existing dischargers for the treatment of conventional pollutants by the 1977 *Clean Water Act*

(CWA).

Best Management Practices (BMP) — (1) A generally accepted practice for some aspect of natural resources management, such as water conservation measures, drainage management measures, or erosion control measures. Typically incorporates conservation criteria. (2) A set of field activities that provide the most effective means for reducing pollution from a nonpoint source. (3) Accepted methods for controlling *Non-Point Source (NPS) Pollution* as defined by the 1977 *Clean Water Act (CWA)*; may include one or more conservation practices. Also refers to water conservation techniques of proven value. See, for example, *Best Management Practices (BMP) – Urban Water Use*.

Best Practicable Control Technology (BPT) — A national goal under the *Water Pollution Control Act* of 1972 (*Public Law 92–500*, or the *Clean Water Act*) which provides that industry shall use the best treatment practices practical, with due consideration to cost, age of the plant and equipment, and other factors.

Bicarbonate — (Water Quality) A compound containing the HCO3 group, for example, sodium bicarbonate (NaHCO3), which ionizes in solution (water) to produce $HCO3^{-}$. Also see *Carbonate* and *Carbonate Buffer System*.

Bifurcate — Dividing structure which splits the flow of water.

Bimodal Distribution — (Statistics) A collection of observations with a large number of values centered (as in a *Normal Distribution*) around each of two points. For example, in a sampling of the heights of a population, the sample results would tend to be concentrated around an average heights for males and a second average height for females.

Biochemical Oxygen Demand (BOD) — (1) A measure of the quantity of dissolved oxygen, in milligrams per liter, necessary for the decomposition of organic matter by microorganisms, such as bacteria. (2) A measure of the amount of oxygen removed from aquatic environments by aerobic micro-organisms for their metabolic requirements. Measurement of BOD is used to determine the level of organic pollution of a stream or lake. The greater the BOD, the greater the degree of water pollution. Also referred to as *Biological Oxygen Demand (BOD)*.

Biodegradable — Capable of being decomposed by biological agents or microorganisms, especially bacteria. The property of a substance that permits it to be broken down by micro-organisms into simple, stable compounds such as carbon dioxide and water.

Biological Opinion — A document which states the opinion of the *U.S. Fish and Wildlife Service (USFWS)* as to whether a federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat.

Biological Oxygen Demand (BOD) — (1) The amount of oxygen required to stabilize decomposable matter by aerobic action. (2) (Water Quality) An indirect measure of the concentration of biologically degradable material present in organic wastes. It usually reflects the amount of oxygen consumed in five days by biological processes breaking down organic waste. Also see *BOD5*. Also referred to as *Biochemical Oxygen Demand (BOD)*.

Bioremediation — Simply, the use of biological techniques to clean up pollution. More specifically, the use of specialized, naturally-occurring micro-organisms with unique biological characteristics, appetites, and metabolisms as a form of waste cleanup. A critical underpinning of this process is the ability to economically generate a sufficient biomass of the appropriate microbes to accomplish in weeks or months what would normally take nature years to do. Typically, this is done either by applying a sufficient concentration of such microbes directly to the polluted area or by applying various concentrations of chemicals which, in turn, stimulate and foster the rapid growth of appropriate micro-organisms.

Biotechnical Slope Protection — A process involving the use of live and dead woody cuttings and poles or posts collected from native plants to revegetate watershed slopes and stream banks. The cuttings, posts, and vegetative systems composed of bundles, layers, and mats of the cuttings and posts provide structure, drains, and vegetative cover to repair eroding and slumping slopes. Also referred to as *Soil Bioengineering*.

Blending — The mixing or combination of one water source with another, typically a finished source of water with raw water to reuse water while still satisfying water quality standards, for example, mixing of product water from a desalting plant with conventional water to obtain a desired dissolved solids content, or mixing brine effluents with sewage treatment plant effluents in order to reduce evaporation pond size.

Blinds — Water samples containing a chemical of known concentration given a fictitious company name and slipped into the sample flow of the lab to test the impartiality of the lab staff.

Bloom — (1) In aquatic ecosystems, the rapid growth or proliferation of algae, commonly referred to as *Algal Bloom* or *Algae Bloom*; often related to pollution, especially when pollutants accelerate growth. (2) Also a visible, colored area on the surface of bodies of water caused by excessive planktonic growth.

Blowout — A sudden escape of a confined gas or liquid, as from a well.

Bog — (1) A term frequently associated with *Wetlands*, bogs are poorly drained freshwater wetlands that are characterized by a build-up of peat. Sphagnum mosses are also frequently found in many bogs. (2) A quagmire filled with decayed moss and other plant and vegetable matter; wet spongy ground, where a heavy body is apt to sink; a small, soggy marsh; a morass. (3) (Ecology) A wet, overwhelmingly vegetative substratum which lacks drainage and where humic and other acids give rise to modifications of plant structure and function. Bogs depend primarily on precipitation for their water source, and are usually acidic and rich in plant residue with a conspicuous mat of living green moss. Only a restricted group of plants, mostly *mycorrhizal* (fungi, heaths, orchids, and saprophytes), can tolerate bog conditions. Also referred to as *Peat Bog*. Also see *Peatland*.

Bog Hole — A hole containing soft mud or quicksand.

Borehole — A hole bored or drilled in the earth, as an exploratory well; a small-diameter well drilled especially to obtain water.

Bottom — (1) The deepest or lowest part, as the bottom of a well. (2) The solid surface under a body of water. (3) Often *Bottoms*: Low-lying alluvial land adjacent to a river, also referred to as bottomland.

Bottomland, also Bottom Land (Soils) — A general term describing generally rich, loamy or fine-textured and poorly drained soils, overlying a shallow water table or possibly adjacent to a stream, lake or other body of water, that exhibits relatively good water holding capacity and slow to moderate infiltration of irrigation water; often associated with a river's floodplain.

Boulder — Rock fragments larger than 60.4 cm (24 inches) in diameter.

Brackish — Having a somewhat salty taste, especially from containing a mixture of seawater and fresh water. Also see *Brackish Water*.

Brackish Water — Generally, water containing dissolved minerals in amounts that exceed normally acceptable standards for municipal, domestic, and irrigation uses. Considerably less saline than sea water. Also, *Marine* and *Estuarine* waters with *Mixohaline* salinity (0.5 to 30‰ due to ocean salts). Water containing between 1,000–4,000 parts per million (PPM) *Total Dissolved Solids (TDS)*. The term brackish water is frequently interchangeable with *Saline Water*. The term should not be applied to inland waters.

Braided Stream — (1) A stream which divides into a network of channels branching and reuniting, separated by islands. (2) A complex tangle of converging and diverging stream channels (*Anabranches*) separated by sand bars or islands. Characteristic of flood plains where the amount of debris is large in relation to the discharge.

Branch — (1) A tributary of a river or other body of water. (2) A divergent section of a river, especially near the mouth.

Breach — A gap or rift, especially in or as if in a solid structure such as a dike or dam.

Break — (1) To emerge above the surface of the water. (2) (Geology) A marked change in topography such as a fault or deep valley.

British Thermal Unit (BTU) — A unit of heat energy equal to the amount of heat required to raise the temperature of one pound of water one degree *Fahrenheit*. More precisely, the quantity of heat required to raise the temperature of one pound of water from 60EF to 61EF at a constant pressure of one atmosphere. Also, the quantity of heat equal to 1/180 of the heat required to raise the temperature of one pound of water from 32EF (its freezing point) to 212EF (its boiling point) at a constant pressure of one atmosphere. The British Thermal Unit is used when the measurement is in degrees Fahrenheit (EF) on the *Fahrenheit Scale* and the *Calorie* is used when temperature is measured in degrees *Celsius* (EC) on the *Centigrade Scale*.

Brook — A natural stream of water, smaller than a river or creek; especially a small stream or rivulet which breaks directly out of the ground, as from a spring or seep; also, a stream or torrent of similar size, produced by copious rainfall, melting snow and ice, etc.; a primary stream not formed by tributaries, though often fed below its source, as by rills or runlets; one of the smallest branches or ultimate ramifications of a drainage system.

Brownian Movement — The constant, random, zigzag movement of small particles dispersed in a fluid medium, caused by collision with molecules of the fluid. Also referred to as *Brownian Motion*.

Buffer — A solution which is resistant to pH changes, or a solution or liquid whose chemical makeup tends to neutralize acids or bases without a great change in pH. Surface waters and soils with chemical buffers are not as susceptible to acid deposition as those with poor buffering capacity.

Buffer Strips — (1) Strips of grass or other erosion-resisting vegetation between or below cultivated strips or fields. (2) Grassed or planted zones which act as a protective barrier between an area which experiences livestock grazing or other activities and a water body. Also referred to as a *Buffer Zone*.

Buffer Zone — (1) A protective, neutral area between distinct environments. (2) An area which acts to minimize the impact of pollutants on the environment or public welfare. For example, a buffer zone may be established between a compositng facility and nearby neighborhoods to minimize odor problems. Also see *Buffer Strips*.

-C-

C–Horizon — A layer of unconsolidated material, relatively little affected by the influence of organisms and presumed to be similar in chemical, physical, and mineralogical composition to the material from which at least a portion of the overlying *Solum* has developed.

Calcareous — Formed of calcium carbonate or magnesium carbonate by biological deposition or inorganic precipitation in sufficient quantities to effervesce carbon dioxide visibly when treated with cold 0.1 normal hydrochloric acid. Calcareous sands are usually formed of a mixture of fragments of mollusk shell, echinoderm spines and skeletal material, coral, foraminifera, and algal platelets.

Calcareous Fens — *Peatlands* formed in areas of ground water discharge, where cold, anoxic, mineral-rich water provides a specialized habitat for disproportionately large numbers of rare and endangered plants. Many of the plants found in calcareous fens are species which would be typical of more northern habitats. The health of such fens is inextricably linked to the presence of the upwelling ground water.

Calcic Horizon — A secondary *Calcium Carbonate* accumulation in the lower *B-Horizon* that occurs as coatings on *Clasts* and as lenses in fine-grained sediment matrices; it is at least 15 centimeters (5.9 inches) thick and contains 15 percent or more calcium carbonate.

Calcite — (Geology) Calcium carbonate (CaCO3), with hexagonal crystallization, a mineral found in the form of limestone, chalk, and marble.

Calcium Carbonate — Chemical symbol: CaCO3. The principal hardness and scale-causing compound in water. A white precipitate that forms in water lines, water heaters, and boilers in hard water areas; also known as scale. Also the principal chemical composition of *Tufa*, a calcareous and siliceous rock deposit of springs, lakes, or ground water.

Calcium Hydroxide — A white crystalline strong alkali Ca(OH)2 that is used especially to make mortar and plaster and to soften water.

Calibrated Model - a model for which all residuals between calibration targets and corresponding model outputs, or statistics computed from residuals, are less than pre-set acceptable values.

Calibration - the process of refining the model representation of the hydrogeologic framework, hydraulic properties, and boundary conditions to achieve a desired degree of correspondence between the model simulations and observations of the ground water flow system, which includes both measured hydraulic head and flux.

Calibration Target - measured, observed, calculated, or estimated hydraulic heads or ground water flow rates that a model must reproduce, at least approximately, to be considered calibrated.

Caliche — (1) A soil layer near the surface, more or less cemented by secondary carbonates of calcium or magnesium precipitated from the soil solution. It may occur as a soft, thin soil horizon, as a hard, thick bed just beneath the *Solum*, or as a surface layer exposed by erosion. (2) *Alluvium* cemented with sodium nitrate, chloride, and/or other soluble salts in the nitrate deposits of Chile and Peru. Also referred to as *Hardpan*.

Calorie — (Abbreviation cal) (1) Basically, A unit of heat energy equal to the amount of heat needed to raise the temperature of one gram of water one degree *Celsius* (EC). More precisely, any of several approximately equal units of heat, each measured as the quantity of heat required to raise the temperature of 1 gram of water by 1EC from a standard initial temperature, especially from 3.98EC (corresponding to the maximum density of water), 14.5EC, or 19.5EC, at 1 atmosphere pressure. Also referred to as the *Gram Calorie* and the *Small Calorie*. (2) The unit of heat equal to 1/100 the quantity of heat required to raise the temperature of 1 gram of water from 0EC (its freezing point) to 100EC (its boiling point) at 1 atmosphere pressure. Also referred to as the *Mean Calorie*. (3) The unit of heat equal to the amount of heat required to raise the temperature of 1 kilogram of water by 1EC at 1 atmosphere pressure. Also referred to as the *Kilocalorie*, *Kilogram Calorie*, and *Large Calorie*. (4) A unit of energy-producing potential equal to this amount of heat that is contained in food and released upon oxidation by the body. Also referred to as the *Nutritionist's Calorie*. The calorie is used when temperature is measured in degrees *Celsius* (EC) on the *Centigrade Scale*. The *British Thermal Unit (BTU)* is used when the measurement is in degrees *Fahrenheit* (EF) on the *Fahrenheit Scale*.

Candidate Species — Plant or animal species designated by the Department of the Interior, *U.S. Fish and Wildlife Service (USFWS)* as candidates for potential future listing as an *Endangered Species* or *Threatened Species* pursuant to the *Endangered Species Act (ESA)* of 1973; plant or animal species that are candidates for designation as endangered (in danger of becoming extinct) or threatened (likely to become endangered).

Cap — A layer of clay, or other impermeable material installed over the top of a closed landfill to prevent entry of rainwater and minimize *Leachate*.

Capa (Critical Aquifer Protection Area) — As defined in the *Safe Drinking Water Act (SDWA)*, is all or part of an area located within an area for which an application of designation as a sole or principal source aquifer (pursuant to Section 1424[e]) has been submitted and approved by the Administrator not later than 24 months after the date of enactment and which satisfies the criteria established by the Administrator; and all or part of an area that is within an aquifer designated as a *Sole Source Aquifer (SSA)*, as of the date of the enactment of the *Safe Drinking Water Act (SDWA)* amendments of 1986, and for which an area wide ground-water protection plan has been approved under Section 208 of the *Clean Water Act (CWA)* prior to such enactment.

Capacity, Field or Soil — The amount of water held in a soil sample after the excess gravitation water has drained away.

Capillarity — (1) The property of tubes or earth-like particles with hairlike openings which, when immersed in fluid, raise (or depress) the fluid in the tubes above (or below) the surface of the fluid in which they are immersed. (2) The interaction between contacting surfaces of a liquid and a solid that distorts the liquid surface from a planar shape. Also referred to as *Capillary Action* or *Capillary Attraction*.

Capillary Action — (1) The action by which water is drawn around soil particles because there is a stronger attraction between the soil particles and the water molecules themselves. (2) The movement of water within the interstices of a porous medium due to the forces of adhesion, cohesion, and surface tension acting in a liquid that is in contact with a solid. Synonymous with the terms *Capillarity*, *Capillary Flow*, and *Capillary Migration*.

Capillary Attraction — The force that results from greater adhesion of a liquid to a solid surface than internal cohesion of the liquid itself and that causes the liquid to be raised against a vertical surface, as water is in a clean glass tube. It is the force that allows a porous material like soil to soak up water from lower levels.

Capillary Fringe — (1) The zone at the bottom of the *Zone of Aeration* (*Vadose Zone*) where ground water is drawn upward by capillary force. (2) The zone immediately above the *Zone of Saturation* (or *Ground water Table*) in which underground water is lifted against gravity by surface tension (*Capillary Action*) in passages of capillary size.

Capillary Water — (1) Water held in the soil above the *Phreatic Surface* by capillary forces; or soil water above hydroscopic moisture and below the field capacity. (2) A continuous film of water found around soil particles.

Capillary Zone — The soil area above the water table where water can rise up slightly through the cohesive force of *Capillary Action*.

Capture — (1) Water withdrawn artificially from an aquifer is derived from a decrease in storage in the aquifer, a reduction in the previous discharge from the aquifer, an increase in the recharge, or a combination of these changes. The decrease in discharge from an aquifer plus the increase in recharge. Capture may occur in the form of decreases in the ground-water discharge into streams, lakes, and the ocean, or from decreases in that component of *Evapotranspiration* derived from the *Zone of Saturation*. (2) Diversion of the flow of water in the upper part of a stream by the headward growth of another stream.
Capture Zone — The zone around a well contributing water to the well; the area on the ground surface from which a well captures water.

Carbonate — (1) The collective term for the natural inorganic chemical compounds related to carbon dioxide that exist in natural waterways. (2) A sediment formed by the organic or inorganic precipitation from aqueous solution of carbonates of calcium, magnesium, or iron. The $CO3^{-2}$ ion in the *Carbonate Buffer System*. Combined with one proton, it becomes *Bicarbonate*, $HCO3^{-}$ and with two protons, *Carbonic Acid*. The carbonate ion forms a solid precipitant when combined with dissolved ions of calcium or magnesium.

Carbonate Aquifer — An aquifer found in limestone and dolomite rocks. Carbonate aquifers typically produced hard water, that is, water containing relatively high levels of calcium and magnesium.

Carbonate Buffer System — The most important buffer system in natural surface waters and wastewater treatment, consisting of a carbon dioxide, water, carbonic acid, *Bicarbonate*, and *Carbonate* ion equilibrium that resists changes in the water’s pH. For example, if acid materials (hydrogen ions) are added to this buffer solution, the equilibrium is shifted and carbonate ions combine with the hydrogen ions to form bicarbonate. Subsequently, the bicarbonate then combines with hydrogen ions to form carbonic acid, which can dissociate into carbon dioxide and water. Thus the system pH is unaltered even though acid was introduced.

Carbonate Hardness — Water hardness caused by the presence of *Carbonate* and *Bicarbonate* of calcium and magnesium. Also see *Temporary Hardness*.

Carbonate Rock — (Geology) A rock consisting chiefly of carbonate minerals, such as limestone and dolomite.

Carbonation, Ground water — The dissolving of carbon dioxide in surface water as it percolates through the ground. The carbon dioxide reacts with water to form carbonic acid, a weak acid that causes the water to have a slightly acidic pH.

Carbonic Acid — A weak, unstable acid, H_2CO_3, present in solutions of carbon dioxide and water. The carbonic acid content of natural, unpolluted rainfall lowers its pH to about 5.6.

Casing — The steel conduit required to prevent waste and contamination of the ground water and to hold the formation open during the construction or use of the well. A tubular structure intended to be water tight installed in the excavated or drilled hole to maintain the well opening and, along with cementing, to confine the ground waters to their zones of origin and prevent the entrance of surface pollutants.

Catchment Area — (1) The intake area of an aquifer and all areas that contribute surface water to the intake area. (2) The areas tributary to a lake, stream, sewer, or drain. (3) A reservoir or basin developed for flood control or water management for livestock and/or wildlife. See also *Drainage Area*; *Watershed*.

Categorical Exclusion — A class of actions which either individually or cumulatively would not have a significant effect on the human environment and therefore would not require preparation of an *Environmental Assessment (EA)* or an *Environmental Impact Statement (EIS)* under the *National Environmental Policy Act (NEPA)*.

Cation — The positively charged particle or ion in an electrolyzed solution which travels to the cathode and is there discharged, evolved, or deposited. Also, by extension, any positive ion.

Cation Exchange — A chemical process in which *Cations* of like charge are exchanged equally between a solid, such as zeolite, and a solution, such as water. The process is often used to soften water.

Cation Exchange Capacity (CEC) — The total of exchangeable cations that a soil can adsorb; expressed in milliequivalents per 100 grams (g) of soil.

Caustic — Alkaline or basic.

Caving — The collapse of a stream bank by undercutting due to wearing away of the toe or an erodible soil layer above the toe.

Cavitation — (1) A process of erosion in a stream channel caused by sudden collapse of vapor bubbles against the channel wall. (2) The formation of cavities filled with air and water vapor due to internal pressure reduced below atmosphere. (3) The formation and collapse of gas pockets or bubbles on the blade of an impeller or the gate of a valve; collapse of these pockets or bubbles drives water with such force that it can cause pitting of the gate or valve surface.

Cell - also called element, a distinct one- two- or three-dimensional model unit representing a discrete portion of a physical system with uniform properties assigned to it.

Celsius [Temperature Scale] (C) — (1) Relating to, conforming to, or having the international thermometric scale on which the interval between the triple point of water and the boiling point of water is divided into 99.99 degrees with 0.01° representing the *Triple Point* and 100° the boiling point at one atmosphere of pressure; Abbreviation C; Compare to *Centigrade [Temperature Scale]*. The Celsius scale, which is identical to the centigrade scale, is named for the 18th-century Swedish astronomer Anders Celsius, who first proposed the use of a scale in which the interval between the freezing and boiling points of water is divided into 100 degrees. By international agreement, the term Celsius has officially replaced Centigrade. (2) Unit of measure for the *Centigrade Temperature Scale* of measuring temperature, as contrasted with the *Fahrenheit* unit of measure. The formula for converting a Celsius temperature to Fahrenheit temperature is FE = [9/5CE + 32]. Also see *Temperature Scale*.

Centigrade [Temperature Scale] (C) — Relating to, conforming to, or having a thermometric scale on which the interval between the freezing point of water and the boiling point of water is divided into 100 degrees with 0° representing the freezing point and 100° the boiling point at one atmosphere of pressure; Abbreviation C; Compare to *Celsius [Temperature Scale]*. The Centigrade scale is identical to the Celsius scale; however, by international agreement, the term Celsius has officially replaced Centigrade. Contrast with the *Fahrenheit Temperature Scale*, using degrees *Fahrenheit* (EF), in which 32EF above the 0E(F) mark indicates the freezing point of water and 212EF indicates the boiling point of water (at sea level). Also see *Temperature Scale*.

Chalk — A mineral composed mainly of the calcareous shells of various marine microorganisms, but whose matrix consists of fine particles of calcium carbonate, some of which may have been chemically precipitated.

Chalybeate — Tasting like iron, as water from a mineral spring.

Channel — (1) (Watercourse) A natural stream that conveys water; a natural or artificial watercourse with definite bed and banks to confine and conduct flowing water; a ditch or channel excavated for the flow of water. River, creek, run, branch, anabranch, and tributary are some of the terms used to describe natural channels, which may be single or *Braided*. Canal, aqueduct, and floodway are some of the terms used to describe artificial (man-made) channels. (2) (Landform) The bed of a single or braided watercourse that commonly is barren of vegetation and is formed of modern alluvium. Channels may be enclosed by banks or splayed across and slightly mounded above a fan surface and include bars and dumps of cobbles and stones. Channels, excepting floodplain playas, are landform elements.

Channel Bank — The sloping land bordering a channel. The bank has steeper slope than the bottom of the channel and is usually steeper than the land surrounding the channel.

Channel Capacity — The maximum rate of flow that may occur in a stream without causing overbank flooding; the maximum flow which can pass through a channel without overflowing the banks.

Channel Inflow — Water which at any instant is flowing into the channel system from surface flow, subsurface flow, base flow, and rainfall directly on the channel.

Channel Lining — Protection of the channel bottom and banks with concrete or *Riprap*.

Channel Modification — The modification of the flow characteristics of a channel by clearing, excavation, realignment, lining, or other means to increase its capacity. Sometimes the term is used to connote *Channel Stabilization*.

Channel Realignment — The construction of a new channel or a new alignment which may include the clearing, snagging, widening, and/or deepening of the existing channel.

Channel Stabilization — Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revetments, vegetation, and other measures.

Channelization — (1) The artificial enlargement or realignment of a stream channel. (2) Straightening a stream or river to allow water to travel through the area more quickly. (3) The process of changing an straightening the natural path of a waterway. Channelization is often used as a means of flood control, but its negative effects often outweigh its advantages. For example, channelization often damages wetlands associated with rivers and streams.

Check Dam — (1) A structure placed bank to bank downhill from a headcut on a hillslope to help revegetate a gully. (2) A small dam constructed in a gully or other small watercourse to decrease the streamflow velocity, minimize channel erosion, promote deposition of sediment, and to divert water from a channel.

Chemical Oxygen Demand (COD) — (Water Quality) (1) A measure of the chemically oxidizable material in the water which provides an approximation of the amount of organic and reducing material present. The determined value may correlate with *Biochemical Oxygen Demand (BOD)* or with carbonaceous organic pollution from sewage or industrial wastes. (2) A chemical measure of the amount of organic substances in water or wastewater. A strong oxidizing agent together with acid and heat are used to oxidize all carbon compounds in a water sample. Non-biodegradable and recalcitrant (slowly degrading) compounds, which are not detected by the test for BOD, are included in the analysis. The actual measurement involves a determination of the amount of oxidizing agent (typically, potassium dichromate) that is reduced during the reaction.

Chemical Weathering — The gradual decomposition of rock by exposure to rainwater, surface water, atmospheric oxygen, carbon dioxide and other gases in the atmosphere, as well as compounds secreted by organisms. Compare to *Physical Weathering*.

Chlorides — Negative chlorine ions, Cl^-, found naturally in some surface waters and ground waters and in high concentrations in seawater. Higher-than-normal chloride concentrations in fresh water, due to sodium chloride (table salt) that is used on foods and present in body wastes, can indicate sewage pollution. The use of highway deicing salts can also introduce chlorides to surface water or ground water. Elevated ground water chlorides in drinking water wells near coastlines may indicate *Saltwater Intrusion*.

Chlorine — One of a group of elements classified as the halogens. Chlorine, Cl2, the most common halogen, is a greenish yellow gas with an irritating odor. Chlorine is very reactive; it forms salts with metals, forms acids when dissolved in water, and combines readily with hydrocarbons. Various forms of chlorine are used to disinfect water. Chlorine is produced by the electrolysis of brine (a concentrated salt solution). Atomic number 17; atomic weight 35.45; freezing point –100.98EC; boiling point –34.6EC; specific gravity 1.56 (–33.6EC).

Chute, or Chute Cutoff — As applied to stream flow, the term “chute” refers to a new route taken by a stream when its main flow is diverted to the inside of a bend, along a trough between low ridges formed by deposition on the inside of the bend where water velocities were reduced. Compare with *Neck Cutoff*.

Circumneutral — Term applied to water with a pH of 5.5 (acidic) to 7.4 (alkaline).

Clast (Clastic) — (1) Pertaining to a rock or sediment composed principally of broken fragments that are derived from pre-existing rocks or minerals and that have been transported some distance from their places of origin. (2) An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering (disintegration) of a larger rock mass.

Clay — (1a) A fine-grained, firm earth material that is plastic when wet and hardens when heated, consisting primarily of hydrated silicates of aluminum and widely used in making bricks, tiles, and pottery; (1b) A hardening or non-hardening material having a consistency similar to clay and used for modeling. (2) (Geology) A sedimentary material with grains smaller than 0.2 millimeters in diameter. (3) Moist, sticky earth; mud.

Clay Liner — A layer of clay soil that is added to the bottom and sides of a pit designed for use as a disposal site for potentially dangerous wastes. The clay prevents or reduces the migration of liquids from the disposal site.

Claypan — (1) A dense, compact layer in the subsoil having a much higher clay content than the overlying material from which it is separated by a sharply defined boundary. Such layers are formed by the downward movement of clay or by synthesis of clay in place during soil formation. Claypans are usually hard when dry, and plastic and sticky when wet. They usually impede movement of water and air, and the growth of plant roots. (2) (Australian) A shallow depression in which water collects after rain. Also see *Hardpan*.

Clay Soil — A soil composed of microscopically small mineral particles that are flattened and fit closely together; spaces between particles for air and water are also small. When clay soil gets wet it dries out slowly because the downward movement if water, i.e., drainage, is slow.

Clean Water Act (CWA) [Public Law 92–500] — More formally referred to as the *Federal Water Pollution Control Act*, the Clean Water Act constitutes the basic federal water pollution control statute for the United States. Originally based on the *Water Quality Act* of 1965 which began setting water quality standards. The 1966 amendments to this act increased federal government funding for sewage treatment plants. Additional 1972 amendments established a goal of zero toxic discharges and "fishable" and "swimmable" surface waters. Enforceable provisions of the CWA include technology-based effluent standards for point sources of pollution, a state-run control program for nonpoint pollution sources, a construction grants program to build or upgrade municipal sewage treatment plants, a regulatory system for spills of oil and other hazardous wastes, and a *Wetlands* preservation program (Section 404).

Clean Water Act (CWA), Section 319 — A federal grant program added by Congress to the CWA in 1987 and managed by the *U.S. Environmental Protection Agency (EPA)*, Section 319 is specifically designed to develop and implement state *Nonpoint Source (NPS) Pollution* management programs, and to maximize the focus of such programs on a watershed or waterbasin basis with each state. Today, all 50 states and U.S. territories receive Section 319 grand funds and are encouraged to use the funding to conduct nonpoint source assessments and revise and strengthen their nonpoint source management programs. Before a grant is provided under Section 319, states are required to: (1) complete a Nonpoint Source (NPS) Assessment Report identifying state waters that require nonpoint source control and their pollution sources; and (2) develop Nonpoint Source Management Programs that outline four-year strategies to address these identified sources.

Clean Water Standards (EPA) — Generally refers to any enforceable limitation, control, condition, prohibition, standard, or other requirement which is promulgated pursuant to the *Federal Water Pollution Control Act (Clean Water Act) [Public Law 92–500]* or contained in a permit issued to a discharger by the *U.S. Environmental Protection Agency (EPA)* or by a state under an approved program, as authorized by Section 402 of the Clean Water Act, or by local governments to ensure compliance with pretreatment regulations as required by Section 307 of the Clean Water Act.

Closed Basin — A hydrographic basin (basin, area or sub-area) is considered closed with respect to surface water flow if its topography prevents the occurrence of visible surface water outflow. It is closed hydrologically if neither surface nor underground water outflow can occur.

Coal Slurry Pipeline — A pipeline which transports pulverized coal suspended in liquid, usually water.

Cobble — Rock fragments 7.6 cm (3 inches) to 25.4 cm (10 inches) in diameter.

Code of Federal Regulations (CFR) — (1) The annual compilation of all current regulations that have been issued in final form by any federal regulatory agency. (2) The codification of the general and permanent rules initially published in the Federal Register by the executive departments and agencies of the federal government. The publication is organized by subject titles. Environmental regulations are covered under Title 40, Protection of the Environment.

Code Selection - the process of choosing the appropriate **computer code**, algorithm, or other analysis technique capable of simulating those characteristics of the physical system required to fulfill the modeling project's objective(s).

Coefficient of Roughness — Factor in fluid flow determination expressing the character of a surface and its fractional resistance to flow. Also referred to as *Roughness Coefficient*.

Coefficient of Runoff — Factor in the rational runoff formula expressing the ratio of peak runoff rate to rainfall intensity.

Coefficient of Storage — The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

Coefficient of Transmissivity (*t*) — The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit *Hydraulic Gradient*. It is equal to an integration of the hydraulic conductivities across the saturated part of the aquifer perpendicular to the flow paths. Also, the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. Transmissivity values are given in gallons per minute through a vertical section of an aquifer 1 foot wide and extending the full saturated height of an aquifer under a hydraulic gradient of one in the *English Engineering System*; in the *Standard International System*, transmissivity is given in cubic meters per day through a vertical section of an aquifer 1 meter wide and extending the full saturated height of an aquifer under hydraulic gradient of one. It is a function of properties of the liquid, the porous media, and the thickness of the porous media. Also see *Transmissivity*.

Coefficient of Viscosity — The degree to which a fluid resists flow under an applied force, measured by the tangential friction force per unit area divided by the velocity gradient under conditions of streamline flow.

Cofferdam — A temporary watertight enclosure that is pumped dry to expose the bottom of a body of water so that construction, as of piers, a dam, and bridge footings, may be undertaken. Also, a watertight chamber attached to the side of a ship to facilitate repairs below the water line. A *Diversion Cofferdam* prevents all downstream flow by diverting the flow of a river into a pipe, channel, or tunnel.

Collector Well — A well located near a surface water supply used to lower the water table and thereby induce infiltration of surface water through the bed of the water body to the well.

Colloidal Suspension — Suspension in water of particles so finely divided that they will not settle under the action of gravity, but will diffuse, even in quiet water, under the random impulses of *Brownian Movement*. Particles typically range in size from about one micron (0.000001 millimeter) to about one millimicron; however, there is no distinct differentiation by particle size between true *Suspension* and colloidal suspension or between colloidal suspension and *Solution*.

Colloids — (1) Any substance with particles in such a fine state of subdivision dispersed in a medium (for example, water) that they do not settle out, but not in so fine a state of subdivision that they can be said to be truly dissolved. (2) Quantities of extremely small particles, typically 0.0001 to 1 micron in size, and small enough to remain suspended in a fluid medium without settling to the bottom. Substances that, when apparently dissolved in water or other liquid, diffuse not at all or very slowly through a membrane and show other special properties, as lack of pronounced effect on the freezing point or vapor pressure of the solvent. Colloids represent intermediate substances between a true dissolved particle and a suspended solid, which will settle out of solution.

Colluvial Material — (Geology) Material consisting of *Alluvium* in part and also containing angular fragments of the original rocks. Typically found at the bottom or on the lower slopes of a hill.

Colluvium — (1) A general term used to describe loose and incoherent deposits of rock moved downslope by gravitational force in the form of soil *Creep*, slides, and local wash. (2) A general term applied to any loose, heterogeneous, and incoherent mass of soil material or rock fragments deposited chiefly by gravity-driven mass-wasting usually at the base of a steep slope or cliff, for example, talus, cliff debris, and avalanche material. (3) *Alluvium* deposited by unconcentrated surface run-off or sheet erosion, usually at the base of a slope. Also see *Colluvial Material*.

Compaction — A physical change in soil properties that result in an increase in soil bulk density and a decrease in *Porosity*. The packing together of soil particles by forces exerted at the soil surface, resulting in increased soil density.

Compliance Monitoring — (Water Quality) Collection and evaluation of data, including self-monitoring reports, and verification to show whether pollutant concentrations and loads contained in permitted discharges are in compliance with the limits and conditions specified in the permit.

Composite Sample — (Water Quality) A representative water or wastewater sample made up of individual smaller samples taken at periodic intervals.

Compound — A substance composed of separate elements, ingredients, or parts. Water is a compound consisting of hydrogen and oxygen, chemical symbol H2O.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) — Also referred to as the *Superfund Law*, this statute, originally enacted in 1980 and substantially modified in 1986, establishes the *U.S. Environmental Protection Agency's (EPA)* authority for emergency response and cleanup of hazardous substances that have been spilled, improperly disposed of, or released into the environment. The primary responsibility for response and cleanup is on the generators or disposers of the hazardous substances, with a backup federal response using a trust fund provision.

Computer Code (computer program) - the assembly of numerical techniques, bookkeeping, and control language that represents the model from acceptance of input data and instructions to delivery of output. Examples: MODFLOW, BIOSCREEN, MT3D, etc.

Concentrate — To make a solution or mixture less dilute, as by removing water from a solution.

Concentration — (1) The density or amount of a substance in a solution. (2) The amount of *Solute* present in proportion to the total *Solution*. More specifically, a measure of the average density of pollutants or other constituents, usually specified in terms of mass per unit volume of water or other *Solvent* (e.g., milligrams per liter) or in terms of relative volume of solute per unit volume of water (e.g., parts per million).

Concentration Gradient - The rate of change in solute concentration per unit distance at a given point and in a given direction.

Concentration Time — The period of time required for storm runoff to flow from the most remote point of a catchment or drainage area to the outlet or point under consideration. Concentration time varies with depth of flow and channel condition.

Conceptualization Error - A modeling error where model formulation is based on incorrect or insufficient understanding of the modeled system.

Conceptual Model - An interpretation of the characteristics and dynamics of an aquifer system which is based on an examination of all available hydrogeological data for a modeled area. This includes the external configuration of the system, location and rates of recharge and discharge, location and hydraulic characteristics of natural boundaries, and the directions of ground water flow throughout the aquifer system.

Condemnation — Taking private property for public use, with compensation to the owner, under the right of *Eminent Domain*.

Condensation — (1) (Physics) The process by which a gas or vapor changes to a liquid or solid; also the liquid or solid so formed. (2) (Chemistry) A chemical reaction in which water or another simple substance is released by the combination of two or more molecules. The opposite of *Evaporation*. In meteorological usage, this term is applied only to the transformation from vapor to liquid.

Conductance — A rapid method of estimating the dissolved solids content of a water supply by determining the capacity of a water sample to carry an electrical current.

Conductivity — A measure of the ability of a solution to carry an electrical current.

Conductor Casing — The temporary or permanent steel casing used in the upper portion of the borehole to prevent collapse of the formation during the construction of the well or to conduct the gravel pack to the perforated or screened areas of the casing.

Cone of Depression (COD)/Cone of Influence (COI) — A cone-like depression of the water table or other piezometric surface that has the shape of an inverted cone and is formed in the vicinity of a well by withdrawal of water. The surface area included in the cone is known as the area of influence of the well. Also referred to as the *Pumping Cone* and the *Cone of Drawdown*.

Confined Aquifer — (1) An aquifer containing water between two relatively impermeable boundaries. The water level in a well tapping a confined aquifer stands above the top of the confined aquifer and can be higher or lower than the water table that may be present in the material above it. In some cases the water level can rise above the ground surface, yielding a flowing well. (2) An aquifer or water-bearing subsurface stratum which is bounded above and below by formations of impermeable or relatively impermeable material; a water-bearing formation whose upper boundary is a layer which does not transmit water readily. (3) An aquifer in which ground water is under pressure significantly greater than atmospheric and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the aquifer itself. See *Artesian Aquifer*.

Confined Ground Water — A body of ground water covered by material so impervious as to sever the hydraulic connection with overlying ground water except at the intake or recharge area. Confined water moves in pressure conduits due to the difference in head between intake and discharge areas of the confined water body.

Confined Water (Artesian) — Water under artesian pressure. Water that is not confined is said to be under water table conditions.

Confining Bed — A body of "impermeable" material stratigraphically adjacent to one or more aquifers. It may lie above or below the aquifer. In nature its hydraulic conductivity may actually range from nearly zero to some value distinctly lower than that of the aquifer. In some literature, the term confining bed has now supplanted the terms *Aquiclude*, *Aquitard*, and *Aquifuge*. Also referred to as *Confining Layer*.

Confining Unit — A hydrogeologic unit of relatively impermeable material, bounding one or more aquifers. This is a general term that has replaced *Aquitard*, *Aquifuge*, and *Aquiclude* and is synonymous with *Confining Bed*.

Confluence — (1) The act of flowing together; the meeting or junction of two or more streams; also, the place where these streams meet. (2) The stream or body of water formed by the junction of two or more streams; a combined flood.

Connate Water — Water that was trapped in the interstices of a sedimentary or extrusive igneous rock at the time of its deposition. It is usually highly mineralized and frequently saline.

Consequent Stream — A stream following a course that is a direct consequence of the original slope of the surface on which it developed.

Conservation District — A public organization crated under state-enabling law as a special purpose district to develop and carry out a program of soil, water, and related resource conservation, use, and development within its boundaries. In the United States, such districts are usually a subdivision of state government with a local governing body and are frequently called a soil conservation district or a soil and water conservation district.

Conservation Easement — An agreement negotiated on privately owned lands to preserve open space or protect certain natural resources.

Consolidated Aquifer — An aquifer made up of consolidated rock that has undergone solidification or lithification.

Consolidated Formation — Geological formations which occur naturally and have been turned to stone. The term is sometimes used interchangeably with the word *Bedrock*. It includes rock such as basalt, rhyolite, sandstone, limestone and shale. Typically, these formations will stand at the edges of a bore hole without caving.

Consolidation — (Soil Mechanics) Adjustment of a soil in response to increased load; involves squeezing of water from the pores and a decrease in void ratio (pore space). Frequently the geologic term *Compaction* is used instead.

Constant-Head Node - a location in the discretized ground water flow model domain (node) where the hydraulic head remains the same over the time period considered.

Constituents — Any of the chemical substances found in water. Typically, measurements of such constituents in sampled drinking water may consist of *Total Dissolved Solids (TDS)*, Hardness (concentrations of Calcium and Magnesium, specifically), Sodium, Potassium, Sulfate, Chloride, Nitrate, Alkalinity, Bicarbonate, Carbonate, Fluoride, Arsenic, Iron, Manganese, Copper, Zinc, Barium, Boron, Silica, as well as other physical characteristics and properties such as water color, turbidity, pH, and electro-conductivity (EC).

Constructed Wetlands — (1) Wetlands constructed by man either as part of a *Wetland Banking*, *Wetland Clumping (Aggregation),* or *Wetland Mitigation* program, or to achieve some other environmental preservation or restoration program. (2) (Water Quality) Wetlands constructed specifically for the purpose of treating waste water effluent before re-entering a stream or other body of water or being allowed to percolate into the ground water. Also see *Lagoon*.

Contaminant Fate - chemical changes and reactions that change the chemical nature of the contaminant, effectively removing the contaminant from the subsurface hydrologic system.

Contaminant Transport Model - a model describing the movement of contaminants in the environment.

Contaminant Transport Velocity - is the rate in which contamination moves through an aquifer.

Contamination (Water) — Impairment of the quality of water sources by sewage, industrial waste, or other matters to a degree which creates a hazard to public health. Also, the degradation of the natural quality of water as a result of man's activities. There is no implication of any specific limits, since the degree of permissible contamination depends upon the intended end use, or uses, of the water.

Continuous-Record Station (USGS) — A gaging station site that meets either of the following conditions: (1) Stage or streamflow are recorded at some interval on a continuous basis; the recording interval is usually 15 minutes, but may be less or more frequent; (2) water quality, sediment, or other hydrologic measurements are recorded at least daily.

Continuous Sample — A flow of water from a particular place in a plant to the location where samples are collected for testing. May be used to obtain *Grab Samples* or *Composite Samples*.

Creek — A small stream of water which serves as the natural drainage course for a drainage basin; a flowing rivulet or stream of water normally smaller than a river and larger than a brook. The term is often relative according to size and locality. Some creeks in a humid region would be called rivers if they occurred in an arid area.

Creep — Slow mass movement of soil and soil material down relatively steep slopes, primarily under the influence of gravity but facilitated by saturation with water and by alternate freezing and thawing.

Crenulation — Small-scale folding that is superimposed on larger-scale folding. Crenulations may occur along the cleavage planes of a deformed rock.

Critical Aquifer Protection Area (CAPA) — As defined in the *Safe Drinking Water Act (SDWA)*, is all or part of an area located within an area for which an application of designation as a sole or principal source aquifer (pursuant to Section 1424[e]) has been submitted and approved by the Administrator not later than 24 months after the date of enactment and which satisfies the criteria established by the Administrator; and all or part of an area that is within an aquifer designated as a sole source aquifer (SSA), as of the date of the enactment of the Safe Drinking Water Act Amendments of 1986, and for which an area-wide ground water protection plan has been approved under Section 208 of the *Clean Water Act (CWA)* prior to such enactment.

Critical Area — An area that, because of its size, location, condition, or importance, must be treated with special consideration because of inherent site factors and difficulty of management. Also, a severely eroded, sediment-producing area that requires special management to establish and maintain vegetation to stabilize the soil.

Critical (Ground Water) Area — An area that has certain ground water problems, such as declining water levels due, for example, to the use of underground water that approaches or exceeds the current recharge rate. These designated areas are usually limited in their development and use.

Critical Flow — (1) The flow conditions at which the discharge is a maximum for a given specific energy, or at which the specific energy is a minimum for a given discharge. (2) In reference to Reynolds' critical velocities, the point at which the flow changes from streamline or non-turbulent to turbulent.

Critical Low-Flow — Low flow conditions below which some standards (*Criteria*) do not apply. The impacts of permitted discharges are typically analyzed at critical low-flow.

Cumulative Impact — The environmental impacts of a proposed action in combination with the impacts of other past, existing and proposed actions. Each increment from each action may not be noticeable but cumulative impacts may be noticeable when all increments are considered together.

Current — (1) The portion of a stream or body of water which is moving with a velocity much greater than the average of the rest of the water. The progress of the water is principally concentrated in the current. (2) The swiftest part of a stream; (3) A tidal or nontidal movement of lake or ocean water; (4) Flow marked by force or strength.

Current Meter — An instrument for measuring the velocity of water flowing in a stream, open channel, or conduit by ascertaining the speed at which elements of the flowing water rotate a vane or series of cups.

Cut Bank — The outside bank of a bend, often eroding opposite a point bar.

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Darcy's Law — An empirically derived equation for the flow of fluids through porous media. It is based on the assumption that flow is laminar and inertia can be neglected, and states that velocity of flow is directly proportional to *Hydraulic Gradient*. For ground water, this is equivalent to the velocity being equal to the product of the hydraulic gradient and the effective subsoil conductivity or permeability. See *Specific Discharge* (*Specific Flux*).

Datum — Any numerical or geometric quantity or set of such quantities that may serve as a reference or base for other, comparable quantities. For example, *Mean Sea Level (MSL)* is the datum used on most topographic maps. However, most river gages use an arbitrary elevation above the *National Geodetic Vertical Datum (NGVD)* of 1929 for use as a zero datum (e.g., datum equals 3412.6 feet above NGVD of 1929). Datums are always chosen so there will never be negative stages.

Debris Flow — (1) A moving mass of rock fragments, soil, and mud with more than one-half of the material being larger than sand size. (2) A mass movement involving rapid flowage of debris of various kinds under various conditions; specifically, a high-density *Mudflow* containing abundant coarse-grained materials and resulting almost invariably from an unusually heavy rain. (3) The rapid mass movement of a dense, viscous mixture of rock fragments, fine earth, water and entrapped air that almost always follows a heavy rain. A mudflow is a debris flow that has predominately sand size or smaller particles.

Declared Underground Water Basin — An area of a state designated in some states by their respective State Engineers to be underlain by a ground water source having reasonably ascertainable boundaries. By such a designation, the State Engineer assumes jurisdiction over the appropriation and use of ground water from the source. May not be applicable in states which already claim regulatory rights over both surface and ground waters.

Deflocculate — To cause the particles of the disperse phase of a colloidal system to become suspended in the dispersion medium.

Deflocculating Agent — A material added to a suspension to prevent settling.
Degradation (River Beds or Stream Channels) — The general lowering of the streambed by erosive processes, such as scouring by flowing water. The removal of channel bed materials and downcutting of natural stream channels. Such erosion may initiate degradation of tributary channels, causing damage similar to that due to gully erosion and valley trenching. Opposite of *Aggradation*.

Degradation Constant - term used to address the decay of contaminant concentration due to factors other than dispersion.

Degrade — The lowering of a stream-channel bed with time due to the erosion and transport of bed materials or the blockage of sediment sources.

Dehydrate — (1) To remove bound water or hydrogen and oxygen from (a chemical compound) in the proportion in which they form water. (2) To remove water from (as foods). (3) To remove water from; make *Anhydrous*. (4) To Lose water or moisture; become dry.

Deionization — The removal of all charged atoms or molecules from some material such as water. For example, the removal of salt from water involves the removal of sodium ions (Na^+) and chloride ions (Cl^-). The process commonly employs one resin that attracts all positive ions and another resin to capture all negative ions.

Deionize — To remove ions from water by *Ion Exchange*. See *Deionization*.

Delay Time — Duration of time for contamination or water to move from point of concern to the well; analogous to time-of-travel.

Delegated State — A state (or other governmental entity such as a tribal government) that has received authority from the *U.S. Environmental Protection Agency (EPA)* to administer an environmental regulatory program in lieu of a federal counterpart. As used in connection with *National Pollutant Discharge Elimination System (NPDES)*, *Underground Injection Control (UIC)*, and *Public Water System (PWS)* programs, the term does not connote any transfer of federal authority to a state. Also see *Primacy*.

Delta — (1) An alluvial deposit made of rock particles (sediment and debris) dropped by a stream as it enters a body of water. (2) A plain underlain by an assemblage of sediments that accumulate where a stream flows into a body of standing water where its velocity and transporting power are suddenly reduced. (3) The low, nearly flat, alluvial tract of land deposited at or near the mouth of a river, commonly forming a triangular or fan-shaped plain of considerable area enclosed and crossed by many distributaries of the main river. Originally so named because many deltas are roughly triangular in plan, like the Greek letter delta (Ä), with the apex pointing upstream.

Demineralization, also Demineralize — The act or treatment process that removes dissolved minerals or mineral salts from a liquid, such as water.

De Minimis — Derived from the Latin meaning that the law does not care for or take notice of very small or trifling matters. De minimis water uses are those deemed by law to be too insignificant to notice.

Dendritic — (1) A drainage pattern in which tributaries branch irregularly in all directions from and at almost any angle to a larger stream. (2) A tree-like pattern, typical of most drainage networks. From an aerial view, it resembles the branching pattern of trees.

Denitrification — The removal of nitrate ions ($NO3^{-}$) from soil or water; involves the *Anaerobic* biological reduction of nitrate to nitrogen gas. The process reduces desirable fertility of an agricultural field or the extent of undesirable aquatic weed production in aquatic environments. Also see *Denitrifying Bacteria*.

Density — (1) Matter measured as mass per unit volume expressed in pounds per gallon (lb/gal), pounds per cubic foot (lb/ft^3), and kilograms per cubic meter (kg/m^3). The mass of quantity of a substance per unit volume. (2) (Biology) The number per unit area of individuals of any given species at any given time. A term used synonymously with *Population Density*.

Density Stratification — The arrangement of water masses into separate, distinct horizontal layers as a result of differences in density. Such differences may be caused by differences in temperature or dissolved and suspended solids. Also see *Thermal Stratification*.

(United States) Department of the Interior (USDI) — Originally established by Congress in 1849 as the executive department of the United States government, the USDI's function has changed from that of performing housekeeping duties for the federal government to its present role as custodian of the nation's natural resources. As the nation's principal conservation agency, the USDI has the responsibility of protecting and conserving the country's land, water, minerals, fish, and wildlife; of promoting the wise use of all these natural resources; of maintaining national parks and recreation areas; and of preserving historic places. It also provides for the welfare of American Indian reservation communities and of inhabitants of island territories under U.S. administration. As of 1988 the USDI managed more than 220 million hectares (550 million acres, or 850,000 square miles) of federal resource lands; about 340 units of the national park system; 70 fish hatcheries, and 442 *National Wildlife Refuges (NWF)*; and numerous reclamation dams that provide water, electricity, and recreation. The USDI also constructs irrigation works, enforces mine safety laws, makes geological surveys and prepares maps, conducts mineral research, and administers wild and scenic rivers as well as national and regional trails. The USDI is currently in charge of the *Bureau of Indian Affairs (BIA)*, the *U.S. Fish and Wildlife Service (USFWS)*, the *National Park Service (NPS)*, and the *U.S. Geological Survey (USGS)*. It also oversees the Bureau of Mines, which is responsible for ensuring that the nation has adequate mineral supplies and for overseeing and evaluating all aspects of minerals research; the *U.S. Bureau of Land Management (BLM)*, which manages public lands and their resources; the *U.S. Bureau of Reclamation (USBR)*, which assists local governments in reclaiming arid lands in western states and provides programs for hydro-electric power generation, flood control, and river regulation; the Minerals Management Service, which deals with leasable minerals on the Outer Continental Shelf and ensures efficient recovery of mineral resources; and the Office of Surface Mining Reclamation and Enforcement, which helps to protect the environment from adverse effects of coal mining operations. Other agencies under the USDI's jurisdiction include the

Office of Small and Disadvantaged Business Utilization and the Office of Territorial and International Affairs.

Depletion — (1) The water consumed within a service area or no longer available as a source of supply; that part of a withdrawal that has been evaporated, transpired, incorporated into crops or products, consumed by man or livestock, or otherwise removed. (2) Net rate of water use from a stream or ground water aquifer for beneficial and nonbeneficial uses. For irrigation or municipal uses, the depletion is the headgate or wellhead diversion minus return flow to the same stream or ground water aquifer. For agriculture and wetlands, it is the *Evapotranspiration of Applied Water (ETAW)* (and *Evapotranspiration (ET)* of flooded wetlands) plus irrecoverable losses. For urban water use, it is the ETAW (water applied to landscaping or home gardens), sewage effluent that flows to a salt sink, and incidental ET losses. For instream use, it is the amount of dedicated flow that proceeds to a salt sink and is not available for reuse.

Depletion (Ground Water) — The withdrawal of water from a ground water source at a rate greater than its rate of recharge, usually over an extended period of several years.

Depletion (Streamflow) — The amount of water that flows into a valley, or onto a particular land area, minus the water that flows out of the valley or off from the particular land area.

Depletion Curve — (Hydraulics) A graphical representation of water depletion from storage-stream channels, surface soil, and ground water. A depletion curve can be drawn for base flow, direct runoff, or total flow.

Deposition — The accumulation of material dropped because of a slackening movement of the transporting medium, e.g., water or wind. Also, the transition of a substance from the vapor phase directly to the solid phase, without passing through an intermediate liquid phase, also referred to as *Sublimation*.

Depression Storage — (1) Water contained in natural depressions in the land surface, such as puddles. (2) Water that is temporarily detained on the surface of the earth in puddles and cavities that have little or no surface outlet.

Depth of Runoff — The total runoff from a drainage basin divided by its area. For convenience in comparing runoff with precipitation, depth of runoff is usually expressed in inches during a given period of time over the drainage area expressed in inches per square mile.

Desiccation — (1) Loss of water from pore spaces of sediments through compaction or through evaporation caused by exposure to air. (2) (Geology) Used to refer to a long period of time between *Pluvial* (wet) episodes.

Desiccation Cracks — Surface fractures that can result from the drying of soil or porous sedimentary rock.

Designated Ground Water Basin — A basin where permitted ground water rights approach or exceed the estimated average annual recharge and the water resources are being depleted or require additional administration. Under such conditions, a state's water officials will so designate a ground water basin and, in the interest of public welfare, declare *Preferred Uses* (e.g., municipal and industrial, domestic, agriculture, etc.). Also referred to as *Administered Ground water Basin*.

Designated Uses — Those water uses identified in state water quality standards that must be achieved and maintained as required under the *Clean Water Act (CWA)*. Such uses may include cold water fisheries, public water supply, irrigation, recreation, minimum stream flows, etc.

Designated Watersheds — Watershed areas that have been set aside as sources of municipal water or other similar purposes would be included in this category. Other uses are either modified or excluded.

Detachment — The removal of transportable fragments of soil material from a soil mass by an eroding agent, usually falling raindrops, running water, or wind. Through this process, soil particles or aggregates are made ready for transport, the first stage in soil erosion.

Detention Basin — A relatively small storage lagoon for slowing stormwater runoff, generally filled with water for only a short period of time after a heavy rainfall.

Detention Facility — A surface water runoff storage facility that is normally dry but is designed to hold (detain) surface water temporarily during and immediately after a runoff event. Examples of detentional facilities are: natural swales provided with crosswise earthen berms to serve as control structures, constructed or natural surface depressions, subsurface tanks or reservoirs, rooftop storage, and infiltration or filtration basins.

Detention Storage — (1) The volume of water, other than *Depression Storage*, existing on the land surface as flowing water which has not yet reached the channel. (2) Water temporarily detained in the non-capillary pores of the soil, free to move by gravity, which it generally does within about 24 hours of the event that filled the pores.

Detention Time — (1) The theoretical calculated time required for a small amount of water to pass through a tank at a given rate of flow. (2) The actual time that a small amount of water is in a settling basin, flocculating basin, or rapid-mix chamber. (3) In storage reservoirs, the length of time water will be held before being used.

Detrital — (Geology) Clastic; rock and minerals occurring in sedimentary rocks that were derived from pre-existing igneous, sedimentary, or metamorphic rocks.

Detritus — (1) The heavier mineral debris moved by natural water courses, usually in the form of *Bed Load*. (2) The sand, grit, and other coarse material removed by differential sedimentation in a relatively short period of detention. (3) Bits of vegetation, animal remains, and other organic material that form the base of food chains in wetlands and many other kinds of habitats.

Dewater, and Dewatering — (1) To remove water from a waste produce or streambed, for example. (2) The extraction of a portion of the water present in sludge or slurry, producing a dewatered product which is easier to handle. (3) (Mining) The removal of ground water in conjunction with mining operations, particularly open-pit mining when the excavation has penetrated below the ground-water table. Such operations may include extensive ground-water removal and, if extensive enough and if not re-injected into the ground water, these discharges may alter surface water (stream) flows and lead to the creation of lakes and wetland areas. As such water removals only last so long as the mine is in operation, eventually surface water impacts, if present, will be eliminated, consequently jeopardizing surface water uses, such as irrigation, livestock, wildlife, or riparian habitat that may have become dependent upon the continuation of these temporary flows. Also, when the mine dewatering operations cease, the remaining open pit will eventually begin to fill up with ground water, resulting in significantly increased evaporation from ground water reservoirs.

Diatomaceous Earth — A yellow, white or light-gray material composed of the siliceous shells of *Diatoms* (fossilized diatoms) and used in water filtration to filter out solid waste in wastewater treatment plants; also used as an active ingredient in some powdered pesticides. Also referred to as *Diatomite*.

Diffusion — The movement of a substance from an area of high concentration to an area of low concentration. Turbulent diffusion results from atmospheric motions diffusing water, vapor, heat, and other gaseous components by exchanging parcels called eddies between regions in space in apparent random fashion.

Diffusion Coefficient — (1) The rate at which solutes are transported at the microscopic level due to variations in the solute concentrations within the fluid phases. (2) The rate of dispersion of a chemical caused by the kinetic activity of the ionic or molecular constituents. Also referred to as the *Coefficient of Molecular Diffusion*.

Dike — (1) (Engineering) An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands; a levee. (2) A low wall that can act as a barrier to prevent a spill from spreading. (3) (groin, spur, jetty, deflector, boom) A structure designed to: (a) reduced water velocity as stream flow passes through the dike so that sediment deposition occurs instead of erosion (permeable dike), or (b) deflect erosive currents away from the stream bank (impermeable dike). (4) (Geology) A tabular body of igneous (formed by volcanic action) rock that cuts across the structure of adjacent rocks or cuts massive rocks.

Dilute — To make thinner or less concentrated by adding a liquid such as water.

Dilution — The reduction of the concentration of a substance in air or water.

Dimictic Lake (or Reservoir) — A stratified lake or reservoir that experiences two periods of full mixing or *(Fall and Spring) Overturns* annually. The water in lakes layer in response to differences in the temperatures of surface and deep waters. The surface water will be warmer because of radiant heating by the sun, and the bottom water will be cooler and therefore denser. The waters in these two layers (termed the *Epilimnion* on the surface and *Hypolimnion* on the bottom) are separated by a boundary referred to as the *Thermocline*. This layering is disrupted in response to variation in air temperature associated with changes in the seasons of the year. As the epilimnion cools, it sinks, mixing the water within the lake. Contrast with *Meromictic Lake*.

Discharge — (1) The volume of water (or more broadly, the volume of fluid including solid- and dissolved-phase material), that passes a given point in a given period of time. (2) The flow of surface water in a stream or the flow of ground water from a spring, ditch, or flowing artesian well. (3) (Hydraulics) The rate of flow, especially fluid flow; the volume of fluid passing a point per unit time, commonly expressed as cubic feet per second, million gallons per day, gallons per minute, or cubic meters per second.

Discharge (Hydrologic) — (1) The volume of water passing through a channel during a given time, usually measured in cubic feet per second (cfs). (2) In its simplest concept, discharge means outflow and is used as a measure of the rate at which a volume of water passes a given point. Therefore, the use of this term is not restricted as to course or location, and it can be used to describe the flow of water from a pipe or a drainage basin. With reference to ground water, the process by which ground water leaves the *Zone of Saturation* via *Evaporation*, *Evapotranspiration*, or by flow to the surface through springs and seeps. The data in the reports of the *U.S. Geological Survey (USGS)* on surface water represent the total fluids measured. Thus, the terms discharge, streamflow, and runoff represent water with the solids dissolved in it and the sediment mixed with it. Of these terms, discharge is the most comprehensive. The discharge of drainage basins is distinguished as follows:

[1] ***Yield*** — The total water runout or "water crop" and includes runoff plus underflow;

[2] ***Runoff*** — That part of water yield that appears in streams; and

[3] ***Streamflow*** — The actual flow in streams, whether or not subject to regulation or underflow. Each of these terms can be reported in total volumes (e.g., acre-feet) or time-related rates of flow (e.g., cubic feet per second or acre-feet per year).

Discharge Area — (1) An area in which ground water is discharged to the land surface, surface water, or atmosphere. (2) An area in which there are upward components of hydraulic head in the aquifer. Ground water is flowing toward the surface in a discharge area and may escape as a spring, seep, or base flow, or by evaporation and transpiration.

Discharge Permit — A permit issued by the state to discharge effluent into waters of the state.

Discharge Point — A location at which effluent is released into a receiving stream or body of water.

Discretization - is the process of subdividing the continuous model and/or time domain into discrete segments or cells. Algebraic equations which approximate the governing flow and/or transport equations are written for each segment or cell.

Dispersivity - a scale dependent property of an aquifer that determines the degree to which a dissolved constituent will spread in flowing ground water. Dispersivity is comprised of three directional components - longitudinal, transverse and vertical.

Dispersion - process by which some of the water molecules and solute molecules travel more rapidly than the average linear velocity and some travel more slowly; spreading of the solute in the direction of the ground water flow (longitudinal dispersion) or direction perpendicular to ground water flow (transverse dispersion).

Dispersion Coefficient - (1) a measure of the spreading of a flowing substance due to the nature of the porous medium, with its interconnected channels distributed at random in all directions; (2) the sum of the coefficients of mechanical dispersion and molecular diffusion in a porous medium.

Displacement — (Geology) The distance by which portions of the same geological layer are offset from each other by a fault.

Dissection — The partial erosional destruction of a land surface or landform by gully, arroyo, canyon or valley cutting leaving flattish remnants, or ridges, or hills or mountains separated by drainageways.

Dissolved — That material in a representative water sample that passes through a 0.45-micrometer membrane filter. This is a convenient operational definition used by federal agencies that collect water data. Determination of "dissolved" constituents are made on subsamples of the filtrate.

Dissolved Load — All the material transported by a stream or river in solution, as contrasted with *Bed Load* and *Suspended Load*.

Dissolved Oxygen (DO) — (1) Concentration of oxygen dissolved in water and readily available to fish and other aquatic organisms. (2) The amount of free (not chemically combined) oxygen dissolved in water, wastewater, or other liquid, usually expressed in milligrams per liter, parts per million, or percent of saturation. The content of water in equilibrium with air is a function of atmospheric pressure, temperature, and dissolved-solids concentration of the water. The ability of water to retain oxygen decreases with increasing temperature or dissolved solids, with small temperature changes having the more significant offset. Photosynthesis and respiration may cause diurnal variations in dissolved-oxygen concentration in water from some streams. Adequate concentrations of dissolved oxygen are necessary for the life of fish and other aquatic organisms and the prevention of offensive odors. Dissolved oxygen levels are considered the most important and commonly employed measurement of water quality and indicator of a water body's ability to support desirable aquatic life. The ideal dissolved oxygen level for fish is between 7 and 9 milligrams per liter (mg/l); most fish cannot survive at levels below 3 mg/l of dissolved oxygen. Secondary and advanced wastewater treatment techniques are generally designed to ensure adequate dissolved oxygen in waste-receiving waters.

Dissolved Solids — (1) Minerals and organic mater dissolved in water. (2) The dissolved mineral constituents or chemical compounds in water or solution; they form the residue that remains after evaporation and drying. Excessive amounts of dissolved solids make water unfit to drink or use in industrial processes.

Dissolved-Solids Concentration — For water this concentration is determined either analytically by the "residue-on-evaporation" method, or mathematically by totaling the concentrations of individual constituents reported in a comprehensive chemical analysis. During that analytical determination of dissolved solids, the bicarbonate (generally a major dissolved component of water) is converted to carbonate. Therefore, in the mathematical calculation of dissolved-solids concentration, the bicarbonate value, in milligrams per liter, is multiplied by 0.4926 to reflect the change. Alternatively, alkalinity concentration (as in mg/L of $CaCO^3$) can be converted to carbonate concentration by multiplying by 0.60.

Distributary — A diverging stream which does not return to the main stream, but discharges into another stream or the ocean. Also refers to conduits that take water from a main canal for delivery to a farm.

Distributary Channel (or Stream) — A river branch that flows away from a main stream and does not rejoin it. Characteristic of *Deltas* and *Alluvial Fans*.

Distribution Coefficient - the quantity of the solute, chemical or radionuclide sorbed by the solid per unit weight of solid divided by the quantity dissolved in the water per unit volume of water.

Distribution Graph (Distribution Hydrograph) — A *Unit Hydrograph* of direct runoff modified to show the portion of the volume of runoff that occurs during successive equal units of time.

Disturbed Area — (Geology) Area where vegetation, topsoil, or overburden has been removed, or where topsoil, spoil, and processed waste has been placed.

Diversion — (1) A structure in a river or canal that divers water from the river or canal to another watercourse. (2) The transfer of water from a stream, lake, aquifer, or other source of water by a canal, pipe, well, or other conduit to another watercourse or to the land, as in the case of an irrigation system. Also, a turning aside or alteration of the natural course of a flow of water, normally considered physically to leave the natural channel. In some states, this can be a consumptive use direct from a stream, such as by livestock watering. In other states, a diversion must consist of such actions as taking water through a canal or conduit.

Divide — An imaginary line indicating the limits of a sub-basin, sub-watershed, or watershed; the boundary line along a topographic ridge or high point which separates two adjacent drainage basins. Also referred to as *Ridge Lines*.

Domestic Well — A water well used solely for domestic, i.e., residential or household purposes to include both indoor and outdoor water uses. Such wells are generally not required to be permitted; however, they may have restrictions in terms of daily pumping amounts, for example, 1,800 gallons per day.

Downgradient — The direction that ground water flows; similar to "downstream" for surface water flows.

Downgradient Well — One or more monitoring wells placed to sample ground water that has passed beneath a facility with the potential to release chemical contaminants into the ground. Results of testing downgradient well water are compared with data from an *Upgradient Well* to determine whether the facility may be contaminating the ground water.

Drainage — (1) The removal of excess surface water or ground water from land by means of surface or subsurface drains. (2) Improving the productivity of agricultural land by removing excess water from the soil by such means as ditches or subsurface drainage tiles (pipes). (3) The downward movement of water through the soil. When this occurs rapidly, the soil is referred to as "well drained"; otherwise poorly drained. Most plant roots need oxygen as well as water, and soil that remains saturated (poorly drained) deprives roots of necessary oxygen. (4) Soil characteristics that affect natural drainage.

Drainage Basin — (1) The land area drained by a river. (2) Part of the Earth's surface that is occupied by a drainage system with a common outlet for its surface runoff. (3) Part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water. The term is used synonymously with *Watershed*, *River Basin*, or *Catchment*.

Drainage Class, Soils — The relative terms used to describe natural drainage and corresponding types of soils are as follows:

- [1] ***Excessive*** – Excessively drained soils are commonly very porous and rapidly permeable, and have low water-holding capacity;
- [2] ***Somewhat Excessive*** – Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile;
- [3] ***Good*** – Well drained soils that are nearly free of mottling and are commonly of intermediate texture;
- [4] ***Moderately Good*** – Moderately well drained soils that commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the surface layers and upper subsoil, and mottling in the lower subsoils and substrata;
- [5] ***Somewhat Poor*** – Somewhat poorly drained soils are wet for significant periods, but not all the time. They commonly have a slowly permeable layer in their profile, a high water table, additions through seepage, or a combination of these conditions;
- [6] ***Poor*** – Poorly drained soils are wet for long periods of time. They are light gray and generally are mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Drainage Divide — The line of highest elevations which separates adjoining drainage basins.

Drawdown — (1) The act, process, or result of depleting, as a liquid or body of water as in the lowering of the water surface level due to release of water from a reservoir. (2) The magnitude of lowering of the surface of a body of water or of its piezometric surface as a result of withdrawal of the release of water there from. (3) The decline of water below the static level during pumping. (4) (Water Table) The lowering of the elevation of the *Ground water Table*, usually from pumping wells, but can occur naturally during periods of prolonged drought. At the well, it is the vertical distance between the static and the pumping level.

Driller's Well Log — A log kept at the time of drilling showing the depth, thickness, character of the different strata penetrated, location of water-bearing strata, depth, size, and character of casing installed.

Drilling Mud — A mixture of clay, water, and other materials, often bentonite clay and barite, commonly used in drilling with a rotary drill rig. The mud is pumped down the drill pipe and through a drill bit and back up to the surface between the drill pipe and the walls of the hole. The mud helps lubricate and cool the drill bit as well as carry the cuttings to the surface. The mud also stabilizes the hole. Also referred to as *Drilling Fluid*.

Drinking Water — A term used synonymously with *Potable Water*, and refers to water that meets federal drinking water standards of the *Safe Drinking Water Act [SDWA] (Public Law 93–523)* as well as state and local water quality standards and is considered safe for human consumption. Freshwater that exceeds established standards for chloride content and dissolved solids limits is often referred to as slightly saline, brackish, or nonpotable water and is either diluted with fresher water or treated through a desalination process to meet drinking-water standards for public supply.

Drinking Water Standards — Drinking water standards established by state agencies, the U.S. Public Health Service, and the *U.S. Environmental Protection Agency (EPA)* for drinking water throughout the United States. [See Appendix B–1 for regulated contaminants and Appendix B–2 for proposed contaminants to be regulated by the *Safe Drinking Water Act [SDWA] (Public Law 93–523)*]

Drumlin — An elongated hill or ridge of *Glacial Drift*.

Dry Adiabatic Lapse Rate — The *Adiabatic Lapse Rate* for air not saturated with water vapor, or 0.98EC per 100 meters rise (5.4EF per 1,000 feet), expressed as:

ãd = –*dT*/*dz*

where:*dT* is the change in air temperature; *dz* is the change in altitude; and ãd is the dry adiabatic lapse rate. Compare to *Wet Adiabatic Lapse Rate*.

Dynamic Equilibrium — (1) (General) An open system in a steady state in which there is continuous inflow of materials, but within which the form or character of the system remains unchanged. (2) (Surface Water) Within dynamic equilibrium the channel exhibits patterns of erosion and deposition but there is no net change in the input and output of materials. The state is stable but features may change over time. (3) (Ground water) A condition of which the amount of recharge to an aquifer equals the amount of natural discharge.

Dystrophic Lake — A lake characterized by a lack of nutrients, and often having a low pH (acidic) and a high humus content. Plant and animal life are typically sparse, and the water has a high oxygen demand. This stage follows the *Eutrophic Phase* in the life cycle of a lake.

-E-

Easement — A legal instrument enabling the giving, selling, or taking or certain land or water rights without transfer of title, such as for the passage of utility lines. An affirmative easement gives the owner of the easement the right to use the land for a stated purpose. A negative easement is an agreement with a private property owner to limit the development of his land in specific ways.

Effective Porosity — The amount of interconnected pore space through which fluids can pass, expressed as a percentage of the total volume occupied by the interconnecting interstices. Porosity may be primary, formed during deposition or cementation of the material, or secondary, formed after deposition or cementation, such as fractures. Part of the total porosity will be occupied by static fluid being held to the mineral surface by surface tension, so effective porosity will be less than total porosity.

Effluent — (1) Something that flows out or forth, especially a stream flowing out of a body of water. (2) (Water Quality) Discharged wastewater such as the treated wastes from municipal sewage plants, brine wastewater from desalting operations, and coolant waters from a nuclear power plant.

Effluent Guidelines — Technical *U.S. Environmental Protection Agency (EPA)* documents which set effluent limitations for given industries and pollutants.

Effluent Limitation — An amount or concentration of a water pollutant that can be legally discharged into a water body by a *Point Source (PS)*, expressed as the maximum daily discharge, the maximum discharge per amount of product, and/or the concentration limit in the wastewater stream, as a 24–hour or 30–day average. The applicable technology-based standard is set by the *U.S. Environmental Protection Agency (EPA)* by *Standard Industrial Classification (SIC) Code*, but differs between new and existing sources and by broad types of water pollutants: conventional pollutants, toxic pollutants, nonconventional, nontoxic pollutants; dredge and fill wastes; and heat discharges.

Effluent Seepage — Diffuse discharge of ground water to the ground surface.

Effluent Standard — The maximum amounts of specific pollutants allowable in wastewater discharged by an industrial facility or wastewater treatment plant. The standards are set for individual pollutants and apply across all industrial categories. This term can be contrasted with *Effluent Limitations*, which are set for individual pollutants by *Standard Industrial Classification (SIC) Code*.

Effluent Streams — Effluent streams are those leaving a lake. Also referred to as *Gaining Stream*. Also see *Stream*.
Eh - also known as redox potential. Eh is a numerical measure of the intensity of oxidation or reducing conditions. A positive potential indicates oxidizing conditions and a negative potential indicates reducing conditions.

Electrical Conductivity — A measure of the salt content of water.

Electrical Log — A record of electrical-resistivity tests made at various depths in a well.
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Electrolyte — (1) (Chemistry) Any compound that dissociates into ions when dissolved in water. The solution that results will conduct an electric current. For example, table salt (NaCl) is an electrolyte. (2) (Physiology) Any of various ions, such as sodium, potassium, or chloride, required by cells to regulate the electric charge and flow of water molecules across the cell membrane.

Elevation Datum Plane — Arbitrary surface that serves as a common reference for the elevations of points above or below it. Elevations are expressed in terms of feet, meters, or other units of measure and are identified as negative or positive depending on whether they are above or below the datum plane.

Elevation Head — The potential energy in a hydraulic system, represented by the vertical distance between the hydraulic system (pipe, channel, etc.) and a reference level, and expressed in length units. The sum of the elevation head and the *Pressure Head* is equal to the *Hydraulic Head*. Also referred to as the *Total Head*.

Eluviation — (1) The removal of soil material in suspension (or in solution) from a layer or layers of a soil. (2) The transportation of dissolved or suspended material within the soil by the movement of water when rainfall exceeds evaporation.

Embankment — An artificial deposit of material that is raised above the natural surface of the land and used to contain, divert, or store water, support roads or railways, or for other similar purposes.

Emergency Spillway — A dam spillway built to carry runoff in excess of that carried by the principal spillway; a secondary spillway designed to operate only during exceptionally large floods. Also referred to as *Auxiliary Spillway*.

Energy Dissipator — (1) A structure for slowing the fast moving spillway flows of a dam in order to prevent erosion of the stream channel below the dam. (2) An apron of rocks, logs, concrete baffles, or other materials that slows down water flowing through a culvert or ditch, or over a dam, and thereby reduces its erosive force.

Entrainment — (Streams) (1) To be moved by water motion involuntarily. (2) The incidental trapping of fish and other aquatic organisms in the water, for example, used for cooling electrical power plants or in waters being diverted for irrigation or similar purposes.

Environmental Assessment (EA) — An environmental analysis prepared pursuant to the *National Environmental Policy Act (NEPA)* that presents the first thorough examination of alternative plans to positively demonstrate that the environmental and social consequences of an applicable project or action were considered. If it is determined that proposed actions would not have a significant impact on the environment, then a *Finding of No Significant Impact (FONSI)* would be issued. If it is shown that such activities do, in fact, significantly impact the environment or are otherwise deemed controversial, then an *Environmental Impact Statement (EIS)* will normally be required.

Environmental Impact Statement (EIS) — A report required by Section 102(2)(c) of Public Law 91–190, *National Environmental Policy Act (NEPA)*, for all major projects which significantly impact on the quality of the human environment or are environmentally controversial. The EIS is a detailed and formal evaluation of the favorable and adverse environmental and social impacts of a proposed project and its alternatives. A tool for decision making, the EIS describes the positive and negative effects of an undertaking and cites possible, less environmentally disruptive alternative actions. Also see *Environmental Assessment (EA)*.

(United States) Environmental Protection Agency (EPA) — The U.S. Environmental Protection Agency (EPA) is responsible for implementing the federal laws designed to protect the environment. EPA endeavors to accomplish it mission systematically by proper integration of a variety of research, monitoring, standard-setting, and enforcement activities. As a complement to its other activities, EPA coordinates and supports research and antipollution activities of state and local governments, private and public groups, individuals, and educational institutions. EPA also monitors the operations of other Federal agencies with respect to their impact on the environment. EPA was created through Reorganization Plan #3 of 1970, which was devised to consolidate the federal government's environmental regulatory activities into a single agency. The plan was sent by the President to Congress on July 9, 1970, and the agency began operation on December 2, 1970. EPA was formed by bringing together 15 components from 5 executive departments and independent agencies. Air pollution control, solid waste management, radiation control, and the drinking water program were transferred from the Department of Health, Education, and Welfare (now the Department of Health and Human Services). The federal water pollution control program was taken from the Department of the Interior, as was part of a pesticide research program. From the Department of Agriculture, EPA acquired authority to register pesticides and to regulate their use, and from the Food and Drug Administration, EPA inherited the responsibility to set tolerance levels of pesticides in food. EPA was assigned some responsibility from the Atomic Energy Commission, and absorbed the duties of the Federal Radiation Council. The enactment of major new environmental laws and important amendments to older laws in the 1970s and 1980s greatly expanded EPA's responsibilities. The agency now administers ten comprehensive environmental protection laws:

[1] Clean Air Act (CAA)
[2] Clean Water Act (CWA)

[3] Safe Drinking Water Act (SDWA)

[4] Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or "Superfund")

[5] Resource Conservation and Recovery Act (RCRA)

[6] Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

[7] Toxic Substances Control Act (TSCA)

[8] Marine Protection, Research, and Sanctuaries Act (MPRSA)

[9] Uranium Mill Tailings Radiation Control Act (UMTRCA)

[10] Pollution Prevention Act The primary mandates for the water-related programs administered through the EPA Water Management Division are the *Federal Water Pollution Control Act (Public Law 92–500)*, as amended, commonly referred to as the *Clean Water Act (CWA)*, and the *Safe Drinking Water Act (SDWA — Public Law 93–523)*. The CWA addresses the discharge of pollutants from point and nonpoint sources into waters of the United States (as defined). The goal of the SDWA is to protect public health over lifetime exposure to drinking water by ensuring that the source water as well as the system storage distribution and service lines are free and protected from contamination. EPA water-related programs establish national and regional objectives, promote delegation of programs to states (primacy), and support that delegation in a manner that ensures achievement of required objectives. Also see *Science Advisory Board (SAB)*. [See Appendix E–1 for a more complete description of the organizational structure of the U.S. Environmental Protection Agency.]

Eolian — Pertaining to the wind; especially said of rocks, soils, and deposits (such as loess, dune sand, sand from volcanic tuffs) whose constituents were transported (blown) and laid down by atmospheric currents, or of landforms produced or eroded by the wind, or of sedimentary structures (such as ripple marks) made by the wind, or of geologic processes (such as erosion and deposition) accomplished by the wind.

Ephemeral (Stream) — A stream that flows only in direct response to precipitation, and thus discontinues its flow during dry seasons. Such flow is usually of short duration. Most of the dry washes of more arid regions may be classified as ephemeral streams. Also see *Stream*.

Equipotential Line — A line in a field of flow such that the total head is the same for all points on the line; therefore, the direction of flow is perpendicular to the line at all points.

Equipotential Surface — A surface (or line) in a three-dimensional ground-water flow field such that the total hydraulic head is the same everywhere on the surface.

Erosion — (1) Detachment of soil particles under the influence of water and/or wind. (2) The wearing away and removal of materials of the earth's crust by natural means. (3) The process by which flood waters lower the ground surface in an area by removing upper layers of soil. As usually employed, the term includes weathering, solution, corrosion, and transportation. The agents that accomplish the transportation and cause most of the wear are running water, waves, moving ice, and wind currents. Most writers include under the term all the mechanical and chemical agents of weathering that loosen rock fragments before they are acted on by the transportation agents; a few authorities prefer to include only the destructive effects of the transporting agents. Various types of water erosion include:

[1] ***Accelerated*** **–** Erosion much more rapid than normal, natural, or geologic erosion, primarily as a result of the influence of the activities of man or, in some cases, of other animals or natural catastrophes that expose bare surfaces, for example, forest fires;

[2] ***Geological*** – The normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building up of floodplains, coastal plains, etc., and also referred to as natural erosion;

[3] ***Gross*** – A measure of the potential for soil to be dislodged and moved from its place of origin, not necessarily the amount of soil that actually reaches a stream or lake, but the amount of soil that can be calculated from water and wind equations;

[4] ***Gully*** – The erosion process whereby water accumulates in narrow channels and, over short periods of time, removes soil from this narrow area to considerable depths, ranging from 1–2 feet (0.3–0.6 meters) to as much as 75–100 feet (23–31 meters);

[5] ***Natural*** – The wearing away of the earth's surface by water, ice, or other natural agents under natural environmental conditions of climate, vegetation, etc., undisturbed by man, and also referred to as geological erosion;

[6] ***Normal*** – The gradual erosion of land used by man that does not greatly exceed natural erosion;

[7] ***Overfall*** **–** Erosion caused by water flowing over an overfall;

[8] ***Rill*** – An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently cultivated soils and/or recent cuts and fills;

[9] ***Sheet*** – The removal of a thin, fairly uniform layer of soil from the land surface by runoff waters;

[10] ***Shore*** – Removal of soil, sand, or rock from the land adjacent to a body of water due to wave action;

[11] ***Splash*** – The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surface runoff;

[12] ***Streambank*** **–** Scouring of material and the cutting of channel banks by running water;

[13] ***Streambed*** **–** Scouring of material and cutting of channel beds by running water;

[14] ***Undercutting*** – Removal of material at the base of a steep slope, overfall, or cliff by falling water, a stream, wind erosion, or wave action; the removal steepens the slope or produces an overhanging cliff.

Erosion Control — Materials, structures, and actions utilized and taken to reduce or prevent erosion. The application of necessary measures including artificial structures, vegetative manipulation, water control, or physical soil changes to minimize soil erosion.

Erosion, Gully — The widening, deepening, and headcutting of small channels and waterways due to erosion.

Erosion, Rill — Removal of soil by running water with formation of shallow channels that can be smoothed out completely by normal cultivation (tillage).

Erosion, Sheet — The removal of a fairly uniform layer of soil or materials from the land surface by the action of rainfall and runoff water.

Escarpment — A steep slope or long cliff that results from erosion or faulting and separates two relatively level areas of differing elevations; the topographic expression of a fault.

Esker — A narrow ridge of gravelly or sandy glacial outwash material deposited by a stream in an ice tunnel within a glacier.

Estuarine — (1) Of, pertaining to, or formed in, an *Estuary*. (2) One of the classification systems under the *Wetlands* and *Deepwater Habitats* classification system. See *Wetlands*. [Also see Appendix D–2, Wetlands and Deepwater Habitats, for additional information on this classification system and specific characteristics of Estuarine Systems.]

Estuarine Waters — Deepwater tidal habitats and tidal wetlands that are usually enclosed by land but have access to the ocean and are at least occasionally diluted by freshwater runoff from the land (such as bays, mouths of rivers, salt marshes, lagoons, etc.).

Estuary — (1) An area where fresh water meets salt water; for example, bays, mouths of rivers, salt marshes, and lagoons. (2) That portion of a coastal stream influenced by the tide of the body of water into which it flows, for example, a bay or mount of a river, where the tide meets the river current; an area where fresh and marine waters mix. The *Coastal Zone Management Act* of 1972 defines an estuary as "that part of a river or stream or other body of water having unimpaired connection with the open sea, where the sea-water is measurably diluted with freshwater derived from land drainage." These brackish water ecosystems shelter and feed marine life, birds, and wildlife.

Eutrophic (Water) — Pertaining to a lake or other body of water characterized by large nutrient concentrations such as nitrogen and phosphorous and resulting high productivity. Such waters are often shallow, with algal blooms and periods of oxygen deficiency. Slightly or moderately eutrophic water can be healthful and support a complex web of plant and animal life. However, such waters are generally undesirable for drinking water and other needs. Degrees of *Eutrophication* typically range from *Oligotrophic* water (maximum transparency, minimum chlorophyll–a, minimum phosphorus) through *Mesotrophic*, *Eutrophic*, to *Hypereutrophic* water (minimum transparency, maximum chlorophyll–a, maximum phosphorus). Also see *Carlson's Trophic State Index (TSI)* and *(Mean) Trophic State Index (TSI)*.

Eutrophication — (1) The degradation of water quality due to enrichment by nutrients, primarily nitrogen (N) and phosphorus (P), which results in excessive plant (principally algae) growth and decay. When levels of N:P are about 7:1, algae will thrive. Low dissoved oxygen (DO) in the water is a common consequence. (2) The process of enrichment of water bodies by nutrients. (3) Over-enrichment of a lake or other water body with nutrients, resulting in excessive growth of organisms and the depletion of oxygen. Degrees of *Eutrophication* typically range from *Oligotrophic* water (maximum transparency, minimum chlorophyll–a, minimum phosphorus) through *Mesotrophic*, *Eutrophic*, to *Hypereutrophic* water (minimum transparency, maximum chlorophyll–a, maximum phosphorus). Eutrophication of a lake normally contributes to its slow evolution into a *Bog* or *Marsh* and ultimately to dry land. Eutrophication may be accelerated by human activities and thereby speed up the aging process.

Eutrophic Lakes — Lakes that are rich in nutrients and organic materials, therefore, highly productive for plant growth. These lakes are often shallow and seasonally deficient in oxygen in the *Hypolimnion*. Also see *Oligotrophic Lakes*.

Evaporation — (1) The physical process by which a liquid (or a solid) is transformed to the gaseous state. (2) The process by which water is changed from a liquid to a vapor. In *Hydrology*, evaporation is vaporization that takes place at a temperature below the boiling point. Also see *Evapotranspiration*.

Extrusive Bedrock — (Geology) Those *Igneous Rocks* derived from volcanic lavas that cooled on the surface of the earth. This lava cools rapidly and forms fine-textured rocks such as basalt and andesite.

-F-

Fahrenheit Temperature Scale — A thermometric scale on which the freezing point of water is at 32EF (Fahrenheit) above the 0E(F) mark on the scale, and the boiling point of water is at 212EF. The Fahrenheit temperature scale was designed by German physicist Daniel Fahrenheit and is commonly used in the United States. Contrast with the *Centigrade Temperature Scale*, using degrees *Celsius* (EC), in which 0E(C) marks the freezing point of water and 100EC indicates the boiling point of water (at sea level). The formula for converting a Fahrenheit temperature to Celsius is CE=5/9 x (FE – 32).

Fall Overturn — A physical phenomenon that may take place in a body of water during early autumn. The sequence of events leading to fall overturn include:
[1] The cooling of surface waters;
[2] A density change in surface waters producing convection currents from top to bottom;
[3] The circulation of the total water volume by wind action; and
[4] Eventual vertical temperature equality. The overturn results in a uniformity of the physical and chemical properties of the entire water body. Also referred to as *Fall Turnover*. Also see *Spring Overturn*.

Falling Limb — The portion of the *Hydrograph* trace immediately following the peak and reflecting the decreasing production of storm flow.

Farmland, Prime — As defined in the *Farmland Protection Policy Act of 1981*: Land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is available for these uses (urban areas are not included). It has the soil quality, growing season, and moisture supply needed for the economic production of sustained high yields of crops when treated and managed (including water management) according to acceptable farming methods. Prime farmland includes land that is being used currently to produce livestock and timber, but it excludes land committed to urban development or water storage.

Fault — (Geology) A fracture in rock along which movement can be demonstrated. A fracture in the earth’s crust forming a boundary between rock masses that have shifted. Faults may be classified as follows:

- [1] ***Active Fault*** – A fault that has moved recently and which is likely to move again, usually defined as one that has shown movement within the last 11,000 years and can be expected to move again within the next 100 years;
- [2] ***Potentially Active Fault*** – A fault that moved within the Quaternary Period (i.e., within the last 2 million years) or a fault which, because it is judged to be capable of ground rupture or shaking, poses an unacceptable risk for a proposed project or structure;

[3] ***Historically Active Fault*** – A fault active within the last 200 years;
[4] ***Inactive Fault*** – A fault which has shown no evidence of movement in recent geologic time and no potential for movement in the relatively near future.

Fault Creep — A very slow movement along a fault which is unaccompanied by perceptible earthquakes.

Fault Escarpment — (Geology) A fracture or fracture zone along which there has been displacement of one side with respect to the other.

Fault-Line Scarp — A steep slope produced along an old fault line by differential weathering and erosion, rather than by fault movement.

Fault Scarp — A cliff formed by a fault, usually modified by erosion unless the fault is very recent.

Fault Trace — The intersection of a fault and the earth's surface as often revealed by dislocation of fences and roads and/or by ridges and furrows in the ground.

Fauna — (1) A term used to describe the animal species of a specific region or time. (2) All animal life associated with a given habitat, country, area, or period.

Feasibility Study (FS) — (1) A complete assessment of alternative courses of action to solve one or more problems, to meet needs, and to recommend the most practical course of action consistent with state and local planning objectives. (2) (Environmental) Analysis of the practicability of a proposal, e.g., a description and analysis of potential cleanup alternatives for a site such as one on the *National Priorities List (NPL)*. The feasibility study usually recommends selection of a cost-effective alternative. It usually starts as soon as the *Remedial Investigation (RI)* is underway; together, they are commonly referred to as the "RI/FS".

Federal Water Pollution Control Act (Public Law 92–500) — More commonly referred to as the *Clean Water Act (CWA)*, constitutes the basic federal water pollution control statute for the United States. Originally based on the *Water Quality Act* of 1965 which began setting water quality standards. The 1966 amendments to this act increased federal government funding for sewage treatment plants. Additional 1972 amendments established a goal of zero toxic discharges and "fishable" and "swimmable" surface waters. Enforceable provisions of the CWA include technology-based effluent standards for point sources of pollution, a state-run control program for nonpoint pollution sources, a construction grants program to build or upgrade municipal sewage treatment plants, a regulatory system for spills of oil and other hazardous wastes, and a wetlands preservation program.

Fen — Low land covered wholly or partly with water; a *Moor* or *Marsh*. A type of *Wetland* that accumulates peat deposits. Fens are less acidic than *Bogs*, deriving most of their water from ground water rich in calcium and magnesium.

Ferrous Sulfate — A greenish crystalline compound, FeSO4•H2O, used as a pigment, fertilizer, and feed additive, in sewage and water treatment, and as a medicine in the treatment of iron deficiency. Also called *Copperas*.

Field Characterization - a review of historical, on- and off-site, as well as surface and sub-surface data and the collection of new data to meet project objectives; field characterization is a necessary prerequisite to the development of a conceptual model.

Fill — (Geology) Any sediment deposited by any agent such as water so as to fill or partly fill a channel, valley, sink, or other depression.

Fill Material — Soil that is placed at a specified location to bring the ground surface up to a desired elevation or angle of slope.

Filling — Depositing dirt, mud or other materials into aquatic areas to create more dry land, usually for agricultural or commercial development purposes, and frequently with ruinous ecological consequences. Also see *Wetland Banking*, *Wetland "Clumping" (Aggregation)*, and *Wetland Mitigation*.

Finding of No Significant Impact (FONSI) — A document prepared by a federal agency showing why a proposed action would not have a significant impact on the environment and thus would not require the preparation of an *Environmental Impact Statement (EIS)*. A FONSI is based on the results of an *Environmental Assessment (EA)*.

Finite Difference Method (FDM) - a discretization technique for solving a partial differential equation (PDE) by (1) replacing the continuous domain of interest by a finite number of regular-spaced mesh- or grid-points (i.e., nodes) representing volume-averaged sub-domain properties; and (2) by approximating the derivatives of the PDE for each of these points using finite differences; the resulting set of linear or nonlinear algebraic equations is solved using direct or iterative matrix solving techniques.

Finite Element Method (FEM) - similar to finite difference method with the exception that (1) the mesh may consist of regular or irregular-spaced grid points which may have irregular shapes; and (2) the PDE is approximated using the method of weighted residuals to obtain a set of algebraic equations. These algebraic equations are solved using direct or iterative matrix solving techniques.

Finite Difference Model - a type of numerical model that uses a mathematical technique called the finite-difference method to obtain an approximate solution to the governing partial differential equation (in space and time).

Finite Element Model - a numerical model that uses a mathematical technique called the finite-element method to obtain an approximate solution to the governing partial differential equation (in space and time).

(United States) Fish and Wildlife Service (USFWS) — Part of the U.S. Department of the Interior, the early beginnings of the Fish and Wildlife Service go back to 1871 when the federal government established the Commissioner of Fisheries. In 1896, the Division of Biological Survey was established within the Department of Agriculture. In 1939, these functions were transferred to the Department of the Interior. Then in 1940, these functions were formally consolidated and redesignated as the Fish and Wildlife Service. Further reorganization came in 1956 when the Fish and Wildlife Act created the Bureau of Sport Fisheries and Wildlife. An amendment to this act in 1974 designated the Bureau as the U.S. Fish and Wildlife Service. Today the USFWS consists of a headquarters in Washington, D.C., eight regional offices, and over 700 field units and installations. Included are more than 470 National Wildlife Refuges, comprising more than 90 million acres, 57 fish and wildlife research laboratories and field units, 43 cooperative research units at universities across the country, nearly 135 national fish hatcheries and fishery assistance stations, and a nationwide network of law enforcement agents and biologists. The functions of the USFWS primarily includes the following:

[1] Acquires, protects and manages unique ecosystems necessary to sustain fish and wildlife,

such as migratory birds and endangered species;

[2] As specified in the *Endangered Species Act (ESA)* (1973), as amended, and in conjunction with the *National Marine Fisheries Service (NMFS)*, determines critical habitat and develops recovery plans for protected endangered and threatened species of plants and animals;

[3] Operates fish hatcheries to support research, develop new techniques and fulfill the public demand for recreational fishing;

[4] Operates wildlife refuges to provide, restore, and manage a national network of lands and waters sufficient in size, diversity and location to meet society's needs for areas where the widest possible spectrum of benefits associated with wildlife and wildlands is enhanced and made available;

[5] Conducts fundamental research on fish, wildlife and their habitats to provide better management and produce healthier and more vigorous animals; also protects fish and wildlife from dislocation or destruction of their habitats;

[6] Renders financial and professional assistance to states, through federal aid programs, for the enhancement and restoration of fish and wildlife resources;

[7] Establishes and enforces regulations for the protection of migratory birds, marine mammals, fish and other non-endangered wildlife from illegal taking, transportation or sale within the United States or from foreign countries; and

[8] Communicates information essential for public awareness and understanding of the importance of fish and wildlife resources, and changes reflecting environmental degradation that ultimately will affect the welfare of human beings.

Fixed Ground Water — Water held in saturated material within pore spaces so small that it is permanently attached to the walls, or moves so slowly that it is usually not available as a source of water for pumping.

Flood Plain, also Floodplain — (1) (FEMA) Any normally dry land area that is susceptible to being inundated by water from any natural source. This area is usually low land adjacent to a river, stream, watercourse, ocean or lake. (2) A strip of relatively smooth land bordering a stream, built of sediment carried by the stream and dropped in the slack water beyond the influence of the swiftest current. It is called a *Living Flood Plain* if it is overflowed in times of high water but a *Fossil Flood Plain* if it is beyond the reach of the highest flood. (3) The lowland that borders a stream or river, usually dry but subject to flooding. (4) The transversely level floor of the axial-stream drainageway of a semi-bolson or of a major desert stream valley that is occasionally or regularly alluviated by the stream overflowing its channel during flood. (5) The land adjacent to a channel at the elevation of the bankfull discharge, which is inundated on the average of about 2 out of 3 years. The floor of stream valleys, which can be inundated by small to very large floods. The one-in-100-year floodplain has a probability of 0.01 chance per year of being covered with water. (6) That land outside of a stream channel described by the perimeter of the *Maximum Probable Flood*. Also referred to as a *Flood-Prone Area*.

Flood Stage — (1) An elevation for the water level at high flows. (2) The elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area in which the elevation is measured.

Floor — A generic term for the nearly level, lower-part of an inter-montane basin (a bolson or semi-bolson) or a major desert stream valley.

Flora — (1) A term used to describe the entire plant species of a specified region or time. (2) The sum total of the kinds of plants in an area at one time. All plant life associated with a given habitat, country, area, or period. *Bacteria* are considered flora.

Flow — (1) The movement of water. (2) The rate of water discharged from a source given in volume with respect to time.

(Ground Water) Flow Model — (1) A digital computer model that calculates a hydraulic head field for the modeling domain using numerical methods to arrive at an approximate solution to the differential equation of ground-water flow. (2) Any representation, typically using plastic or glass cross-sectional viewing boxes, with representative soil samples, depicting ground-water flows and frequently used for educational purposes.

Flow, Laminar — Flow of water in well-defined flow lines in which the viscous force is predominant; in channels it occurs at a *Reynolds Number* smaller than 500–2,000 and through porous media at Reynolds Number smaller than 1–10.

Flow, Natural — The rate of water movement past a specified point on a natural stream from a drainage area which has not been affected by stream diversion, storage, import, export, return flow or change in consumptive use resulting from man's modification of land use. Natural flow rarely occurs in a developed country.

Flow, Net — A graphical representation of flow lines and *Equipotential Lines* for two-dimensional, steady-state ground-water flow.

Flow, Overland — The flow of rainwater or snowmelt over the land surface toward stream channels. Upon entering a stream, it becomes runoff.

Flow Path — The subsurface course a water molecule or solute would follow in a given ground-water velocity field.

Flow Rate — (1) The speed or rate at which water is taken from a water course or the speed at which it flows past a point, usually measured in gallons per hour or cubic feet per second (cfs). (2) The rate, expressed in gallons or liters-per-hour, at which a fluid escapes from a hole or fissure in a tank. Such measurements are also made of liquid waste, effluent, and surface water movement.

Flow, Turbulent — A flow in which successive flow particles follow independent path lines, and head loss varies approximately with the square of the velocity. In stream channels it occurs at a *Reynolds Number* greater than 5,000.

Flow, Uniform — A characteristic of a flow system where specific discharge has the same magnitude and direction at any point.

Flow Velocity — (1) The volume of water flowing through a unit cross-sectional area of an aquifer. Also referred to as *Specific Discharge*. (2) Speed at which water moves during a flood. Velocities usually vary across the floodplain. They are usually greatest near the channel and lowest near the edges of the floodplain.

Flowing Well — An *Artesian Well* having sufficient head to discharge water above the land surface; a well where the *Piezometric Surface* lies above the ground surface.

Flowmeter — A gauge indicating the velocity of wastewater moving through a treatment plant or of any liquid moving through various industrial processes.

Fluve — A linear depression, rill, gully, arroyo, canyon, valley, etc., of any size, along which flows at some time, a drainageway.

Fluvial — Of or pertaining to rivers and streams; growing or living in streams or ponds; produced by the action of a river, stream or flood flow, as in a fluvial plain.

Fluvial Geomorphology (Geomorphologist) — The science concerned specifically with the influences of water and rivers on the erosional cycle of land deposition and degradation over time. While hydrology concentrates on the description, measurement, and analysis of precipitation and the flow of water on the earth's surface and underground, fluvial geomorphology concentrates on understanding the processes that govern the influence of water on the landscape over time.

Flux - the volume of fluid crossing a unit cross-sectional surface area per unit time.

Fold — (Geology) A bend or flexure in a layer or layers of rock.

Footslope — The relatively gently sloping, slightly concave slope component of an erosional slope that is at the base of the backslope component. Synonymous with *Pediment.*

Ford — (1) A shallow place in a body of water, such as a river, where one can cross by walking or riding on an animal or in a vehicle. (2) An at-grade stream crossing that uses the bottom of the channel in lieu of a bridged or culverted crossing.

(United States) Forest Service (USFS) — The largest and most diverse agency of the U.S. Department of Agriculture, the Forest Service provides leadership in the management, protection, and use of the nation's forests and rangelands, which comprise almost two-thirds of the nation's federally owned lands. The creation of the Forest Service go back to 1891 when the President was authorized to establish Forest Reserves from forest and range lands in the *Public Domain*. In 1905 the responsibilities for the management and protection of these Forest Reserves was transferred from the Department of the Interior to the Department of Agriculture and the Forest Service was formally established. The Forest Reserves were then renamed National Forests. Today the Forest Services manages 156 National Forests, 19 National Grasslands, and 16 Land Utilization Projects that make up the National Forest System located in 44 states, Puerto Rico, and the Virgin Islands. Much of the nation's fresh water supply flows from National Forest System lands and insuring adequate yields of high quality water and continuing soil productivity are primary aims of the Forest Service's watershed management programs. The Forest Service manages more than 14 percent of the nation's 1.2 billion acres of forest range. This National Forest System (NFS) rangeland is managed to conserve the land and its vegetation while providing food for both domestic livestock and wildlife. The Forest Service manages fish and wildlife habitat on the National Forests and National Grasslands in cooperation with the individual states' fish and game departments. Of the 191 million acres of National Forests, 86.5 million acres are classified as commercial forests, available for, and capable of, producing crops of industrial wood. National Forest timber reserves are managed on a sustained-yield basis to produce a continuous supply of wood products to meet the nation's economic demands while maintaining the productive capacity of these lands. In 1924 the Forest Service pioneered the establishment of wilderness areas on National Forest lands. National Forest lands are a major source of mineral and energy supplies with regulatory and management responsibilities for mineral activities shared with the Department of the Interior, Bureau of Mines. The Forest Service, with one of the world's largest wildland firefighting forces, provides direct fire protection and control for National Forest System lands as well as cooperative fire control on several million additional acres. The Forest Service is responsible for the forest management aspects of the Watershed Protection and Flood Prevention Program administered by the *Natural Resources Conservation Service (NRCS)*. The Forest Service also participates in the forestry aspects of the River Basin Program, which guides and coordinates water and related land resource planning among several federal departments. The Forest Service operates an extensive forestry research program consisting of eight Forest and Range Experiment Stations, a Forest Products Laboratory, and 75 research labs located throughout the U.S., Puerto Rico, and the Pacific Trust Territories. The Forest Service is organized into nine (9) regions as listed below (regional headquarters are in parentheses):

[1] ***Eastern Region*** (Milwaukee, Wisconsin) – Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, West Virginia, Ohio, Indiana, Michigan, Illinois, Missouri, Iowa, Wisconsin, Minnesota;
[2] ***Southern Region*** (Atlanta, Georgia) – Virginia, North Carolina, South Carolina, Kentucky, Tennessee, Georgia, Florida, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas;
[3] ***Rocky Mountain Region*** (Denver, Colorado) – South Dakota, Nebraska, Kansas, Wyoming, Colorado;
[4] ***Northern Region*** (Missoula, Montana) – North Dakota, Montana, Idaho (northern part only), South Dakota (northwest corner only), Wyoming (northwest corner only);
[5] ***Intermountain Region*** (Ogden, Utah) – Nevada, Utah, Idaho (except northern portion), Wyoming (western portion only);
[6] ***Southwest Region*** (Albuquerque, New Mexico) – Arizona, New Mexico;
[7] ***Pacific Northwest Region*** (Portland, Oregon) – Washington, Oregon;
[8] ***Pacific Southwest Region*** (San Francisco, California) – California, Hawaii;
[9] ***Alaska Region*** (Juneau, Alaska) – Alaska.

Formation — (Geology) A body of rock or soil of considerable thickness that has characteristics making it distinguishable from adjacent geologic structures.

Fossil Water — Limited subterranean water deposits laid down in past ages but drawn on by modern man.

Fracture — A general term for any break in rock, which includes cracks, joints, and faults.

Fractured Bedrock Aquifer — An aquifer composed of solid rock, but where most water flows through cracks and fractures in the rock instead of through pore spaces. Flow through fractured rock is typically relatively fast.

Fragile Area — Areas that, due to steepness, soil type, exposure, and cover, are especially subject to soil erosion and rapid deterioration. Also referred to as *Critical Area*.

Freeboard — (1) The vertical distance between a design maximum water level and the top of a structure such as a channel, dike, floodwall, dam, or other control surface. The freeboard is a safety factor intended to accommodate the possible effect of unpredictable obstructions, such as ice accumulation and debris blockage, that could increase stages above the design water surface. (2) (Nautical) The distance between the water line and the uppermost full deck of a ship. For dams, the terms "net freeboard", "dry freeboard", "flood freeboard", or "residual freeboard" refer to the vertical distance between the estimated maximum water level and the top of a dam. "Gross freeboard" or "total freeboard" is the vertical distance between the maximum planned controlled retention water level and the top of a dam. (3) (FEMA) A factor of safety expressed in feet above a design flood level for flood protective or control works. Freeboard is intended to allow for all of the uncertainties in analysis, design and construction which cannot be fully or readily considered in an analytical fashion.

Free Flow — (Hydraulics) Flow through or over a structure not affected by submergence or backwater.

Free-Flowing Stream — A stream or a portion of a stream that is unmodified by the works of man or, if modified, still retains its natural scenic qualities and recreational opportunities.

Free-Flowing Well — An *Artesian Well* in which the potentiometric surface is above the land surface. Also see *Potentiometric Surface*.

Free Ground Water — Water in interconnected pore spaces in the *Zone of Saturation* down to the first impervious barrier, moving under the control of the water table slope.

Free Water Surface (FWS) Constructed Wetland — A type of constructed wetland, a man-made marsh-like area used to treat wastewater. In this type of wetland, the effluent flows through various aquatic plants, with the water level exposed to the air. While this type of wetland is relatively easy to construct, it is not as effective as the *Subsurface Flow (SF) Constructed Wetland* with respect to associated odors, potential for insect breeding, and risk of public exposure and contact with the water in the system. Also see *Wetlands, Benefits*.

French Drain — An underground passageway for water through the interstices among stones placed loosely in a trench.

Fresh-Salt Water Interface — The region where fresh water and salt water meet.

Freshwater (Fresh Water) — (1) Of, relating to, living in, or consisting of water that is not salty. (2) Water with salinity less than 0.5‰ (parts per thousand) dissolved salts. (3) Water that contains less than 1,000 milligrams per liter (mg/l) of dissolved solids; generally, more than 500 mg/l of dissolved solids is undesirable for drinking and many industrial uses. (4) (Nautical) Accustomed to sailing on inland waters only as a fresh water sailor. Also see *Sweet Water*.

Freshwater Marsh — (1) Open wetlands that occur along rivers and lakes, and in many other areas. Sedges, reeds, rushes, and grasses are the dominant plants in freshwater marshes. (2) A *Circumneutral Ecosystem* of more or less continuously water-logged soil dominated by emersed herbaceous plants, but without a surface accumulation of peat.

Freshwater Swamps — Forested or shrubby wetlands. *Pocosins* and heaths are two examples of freshwater swamps.

Friable — (1) Said of a rock or mineral that crumbles naturally or is easily broken, pulverized, or reduced to powder, such as a soft or poorly cemented sandstone. (2) Said of a soil consistency in which moist soil material crushes easily under gentle to moderate pressure (between thumb and forefinger) an coheres when pressed together.

Fringe Water — Water occurring in the *Capillary Fringe*.

Fringe Marsh — A saturated, poorly drained area, intermittently or permanently water covered, close to and along the edge of a land mass.

Front — (1) Land bordering a lake or river. (2) (Meteorology) A line of separation or interface between air masses of different temperatures or densities.

Frontage — Land adjacent to something, such as a body of water.

Frost Heave — Ruptured soil, rock, or pavement caused by the expansion of freezing water immediately beneath the surface.

Frost Line — The depth to which frost penetrates the earth.

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Gabion — A wire cage, usually rectangular, filled with cobbles and used as a component for water control structures or for channel and bank protection.

Gaging Station — A particular site on a stream, canal, lake, or reservoir where systematic observations of *Gage Height* or discharge are obtained through mechanical or electrical means. When used in connection with a discharge record, the term is applied only to those gaging stations where a continuous record of discharge is computed. Also referred to as a *Gage*.

Gaining Stream — A stream or reach of a stream, the flow of which is being increased by the inflow of ground water seepage or from springs in, or alongside, the channel. Also referred to as an *Effluent Stream*. Also see *Stream*.

Geographic Information System (GIS) — A computer information system that can input, store, manipulate, analyze, and display geographically referenced (spatial) data to support the decision-making processes of an organization. A map based on a database or databases. System plots locations of information on maps using latitude and longitude.

Geography — The science of the earth and life, especially the description of land, sea, air, and the distribution of plant and animal life, including man and his industries, with reference to the mutual relations among these diverse elements. As general areas of study, geography is divided into:

[1] ***Mathematical Geography*** — deals with the figure and motion of the earth, of its seasons, tides, etc., of its measurement, and of its representation on maps and charts by various methods of projection;

[2] ***Physical Geography*** — deals with the exterior physical features and changes of the earth's land, water, and air;

[3] ***Biological Geography*** — has to do with the relation of living things to their physical environment; and

[4] ***Commercial Geography*** — deals with commodities, their place of origin, paths of transactions, etc.

Geohydrology — A term which denotes the branch of *Hydrology* relating to subsurface or subterranean waters; that is, to all waters below the surface. Related terms include *Geohydrologic* and *Geohydrologist*.

Geologic Erosion — Normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building up of flood plains, coastal plains, etc.

Geologic Log — A detailed description of all underground features (e.g., depth, thickness, type of formation, etc.) discovered during the drilling of a well.

Geological Survey — A systematic examination of an area to determine the character, relations, distribution and origin or mode of formation, of its rock masses and other natural resources.

(United States) Geological Survey (USGS) — An agency of the U.S. Department of Interior responsible for providing extensive earth-science studies of the Nation's land, water, and mineral resources. The USGS was established by an act of Congress on March 3, 1879, to provide a permanent federal agency to conduct the systematic and scientific "classification of the public lands, and examination of the geological structure, mineral resources, and products of national domain." An integral part of that original mission is to publish and distribute the earth-science information needed to understand, plan the use of, and manage the nation's energy, land, mineral, and water resources. Since 1879, the research and fact-finding role of the USGS has grown and been modified to meet the changing needs of the nation it serves. As part of that evolution, the USGS has become the map-making agency for the federal government, the primary source of data on surface- and ground-water resources of the nation, and the employer of the largest number of professional earth scientists. The USGS is organized into three operational Divisions: the National Mapping Division (NMD), charged with development and application of mapping and *Geographic Information System (GIS)* technology; the Geologic Division (GD), which conducts geologic mapping and research; and the Water Resources Division (WRD). The mission of the Water Resources Division of the USGS is to provide the hydrologic information and understanding needed to manage the nation's water resources to benefit its residents. Typical water resource programs sponsored by the WRD include:

[1] Data collection to aid in evaluating the quantity, quality, distribution, and use of the nation's water resources;
[2] Analytical and interpretive water-resources appraisals to describe the occurrence, quality, and availability of surface and ground water throughout the nation;
[3] Basic and problem-oriented research in hydraulics, hydrology, and related fields of science and engineering;
[4] Scientific and technical assistance in hydrology to other federal, state, and local agencies;
[5] Development and maintenance of national computer data bases and associated Geographic Information Systems (GIS) of hydrologic data — streamflow, water quality and biology, ground water characteristics, and water use; and
[6] Public distribution of water-resources data and results of water-resources investigations through reports, maps, computerized information services, and other forms of release. Programs of the Water Resources Division are funded under three types of arrangements:

[1] ***Federal Program*** — funding is appropriated directly to USGS by the U.S. Congress for projects of national interest;
[2] ***Cooperative Program*** — funding is shared by USGS and interested state and local agencies; and
[3] ***Other Federal Agencies (OFA) Program*** — funding is supplied by federal agencies requesting technical assistance from the USGS. The Water Resources Division's headquarters is at the USGS National Center in Reston, Virginia. Regional offices are maintained in Reston; Atlanta, Georgia; Denver, Colorado; and Menlo Park, California. With the exception of the National Research Program (NRP) centers at Reston, Denver, and Menlo Park, most of the WRD program is distributed to 51 USGS District Offices organized by state boundaries.

Geomorphic Surface — A mappable area of the land surface formed during a defined time period by deposition or erosion (or both, in different parts) of at least a thickness of material sufficient to accommodate a pedogenic soil. Its age (i.e., period of formation) ordinarily is defined by relations to other geomorphic surfaces, or by the soils or sediments that form or underlie the surface.

Geomorphology (Geomorphic) — That branch of both physiography and geology that deals with the form of the earth, the general configuration of its surface, and the changes that take place in the evolution of land forms. The term usually applies to the origins and dynamic morphology (changing structure and form) of the earth's land surfaces, but it can also include the morphology of the sea floor and the analysis of extraterrestrial terrains. Sometimes included in the field of physical geography, geomorphology is really the geological aspect of the visible landscape. Also see *Geomorphology, Historical*, and *Geomorphology, Process*.

Geomorphology, Historical — Historical geomorphology represents one branch of *Geomorphology* which provides the means to analyze the long-term change in landforms through the concept of cyclic change. The concepts evolved at the turn of the 20th century and were put forward by the American geologist William Morris Davis. The theory stated that every landform could be analyzed in terms of structure, process, and stage. Structure and process are treated by the science of geomorphology. However, the concept of stage introduced the element of time, and is subject to a far greater degree of interpretation. As postulated by Davis, every landform underwent development through a predictable, cyclic sequence: i.e., youth, maturity, and old age. Historical geomorphology relies on various chronological analyses, notably those provided by stratigraphic studies of the last 2 million years, known as the *Quaternary Period*. The relative chronology usually may be worked out by observation of stratigraphic relationships, with the time intervals involved established more precisely by dating methods such as historical records, radiocarbon analysis, tree-ring counting (*Dendrochronology*), and paleomagnetic studies. By applying such methods to stratigraphic data, a quantitative chronology of events is constructed that provides a means for calculating long-term rates of change. Also see *Geomorphology, Process*.

Geomorphology, Process — The second branch of *Geomorphology*, process geomorphology analyzes contemporary dynamic processes at work in landscapes. The mechanisms involved are weathering and erosion and combine processes that are in some respects destructive and in others constructive. The bedrock and soil provide the passive material, whereas the climatic regime and crustal dynamics together provide the principal active variables.

Geophysical Log — A record of the structure and composition of the earth encountered when drilling a well or similar type of test or boring hole.

Geophysics, also Geophysical — The study of the physical characteristics and properties of the earth, including geodesy, seismology, meteorology, oceanography, atmospheric electricity, terrestrial magnetism, and tidal phenomena.

Glacial Drift — All earth material transported and deposited by the ice and/or by water flowing from a glacier. It consists of rock flour, sand, pebbles, cobbles, and boulders, and may occur in a heterogeneous mass or be reasonably well sorted, depending on the manner of deposition.

Glacial Epochs — (Geology) Any of those parts of geological time, from Pre-Cambrian time onward in both the Northern and Southern hemispheres, during which a much larger portion of the earth was covered by glaciers than at present. More specifically refers to the latest of the glacial epochs, that of the Quaternary period, known as the *Pleistocene Epoch*, beginning some 3 million years ago, during which Canada, northern and northeastern U.S., northern and northwestern Europe, and northern Asia, together with most high mountain regions in the Northern Hemisphere were largely covered with ice. It has been divided into a number of stages. Those recognized for the interior of North America are, in order of age: *Jerseyan* or *Nebraskan* (glacial); *Aftonian* (interglacial); *Kansan* (glacial); *Yarmouth* and *Buchanan* (interglacial); *Illinoian* (glacial); *Sangamon* (interglacial); *Iowan* (glacial); *Peorian* (interglacial); *Earlier Wisconsin* (glacial); an unnamed (interglacial) interval; *Later Wisconsin* (glacial); *Champlain* (glaciolacustrine epoch).

Glacial Outwash — Stratified material, chiefly sand and gravel deposited by meltwater streams in front of the margin of a glacier.

Glacial Period — (Geology) The period of time encompassing the *Glacial Epochs*.

Glacial Till — Till is the mixture of rocks, boulders, and soil picked up by a moving glacier and carried along the path of the ice advance. The glacier deposits this till along its path — on the sides of the ice sheet, at the toe of the glacier when it recedes, and across valley floors when the ice sheet melts. These till deposits are akin to the footprint of a glacier and are used to track the movement of glaciers. These till deposits can be good sources of ground water, if they do not contain significant amounts of impermeable clays.

Glacier Meal — Finely ground rock particles produced by glacial abrasion. Also referred to as *Rock Flour*.

Glaciofluvial Deposits — Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and may occur in the form of outwash plains, deltas, kames, eskers, and kame terraces. Also see *Glacial Action*, *Glacial Drift* and *Glacial Till*.

Glaciolacustrine — (Geology) Pertaining to, or characterized by, glacial and lacustrine processes or conditions applied especially to deposits made in lakes.

Glade — An open, spacious *Wetland*, as in the *Everglades*.

Glauconite — A greenish clay mineral, a hydrous silicate of potassium, iron, aluminum, or magnesium, (K,Na)(Al,Fe,Mg)2(Al,Si)4O10(OH)2, found in greensand and used as a fertilizer and water softener.

Global Positioning System (GPS) — A system which verifies latitude and longitude of a location on the ground through the use of a transmitter and a remote (satellite) vehicle.

Grab Sample — Typically, a single water or air sample drawn over a short time period. As a result, the sample is not representative of long-term conditions at the sampling site. This type of sampling yields data that provides a snapshot of conditions or concentrations at a particular point in time.

Graben — (Geology) (1) A depressed tract bounded on at least two sides by faults and generally of considerable length as compared to its width. (2) A rather steeply sided valley formed when faulting caused a block-shaped area to drop relative to the surrounding terrain. Lake Tahoe, situated on the border between the states of California and Nevada, occupies a graben.

Graded Stream — A stream in which, over a period of years, the slope is delicately adjusted to provide, with available discharge and with prevailing channel characteristics, just the velocity required for transportation of the sediment load supplied from the drainage basin. Also, a stream in which most irregularities, such as waterfalls and cascades, are absent. Streams tend to cut their channels lower at a very slow rate after they become graded.

Grade Stabilization Structure — A structure for the purpose of stabilizing the grade of a gully or other watercourse, thereby preventing further head-cutting or lowering of the channel grade.

Gradient — Degree of incline; slope of a stream bed. The vertical distance that water falls while traveling a horizontal distance downstream. Also see *Hydraulic Gradient* and *Temperature Gradient*.

Gram Molecular Weight (GMW) — The mass, in grams, of a substance equal to its molecular weight. For example, the molecular weight of water (H2O) is 18 (the sum of the atomic weights of two hydrogen atoms and one oxygen atom), so its gram molecular weight is 18 grams. The amount of a material equal to its gram molecular weight comprises one gram-mole of the substance.

Granite — (Geology) A light-colored plutonic igneous rock made up of interlocking grains of glassy or milky quartz, white or pink feldspar, and specks of dark mica or hornblende. The Sierra Nevada Mountains (California and Nevada) are made up of granite and similar rock types.

Gravel — A mixture composed primarily of rock fragments 2 mm (0.08 inch) to 7.6 cm (3 inches) in diameter. Usually contains much sand.

Gravel Envelope — In well construction, a several-inch thickness of uniform gravel poured into the annular space between the well casing and the drilled hole. Also referred to as *Gravel Pack.*

Gravitational Head — Component of total *Hydraulic Head* related to the position of a given mass of water relative to an arbitrary datum.

Gravitational Water — Water that moves into, through, or out of a soil or rock mass under the influence of gravity.

Gravity Flow — The downhill flow of water through a system of pipes, generated by the force of gravity.

Greenbelt — (1) A strip of natural vegetation growing parallel to a stream that provides wildlife habitat and an erosion and flood buffer zone. This strip of vegetation also retards rainfall runoff down the bank slope and provides a root system that binds soil particles together. (2) An area where measures are applied to mitigate fire, flood and erosion hazards to include fuel management (suppression of combustibles), land use planning, and development standards. More traditionally, an irrigated landscaped buffer zone between developed areas and wildlands, usually put to additional uses such as parks, bike and riding trails, golf courses, etc.

Ground Rupture — The movement of the ground along one side of a *Fault* relative to the other side, caused by an earthquake.

Ground Truth — (Data Analysis and Interpretation) Verification of aerial photointerpretation by observers on the ground.

Ground Water, also Ground water — (1) Generally, all subsurface water as distinct from *Surface Water*; specifically, the part that is in the saturated zone of a defined aquifer. (2) Water that flows or seeps downward and saturates soil or rock, supplying springs and wells. The upper level of the saturate zone is called the Water Table. (3) Water stored underground in rock crevices and in the pores of geologic materials that make up the earth's crust. Ground water lies under the surface in the ground's *Zone of Saturation*, and is also referred to as *Phreatic Water*.

Ground Water Barrier — Rock, clay, or other natural or artificial materials with a relatively low permeability that occurs (or is placed) below ground surface, where it impedes the movement of ground water and thus causes a pronounced difference in the heads on opposite sides of the barrier.

Ground Water Basin — A ground-water reservoir together with all the overlying land surface and the underlying aquifers that contribute water to the reservoir. In some cases, the boundaries of successively deeper aquifers may differ in a way that creates difficulty in defining the limits of the basin. A ground-water basin could be separated from adjacent basins by geologic boundaries or by hydrologic boundaries.

Ground Water, Confined — Ground water under pressure significantly greater than atmospheric, with its upper limit the bottom of a bed with hydraulic conductivity distinctly lower than that of the material in which the confined water occurs.

Ground Water Discharge — (1) The flow of water from the *Zone of Saturation*. (2) (Water Quality) Ground water entering near coastal waters which has been contaminated by landfill leachate, deep well injection of hazardous wastes, septic tanks, etc.

Ground Water Divide — A line on a water table on either side of which the water table slopes downward. It is analogous to a drainage divide between two drainage basins on a land surface. It is also the line of highest *Hydraulic Head* in the water table or *Potentiometric Surface*.

Ground Water Flow — (1) Water that moves through the subsurface soil and rocks. (2) The movement of water through openings in sediment and rock that occurs in the *Zone of Saturation*.

Ground Water Flow Model — (1) A digital computer model that calculates a hydraulic head field for the modeling domain using numerical methods to arrive at an approximate solution to the differential equation of ground-water flow. (2) Any representation, typically using plastic or glass cross-sectional viewing boxes, with representative soil samples, depicting ground-water flows and frequently used for educational purposes.

Ground Water, Free — Unconfined ground water whose upper boundary is a free water table.

Ground Water Hydraulics — The study of the movement of water, especially water under pressure and water's movement through various soil medium.

Ground Water Hydrology — The branch of *Hydrology* that deals with ground water; its occurrence and movements, its replenishment and depletion, the properties of rocks that control ground water movement and storage, and the methods of investigation and utilization of ground water. Also referred to as *Ground Water Hydraulics*, although this term pertains more to the study of the motion of water.

Ground Water Law — The common law doctrine of *Riparian Rights* and the doctrine of prior appropriation (*Appropriative Rights*) as applied to ground water.

Ground Water Level — The elevation of the water table or another potentiometric surface at a particular location.

Ground Water Mining — (1) The withdrawal of ground water through wells, resulting in a lowering of the ground water table at a rate faster than the rate at which the ground water table can be recharged. (2) The withdrawal of water from an aquifer in excess of recharge which, if continued over time, would eventually cause the underground supply to be exhausted or the water table could drop below economically feasible pumping lifts.

Ground Water Modeling Code - the computer code used in ground water modeling to represent a non-unique, simplified mathematical description of the physical framework, geometry, active processes, and boundary conditions present in a reference subsurface hydrologic system.

Ground Water Mound — Raised area in a water table or other *Potentiometric Surface*, created by *Ground Water Recharge*. See *Ground water Mounding*.

Ground water Mounding — Commonly, an outward and upward expansion of the free water table caused by shallow re-injection, percolation below and impoundment, or other surface recharge method (essentially, the reverse of the cone of depression effect created by a pumping well). Mounding can alter ground water flow rates and direction; however, the effects are usually localized and may be temporary, depending upon the frequency and duration of the surface recharge events.

Ground Water Outflow — That part of the discharge from a drainage basin that occurs through the ground water. The term "underflow" is often used to describe the ground water outflow that takes place in valley alluvium (instead of the surface channel) and thus is not measured at a gaging station.

Ground Water Overdraft — The condition of a ground water basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years during which water supply conditions approximate average. Sometimes used interchangeably with *Ground Water Mining*.

Ground Water, Perched — Ground water that is separated from the main body of ground water by an impermeable (unsaturated) layer.

Ground Water Plume — A volume of contaminated ground water that extends downward and outward from a specific source; the shape and movement of the mass of the contaminated water is affected by the local geology, materials present in the plume, and the flow characteristics of the area ground water.

Ground Water Prime Supply — The long-term average annual percolation to the major ground water basins from precipitation falling on the land and from flows in rivers and streams. Also includes recharge from local sources that have been enhanced by construction of spreading ground or other means. Recharge of imported and reclaimed water is not included nor is recharge using applied irrigation water.

Ground Water Recharge — (1) The infiltration of water into the earth. It may increase the total amount of water stored underground or only replenish the ground water supply depleted through pumping or natural discharge. (2) The natural or intentional infiltration of surface water into the *Zone of Saturation*, i.e., into the *Ground Water*. (2) Inflow of water to a ground water reservoir (Zone of Saturation) from the surface. Infiltration of precipitation and its movement to the water table is one form of natural recharge. Also, the volume of water added by this process.

Ground Water Reservoir — An aquifer or aquifer system in which ground water is stored. The water may be introduced into the aquifer by artificial or natural means.

Ground Water Reservoir Storage — The amount of water in storage within the defined limit of the aquifer.

Ground Water Runoff — A portion of runoff which has passed into the ground, has become ground water, and has been discharged into a stream channel as spring or seepage water.

Ground Water Storage Capacity — The space or voids contained in a given volume of soil and rock deposits. Also, the reservoir space contained in a given volume of deposits. Under optimum conditions of use, the usable ground water storage capacity volume of water that can be alternately extracted and replaced in the deposit, within specified economic limitations.

Ground Water System — All the components of subsurface materials that relate to water, including *Aquifers* (confined and unconfined), *Zones of Saturation*, and *Water Tables*.

Ground Water Table — (1) The depth below the surface of the ground where the soil is saturated (the open spaces between the individual soil particles are filled with water). (2) The upper surface of the *Zone of Saturation* for underground water. It is an irregular surface with a slope or shape determined by the quantity of ground water and the permeability of the earth materials. In general, it is highest beneath hills and lowest beneath valleys. Also referred to as the *Water Table*.

Ground Water, Unconfined — Water in an aquifer that has a water table.

Ground Water Under the Direct Influence (UDI) of Surface Water — Any water beneath the surface of the ground with: (1) a significant occurrence of insects or other microorganisms, algae, or large-diameter *Pathogens*; or (2) significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions. Under direct influence conditions are determined for individual sources in accordance with criteria established by the state.

Ground Water Velocity — The rate of water movement through openings in rock or sediment. Also see *Darcy's Law*.

Grout Curtain — (Dam) A barrier produced by injecting grout into a vertical zone, usually narrow horizontally, in the foundation of a dam to reduce seepage under the dam. Also referred to as *Grout Cutoff*.

Gully, also Gulley — (1) A channel or miniature valley cut by concentrated runoff but through which water commonly flows only during and immediately after heavy rains or during the melting of snow; may be *Dendritic* or branching or it may be linear, rather long, narrow, and of uniform width. (2) A small valley or gulch. The distinction between *Gully* and *Rill* is one of depth. A gully is sufficiently deep that it would not be obliterated by normal tillage operations, whereas a rill is of lesser depth and would be smoothed by ordinary farm tillage.

Gully Erosion — The widening, deepening, and headcutting of small channels and waterways due to erosion; severe erosion in which trenches are cut to a depth greater than 30 centimeters (approximately one foot). Also see *Erosion*.

Gully Reclamation — Projects designed to prevent erosion in gullies by either filling them in or planting vegetation to stabilize the banks. May include the use of small dams of manure and straw, earth, stone, or concrete to collect silt and gradually fill in channels of eroded soil.

Gumbo — A fine, silty soil, common in the southern and western United States, that forms an unusually sticky mud when wet.

-H-

Hardness — (1) A characteristic of water which describes the presence of dissolved minerals. Carbonate hardness is caused by calcium and magnesium bicarbonate; noncarbonate hardness is caused by calcium sulfate, calcium chloride, magnesium sulfate, and magnesium chloride. (2) A property of water which causes an increase in the amount of soap that is needed to produce foam or lather and that also produces scale in hot water pipes, heaters, boilers and other units in which the temperature of water is increased materially. Hardness is produced almost completely by the presence of calcium and magnesium salts in solution. The following scale may assist in appraising water hardness, measured by weight of dissolved salts (in milligrams) per unit (in liters) of water:

[1] ***Soft*** — 0–60 milligrams/liter (mg/l);
[2] ***Moderately Hard*** — 61–120 mg/l;
[3] ***Hard*** — 121–180 mg/l; and
[4] ***Very Hard*** — over 180 mg/l
.

Hardpan — (1) A layer of nearly impermeable soil beneath a more permeable soil, formed by natural chemical cementation of the soil particles. (2) A hard impervious layer composed chiefly of clay or organic materials cemented by relatively insoluble materials, which does not become plastic when wet, and definitely limits the downward movement of water and roots.

Hard Water — Water which forms a precipitate with soap due to the presence of calcium, magnesium, or ferrous ions in solution.

Head — Difference in elevation between intake and discharge points for a liquid. In geology, most commonly of interest in connection with the movement of underground water.

Head, Static — The height above a standard datum of the surface of a column of water (or other liquid) that can be supported by the static pressure at a given point. The static head is the sum of the *Elevation Head* and the *Pressure Head*.

Head, Total — The sum of the *Elevation Head* (distance of a point above datum), the *Pressure Head* (the height of a column of liquid that can be supported by static pressure only at the point), and the *Velocity Head* (the height to which the liquid can be raised by its own kinetic energy. Also see *Hydraulic Head*.

Headward Erosion — Erosion which occurs in the upstream end of the valley of a stream, causing it to lengthen its course in that direction.

Headwater(s) — (1) The source and upper reaches of a stream; also the upper reaches of a reservoir. (2) The water upstream from a structure or point on a stream. (3) The small streams that come together to form a river. Also may be thought of as any and all parts of a river basin except the mainstream river and main tributaries.

Heavy Metals — (1) Those metals that have high density; in agronomic usage these include copper, iron, manganese, molybdenum, cobalt, zinc, cadmium, mercury, nickel and lead. These substances are considered toxic at specified concentrations. (2) Metals having a specific gravity of 5.0 or greater; generally toxic in relatively low concentrations to plant and animal life and tend to accumulate in the food chain. Examples include lead, mercury, cadmium, chromium, and arsenic.

Heterogeneity — Characteristic of a medium in which material properties vary from point to point. Contrast with *Homogeneity*.

Heterotrophic — Pertains to a system in which respiratory demand exceeds *Photosynthesis*. In a heterotrophic system biological fertility is based upon past production, organic matter accumulation and material imported from other systems (e.g., *Allochthonous Material* falling from terrestrial systems into aquatic systems.)

"Highest and Best Use" — The classification of water based on an analysis of the greatest needs of the future. Certain quantities of water (rights) are reserved for appropriation according to this classification.

History Matching - Also referred to as **Model Verification.**

Hoarfrost — A silvery-white deposit of ice needles formed by direct condensation at temperatures below freezing due to nocturnal radiation. Hoarfrost forms during still, clear nights, is small in amount, needlelike in texture, the “needles” approximately perpendicular to the objects on which they occur, and most abundant along the edges. Sometimes confused with *Rime*.

Hogback Ridge — Any ridge with a sharp summit and steep slopes of nearly equal inclination on both flanks, and resembling in outline the back of a hog.

Holistic — Of, concerned with, or dealing with wholes or integrated systems rather than with their parts. With respect to water-related issues, the term most typically describes an analytical and planning approach which examines and considers the inter-related linkages and interdependencies of a socioeconomic system with resource use, pollution, environmental impacts, and preservation of an entire ecosystem.

Holocene — (Geology) The present epoch of time, beginning about 10,000 years ago. Also see *Quaternary*.

Hummock — (1) A small but steep, irregular hill rising above the general level of the surrounding land; a low mound or ridge of earth, a knoll. (2) Also *Hammock*. A tract of forested land that rises above an adjacent marsh in the southern United States. (3) A ridge or hill of ice in an *Ice Field*.

Hydraulic Barrier — (1) Modifications to a ground-water flow system that restrict or impede movement of water and contaminants. (2) Also, a barrier developed in the *Estuary* by the release of fresh water from upstream reservoirs to prevent intrusion of sea water into the body of fresh water. (3) A barrier created by injecting fresh water to control seawater intrusion in an aquifer, or created by water injection to control migration of contaminants in an aquifer.

Hydraulic Conductivity (Ê) — Simply, a coefficient of proportionality describing the rate at which water can move through an aquifer or other permeable medium. The density and kinematic viscosity of the water must be considered in determining hydraulic conductivity. More specifically, the volume of water at the existing kinematic viscosity that will move, in unit time, under a unit *Hydraulic Gradient* through a unit area measured at right angles to the direction of flow, assuming the medium is isotropic and the fluid is homogeneous. In the Standard International System, the units are cubic meters per day per square meter of medium ($m^3/day/m^2$) or m/day (for unit measures).

Hydraulic Conductivity, Effective — The rate of water flow through a porous medium that contains more than one fluid (such as water and air in the unsaturated zone), which should be specified in terms of both the fluid type and content and the existing pressure.

Hydraulic Gradient (*I*) — (1) The slope of the water surface. (2) The gradient or slope of a water table or *Piezometric Surface* in the direction of the greatest slope, generally expressed in feet per mile or feet per feet. Specifically, the change in static head per unit of distance in a given direction, generally the direction of the maximum rate of decrease in head. The difference in hydraulic heads (h1 – h2), divided by the distance (L) along the flowpath, or, expressed in percentage terms:

$I = (h1 - h2) / L \times 100$

A hydraulic gradient of 100 percent means a one foot drop in head in one foot of flow distance.

Hydraulic Head — (1) The height of the free surface of a body of water above a given point beneath the surface. (2) The height of the water level at the headworks or an upstream point of a waterway, and the water surface at a given point downstream. (3) The height of a hydraulic grade line above the center line of a pressure pipe, at a given point.

Hydraulic Permeability — The flow of water through a unit cross-sectional area of soil normal to the direction of flow when the *Hydraulic Gradient* is unity.

Hydraulic Radius — (1) Cross-sectional area divided by the wetter perimeter. (2) The cross-sectional area of a stream of water divided by the length of that part of its periphery in contact with its containing conduit; the ratio of area to wetted perimeter. Also referred to as *Hydraulic Mean Depth*.

Hydric Soil — A soil that, in its undrained condition, is saturated, flooded, or ponded long enough during the growing season to develop *Anaerobic* conditions that favor the growth and regeneration of hydrophytic vegetation (*Hydrophytes*).

Hydrocarbons — Chemical compounds that consist entirely of carbon and hydrogen, such as petroleum, natural gas, and coal.

Hydrogen — (Chemical symbol H) An element commonly isolated as a colorless, tasteless, odorless gas, inflammable (burning with a hot, almost nonluminous flame to form water), and lighter than any other known substance. Free hydrogen occurs only very sparingly on the earth, though it is abundant in the atmospheres of the sun and many stars. Hydrogen is combined with *Oxygen* in *Water* (H2O), of which it constitutes 11.188 per cent by weight. It is also a constituent of most organic compounds, of acids and bases. Ordinary hydrogen gas is diatomic (its molecules consisting of two atoms, H2), but dissociates into free atoms at high temperatures. The hydrogen atom is the simplest of all atoms, the ordinary isotope (H^1) consisting of a single proton and a single valence electron. It is accompanied by a minute amount of a heavier isotope called Deuterium (H^2 or D) which is used in *Heavy Water* (D2O). Atomic number 1; atomic weight 1.00797; melting point –259.14EC (–434.45EF); boiling point –252.8EC (–423.04EF); density at 0EC (32EF) 0.08987 gram per liter.

Hydrogen Bond — A type of chemical bond caused by electromagnetic forces, occurring when the positive pole of one molecule (e.g., water) is attracted to and forms a bond with the negative pole of another molecule (e.g., another water molecule).

Hydrogen Sulfide (Gas) — Chemical symbol H2S, hydrogen sulfide is produced naturally by the *Anaerobic Decomposition* of any type of organic or inorganic matter that contains sulfur, e.g., rotting eggs, wallboard decomposition in landfills, the formation of natural gas from decomposing plant life, sulfate decomposition in sewers, etc. However produced, hydrogen sulfide presents severe health and corrosion hazards as well as being an odor nuisance. Few gases are as potent as hydrogen sulfide to the human olfactory senses. The human nose can detect the rotten egg odor at a level of only 0.4 parts per billion (ppb); few other compounds can be detected at such low levels of concentration.

Hydrogeologic — Those factors that deal with subsurface waters and related geologic aspects of surface waters.

Hydrogeologic Parameters — Numerical parameters that describe the hydrogeologic characteristics of an aquifer such as *Porosity*, *Permeability*, and *Transmissivity*.

Hydrogeologic Unit — Any soil or rock unit or zone that because of its hydraulic properties has a distinct influence on the storage or movement of ground water.

Hydrogeological Cycle — The natural process recycling water from the atmosphere down to (and through) the earth and back to the atmosphere again. Also see *Hydrologic Cycle*.

Hydrogeology — The part of geology concerned with the functions of water in modifying the earth, especially by erosion and deposition; geology of ground water, with particular emphasis on the chemistry and movement of water.

Hydrograph — (1) A graphic representation or plot of changes in the flow of water or in the elevation of water level plotted against time. (2) The trace of stage (height) or discharge of a stream over time, sometimes restricted to the short period during storm flow. (3) A graph showing stage, flow, velocity, or other hydraulic properties of water with respect to time for a particular point on a stream. Hydrographs of wells show the changes in water levels during the period of observation.

Hydrographic Area — In its most general sense, may refer to an defined geographic area, sub-area, sub-basin, basin, region or watershed encompassing the drainage area or catchment area of a stream, its tributaries, or a portion thereof. Typically defined as a study area for analysis or planning purposes in which the land or undersea contours results in surface water flows or measures of elevation draining to a single point. At its smallest extent, a hydrographic area may encompass a single valley containing a single stream system, or a portion of a valley or stream system with distinctive drainage characteristics. At its greatest extent, a hydrographic area may encompass the entire drainage area of a major river system, e.g., the Mississippi River hydrographic area, including all tributary rivers, streams and other sources of surface water flow. Conventionally, a number of hydrographic subareas comprise a hydrographic area whereas a number of hydrographic areas comprise a hydrographic basin or region.

Hydrographic Survey — An instrumental survey to measure and determine characteristics of streams and other bodies of water within an area, including such things as location, areal extent, and depth of water in lakes or the ocean, the width, depth, and course of streams; position and elevation of high water marks; location and depth of wells.

Hydrologic Balance — An accounting of all water inflows to, water outflows from, and changes in water storage within a hydrologic unit over a specified period of time.

Hydrologic Basin — The complete drainage area upstream from a given point on a stream.

Hydrologic Benchmark — A hydrologic unit, such as a basin or a ground-water body, that because of its expected freedom from the effects of man, has been designated as a benchmark. Data from such basins may provide a standard with which data from less independent basins can be compared so that changes wrought by man's interference can be distinguished from changes caused by variations in the natural regimen.

Hydrologic Benchmark Station — A station that provides hydrologic data for a basin in which the hydrologic regimen will likely be governed solely by natural conditions. Data collected at a benchmark station may be used to separate effects of natural from human-induced changes in other basins that have been developed and in which the physiography, climate, and geology are similar to those in the undeveloped benchmark basin..

Hydrologic Budget — An accounting of the inflow, outflow, and storage in a hydrologic unit, such as a drainage basin, aquifer, soil zone, lake, reservoir, or irrigation project.

Hydrologic Cycle — (1) The cycling of water from the atmosphere, onto and through the landscape and eventually back into the atmosphere. (2) The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transportation. Also referred to as the *Water Cycle* and *Hydrogeologic Cycle*.

Hydrologic Unit — (1) A geographic area representing part or all of a surface drainage basin or distinct hydrologic feature. (2) (USGS) A geographic area representing part or all of a surface drainage basin or distinct hydrologic feature as defined by the former Office of Water Data Coordination and delineated on the State Hydrologic Unit Maps by the U.S. Geological Survey. Each hydrologic unit is identified by an 8-digit number. (3) A classification of soils concerning water infiltration characteristics used in hydrologic analyses. See *Hydrologic Unit Maps*.

Hydrologic Unit Maps [USGS] — A set of maps developed by the U.S. Geological Survey (USGS) that present information on drainage, culture, hydrography, and hydrologic boundaries and codes of (1) the 21 major water-resources regions and the 222 subregions designated by the U.S. Water Resources Council, (2) the 352 accounting units of the U.S. Geological survey's National Water Data Network, and (3) the 2,149 cataloging units of the U.S. Geological Survey's "Catalog of Information on Water Data." The hydrologic unit map series was initiated in the fall of 1972 by the U.S. Geological Survey's Office of Water Data Coordination, in cooperation with the U.S. Water Resources Council and supported by the U.S. Geological Survey's Resources and Land Information program. These maps and associated codes provide a standardized base for use by water-resources organizations in locating, storing, retrieving, and exchanging hydrologic data, in indexing and inventorying hydrologic data and information, in cataloging water-data acquisition activities, and in a variety of other applications. Because the maps have undergone extensive review by all principal federal, regional and state water-resource agencies, they are widely accepted for use in planning and describing water-use and related land-use activities, and in geographically organizing hydrologic data. The maps depict a hydrologic system that divides the United States into 21 major regions. These regions are further subdivided into 222 subregions, 352 accounting units, and finally, into 2,149 cataloging units. These four levels of subdivisions, used for the collection and organization of hydrologic data, are referred to as *Hydrologic Units*. Also see *Water Resources Regions [United States]*.

Hydrologic Units (Classification Codes) [USGS] — A means by which the Unites States has been divided and subdivided into successively smaller *Hydrologic Units* which have been classified into four levels consisting of 21 major water resources regions, 222 subregions, 352 accounting units and 2,149 cataloging units. The first level of this U.S. Geological Survey (USGS) classification system divides the U.S. into 21 major geographic areas, or regions. These geographic areas (hydrologic areas based on surface topography) contain either the drainage area of a major river or the combined drainage areas of a series of rivers. Eighteen of the regions occupy the land area of the conterminous U.S.; Alaska is region 19, the Hawaiian Islands constitute region 20, and Puerto Rico and other outlying Caribbean areas are region 21. (The Pacific Trust Territories are a potential region 22.) The second level of classification divides the 21 regions into 222 subregions. A subregion includes the area drained by a river system, a reach of a river and its tributaries in that reach, a closed basin(s), or a group of streams forming a coastal drainage area. The third level of classification subdivides many of the subregions into accounting units. These 352 hydrologic accounting units nest within, or are equivalent to, the subregions. The accounting units are used by the USGS for designing and managing the National Water Data Network. The fourth level of classification is the cataloging unit, the smallest element in the hierarchy of hydrologic units. A cataloging unit is a geographic area representing part or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature. These units subdivide the subregions and accounting units into smaller areas (2,149 in the U.S.) that are used by the USGS for cataloging and indexing water-data acquisition activities in the "Catalog of Information on Water Data." An eight-digit code uniquely identifies each of the four levels of classification within four two-digit fields. The first two digits identify the water resources region; the first four digits identify the subregions; the first six digits identify the accounting unit; and the addition of two more digits identify the cataloging unit. See *Water Resources Regions [United States]* for a complete listing of the 21 major water resources regions.

Hydrology — (1) The science of waters of the earth, their occurrence, distribution, and circulation; their physical and chemical properties; and their reaction with the environment, including living beings. (2) The study of the movement and storage of water in the natural and disturbed environment. (3) The condition of the aquatic environment at some specified time and place. Most frequently, the term is used in reference to water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

Hydroseeding — Dissemination of seed under pressure, in a water medium. Mulch, lime, and fertilizer can be incorporated in the spraying mixture.

Hydrostatic Head — A measure of pressure at a given point in a liquid in terms of the vertical height of a column of the same liquid which would produce the same pressure.

-I-

Identification — (Statistics) A term used to describe the ability to determine an econometric model's structural parameters, i.e., the coefficients of the exogenous (or independent) variables. An econometric model is said to be exactly identified if the data support a unique set of parameters for the independent variables. A model is said to be *Under-identified* if there is no way of estimating all the structural parameters and *Over-identified* if more than one value is obtainable for some parameters.

Igneous Rock — (Geology) A rock formed by the solidification of molten materials (magma). The rock is extrusive (or volcanic) if it solidifies on the surface and intrusive (or plutonic) if it solidifies beneath the surface.

Illinoian — (Geology) Of or relating to one of the glacial stages of the *Pleistocene* epoch which occurred in North America, which consisted of the *Nebraskan* (first stage), *Kansan* (second stage), *Illinoian* (third stage), and *Wisconsin* (fourth stage).

Impaired — Water bodies that cannot reasonably be expected to attain or maintain applicable water quality standards, and at least one beneficial use shows some degree of degradation.

Impermeability — Characteristic of geologic materials that limit their ability to transmit significant quantities of water under the pressure differences normally found in the subsurface environment.

Impermeable — Unable to transmit water; not easily penetrated. The property of a material or soil that does not allow, or allows only with great difficulty, the movement or passage of water. Not the same as *Nonporous*.

Impermeable Material — A material that has properties preventing movement of water through it. Nonporous.

Impervious — A term denoting the resistance to penetration by water or plant roots; incapable of being penetrated by water; non-porous

Impoundment — (1) Generally, an artificial collection or storage of water, as a reservoir, pit, gugout, or sump. (2) A body of water such as a pond, confined by a dam, dike, floodgate or other barrier. It is used to collect and store water for future use. (3) (Water Quality) Generally an artificial collection and storage area for water or wastewater confined by a dam, dike, floodgate, or other barrier.

Inactive Storage — Lake or reservoir storage not available for release without pumping.

Incidental Recharge — Ground water recharge (infiltration) that occurs as a result of human activities unrelated to a recharge project, for example, irrigation and water diversion (unlined canals). Also see *Artificial* (or *Induced*) *Recharge*, *Natural Recharge*, and *Perennial Yield*.

Incised Channel (River) — (1) A river which cuts its channel through the bed of the valley floor, as opposed to one flowing on a floodplain; its channel formed by the process of degradation. (2) A stream that has degraded and cut its bed into the valley bottom. Indicates accelerated and often destructive erosion.

Indicator Species — (Environmental) Any organism that by its presence or absence, its frequency, or its vigor indicates a particular property of its surrounding environment. A species whose presence is a sign that certain environmental conditions exist. Also see *Management Indicator Species*.

Induced Recharge — The designed (as opposed to the natural or incidental) replenishment of ground water storage from surface water supplies. There exist five (5) common techniques to effect artificial recharge of a ground water basin:

[1] ***Water Spreading*** consisting of the basin method, stream-channel method, ditch method, and flooding method, all of which tend to divert surface water supplies to effect underground infiltration;

[2] ***Recharge Pits*** designed to take advantage of permeable soil or rock formations;

[3] ***Recharge Wells*** which work directly opposite of pumping wells although have limited scope and are better used for deep, confined aquifers;

[4] ***Induced Recharge*** which results from pumping wells near surface supplies thereby inducing higher discharge towards the well; and

[5] ***Wastewater Disposal*** which includes the use of secondary treatment wastewater in combination with spreading techniques, recharge pits, and recharge wells to reintroduce the water to deep aquifers thereby both increasing the available ground water supply and also further improving the quality of the wastewater. Also referred to as *Artificial Recharge*. Also see *Natural Recharge*, *Incidental Recharge*, and *Perennial Yield*.

Infiltrate, also Infiltration — (1) The rate of movement of water from the atmosphere into the soil; that portion of rainfall or surface runoff that moves downward into the subsurface rock and soil; the entry of water from precipitation, irrigation, or runoff into the soil profile. (2) The flow of a fluid into a substance through pores or small openings; to cause a liquid to permeate a substance by passing through its interstices or pores. It connotes flow into a substance in contradistinction to the word *Percolation*, which connotes flow through a porous substance. Also the process whereby water passes through an interface, such as from air to soil or between two soil horizons. (3) The technique of applying large volumes of waste water to land to penetrate the surface and percolate through the underlying soil.

Infiltration and Inflow — (Water Quality) The entrance of ground water (infiltration) or of surface water (inflow) into sewer pipes. Ground water can seep through defective pipe joints or cracked pipe sections; roof or basement drains are sources of surface water inflow. Excessive infiltration and inflow can cause sewers to back up or can overload sewage treatment plants, causing a reduction in treatment time or a complete bypass of the treatment process during periods of significant rainfall.

Infiltration Capacity — The maximum rate at which the soil, when in a given condition, can absorb falling rain or melting snow.

Infiltration Rate — Rate of downward movement or flow of water from the surface into the soil. (1) The rate at which infiltration takes place, expressed in depth of water per unit time, usually in inches per hour. (2) The rate, usually expressed in cubic feet per second, or million gallons per day per mile of waterway, at which ground water enters an infiltration ditch or gallery, drain, sewer, or other underground conduit.

Inflow — (1) The act or process of flowing in or into. (2) Something that flows in or into, as all water that enters a *Hydrologic System*. (3) (Water Quality) Water, other than wastewater, that enters a sanitary sewer system (including sewer service connections) from sources such as roof leaders, cellar drains, yard drains, area drains, foundation drains, drains from springs and swampy areas, manhole covers, cross connections between storm sewers and sanitary sewers, catch basins, cooling towers, surface runoff, street wash waters, or drainage. Inflow does not include, and is distinguished from, *Infiltration*.

Influent Seepage — The movement of gravity water in the *Zone of Aeration* from the ground surface toward the water table.

Influent Stream — A stream that contributes water to the *Zone of Saturation* and to *Bank Storage*. This term has generally been replaced by the term *Losing Stream*. Also see *Stream*.

Influent Water — Water that flows into sink holes, open cavities, and porous materials and disappears into the ground.

Injection — Generally refers to a system of artificially introducing surface water into the ground water system as a means of storage or recharge. Most typically, this includes the use of *Recharge Wells* which work directly opposite of pumping wells to inject surface water into underlying formations. Depending on the water-bearing formation, these methods may have limited usefulness and are generally better used for pumping water into deep, confined aquifers. (Water Quality) Refers to a system of subsurface disposal of brine effluent into an acceptable formation. Also see *Induced Recharge*.

Injection Well — Refers to a well constructed for the purpose of injection treated wastewater directly into the ground. Wastewater is generally forced (pumped) into the well for dispersal or storage into a designated aquifer. Injection wells are generally drilled into nonpotable aquifers, unused aquifers, or below freshwater levels.

Injection Zone — A geological formation receiving fluids through an *Injection Well*.

Instream Flow — (1) The amount of water remaining in a stream, without diversions, that is required to satisfy a particular aquatic environment or water use. (2) Nonconsumptive water requirements which do not reduce the water supply; water flows for uses within a defined stream channel. Examples of instream flows include:

[1] ***Aesthetics*** — Water required for maintaining flowing steams, lakes, and bodies of water for visual enjoyment;
[2] ***Fish and Wildlife*** — Water required for fish and wildlife;
[3] ***Navigation*** — Water required to maintain minimum flow for waterborne commerce;
[4] ***Quality Dilution*** — Water required for diluting salt and pollution loading to acceptable concentrations; and
[5] ***Recreation*** — Water required for outdoor water recreation such as fishing, boating, water skiing, and swimming. Also referred to as *Instream Use*.

Interference (Wells) — A change in the water level of one well caused by the pumping at another well. The condition occurring when the area of influence of a water well comes into contact with or overlaps that of a neighboring well, as when two wells are pumping from the same aquifer or are located near each other.

Interfluve — (1) The area between rivers; especially the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. (2) The elevated areas between two *Fluves* (drainageways) that sheds water to them.

Intermediate Zone — The subsurface water zone below the *Root Zone* and above the *Capillary Fringe*.

Intermittent Stream — A stream that carries water only part of the time, generally in response to periods of heavy runoff either from snowmelt or storms; a stream or part of a stream that flows only in direct response to precipitation. It receives little or no water from springs or other sources. It is dry for a large part of the year, generally more than three months. Flow generally occurs for several weeks or months in response to seasonal precipitation, due to ground water discharge, in contrast to the *Ephemeral Stream* that flows but a few hours or days following a single storm. Also referred to as *Seasonal Streams*. Also see *Stream*.

Intermontane Basin — A generic term for wide structural depressions between mountain ranges that are partly filled with alluvium and are called "valleys" in the vernacular. Intermontane basins may be drained internally (*Bolsons*) or externally (*Semi-Bolsons*).

Internal Drainage — (1) Movement of water down through soil to porous aquifers or to surface outlets at lower elevations. (2) Drainage within a basin that has no outlet.

Interstate Waters — According to federal law, interstate waters are defined as: (1) rivers, lakes and other waters that flow across or form a part of state or international boundaries; (2) waters of the Great Lakes; and (3) coastal waters whose scope has been defined to include ocean waters seaward to the territorial limits and waters along the coastline (including inland steams) influenced by the tide.

Interstices — The openings or pore spaces in a rock, soil, and other such material. In the *Zone of Saturation* they are filled with water. Synonymous with *Void* or *Pore*.

Interstitial — Referring to the *Interstices* or pore spaces in rock, soil, or other material subject to filling by water.

Intramontane Basin — A relatively small structural depression within a mountain range that is partly filled with alluvium and commonly drains externally through a narrower mountain valley.

Intrinsic Permeability — Pertaining to the relative ease with which a porous medium can transmit a liquid under a hydraulic or potential gradient. It is a property of the porous medium and is independent of the nature of the liquid or the potential field.

Intrusive — Where a fluid (e.g., magma) has penetrated into or between other rocks, but has solidified before reaching the surface.

Intrusive Bedrock — (Geology) Denoting igneous rocks in a molten state which have evaded other, older rock formations and cooled below the surface of the earth. These magmas are slow-cooling and form coarse-textured rocks, such as granite.

Inverse Method - a method of calibrating a ground water flow model using a computer code to systematically vary inputs or input parameters to minimize residuals or residual statistics.

Ion — (1) An atom or molecule that carries a net charge (either positive or negative) because of an imbalance between the number of protons and the number of electrons present. If the ion has more electrons than protons, it has a negative charge and is called an anion; if it has more protons than electrons it has a positive charge and is called a cation. (2) (Water Quality) An electrically charged atom that can be drawn from waste water during electrodialysis.

Ion Exchange — The substitution of one *Ion* for another in certain substances. Either *Anion Exchange* or *Cation Exchange* is possible. The most common cation exchange involves the conversion of *Hard Water* to *Soft Water* by means of a *Water Softening* process. Hard water contains the divalent ions of calcium (Ca^{+2}) and magnesium (Mg^{+2}), which cause soap and detergents to form precipitates in water. A *Water Softener* consists of a resin that is saturated with sodium ions (Na^{+}). As hard water percolates through the resin, the ions of calcium or magnesium are removed as they attach to the resin, thus releasing (being exchanged for) sodium ions.

Ionic Strength — The weighted concentration of ions in solutions, computed by the formula:
Ionic Strength = ½3(Zi^2Ci)
where:
Z = the charge on a particular ionic species; and
C = the concentration of a particular ionic species.

Isobar — A line on a weather map connecting points of equal atmospheric pressure. Also referred to as *Isopiestic*.

Isobath — An imaginary line on the earth's surface or a line on a map connecting all points which are the same vertical distance above the upper or lower surface of a water-bearing formation or aquifer.

Isochrone — Plotted line graphically connecting all points having the same time of travel for contaminants to move through the saturated zone and reach a well.

Isoconcentration — Graphic plot of points having the same contaminant concentration levels.

Isohyet — A line drawn on a map connecting points that receive equal amounts of rainfall.

Isohyetal — Indicating equal rainfall, generally expressed as lines of equal rainfall.

Isohyetal Line — A line drawn on a map or chart joining points that receive the same amount of precipitation. Also referred to as an *Isohyet* and *Isopluvial Line*.

Isopiestic — Having, or denoting, equal pressure; *Isobaric*.

Isopleth — A graph showing the occurrence or frequency of any phenomenon as a function of two variables

Isotherm — A line drawn on a weather map or chart linking all points of equal or constant temperature.

Isothermy — In *Limnology*, a state in which a lake is at the same temperature throughout and is well-mixed. Periods of isothermy occur in Spring and Autumn in *Dimictic Lakes*.

Isotropy — That condition in which a medium has the same properties in all directions.

-J-

Jackson Turbidity Unit (JTU) — The JTU is a measurement of the turbidity, or lack of transparency, of water. It is measured by lighting a candle under a cylindrical transparent glass tube and pouring a sample of water into the tube until an observer looking from the top of the tube cannot see the image of the candle flame. The number of JTU's varies inversely and nonlinearly with the height of the sample (e.g., a sample which measures 2.3 cm has a turbidity of 1,000 JTU's whereas a sample measuring 72.9 cm has a turbidity of 25 JTU's).

Jurisdictional Wetland — An area that meets the criteria established by the *U.S. Army Corps of Engineers (Corps or COE)* for a *Wetlands* (as set forth in their ***Wetlands Delineation Manual***). Such areas come under the jurisdiction of the Corps of Engineers for permitting certain actions such as dredge and fill operations. See *Wetlands*. [Also see ***Classification of Wetlands and Deepwater Habitats of the United States***, U.S. Department of the Interior, Fish and Wildlife Service (USFWS).

Juvenile Water — Water brought to the surface or added to undergournd supplies from magma.

-K-

Kansan — (Geology) Of or relating to one of the glacial stages of the *Pleistocene* epoch which occurred in North America, which consisted of the *Nebraskan* (first stage), *Kansan* (second stage), *Illinoian* (third stage), and *Wisconsin* (fourth stage).

Karst, also Karstic Region — Limestone and dolomite areas with a topography peculiar to and dependent on underground solution and the diversion of surface waters to underground routes. Characteristic of an area of irregular limestone in which erosion has produced fissures, sinkholes, underground streams, and caverns. Also referred to as *Karst Topography*.

Karst Hydrology — The branch of *Hydrology* that deals with the hydrology of geological formations having large underground passages or fractures which enable underground movement of large quantities of water.

Karst Topography — The structure of land surface resulting from limestone, dolomite, gypsum beds, and other rocks formed by dissolution and characterized by closed depressions, sinkholes, caves, and underground drainage.

Karstic River — A river which originates from a karstic spring or flows in a *Karstic Region*.

Kelvin (K) — The *SI Unit* of temperature. The base unit of temperature in the International System of Units that is equal to 1/273.16 of the Kelvin scale temperature of the triple point of water. Zero Kelvin is *Absolute Zero*, and an interval of 1 K is equal to 1E on the *Celsius Scale* (*Centigrade Temperature Scale*) and 1.8E on the *Fahrenheit Temperature Scale*. 0EC = 273.15 K.

Kelvin Scale — An absolute scale of temperature in which each degree equals one kelvin. Water freezes at 273.15 K and boils at 373.15 K.

Kettle — (1) (Geology) A depression left in a mass of *Glacial Drift*, formed by the melting of an isolated block of glacial ice. (2) A pothole.

Keyway (Key) — The notch excavated into the side of a gully or stream to anchor a check dam or other structure.

Kinematic Viscosity — The ratio of dynamic viscosity to mass density. It is obtained by dividing dynamic viscosity by the fluid density. Units of kinematic viscosity are square meters per second.

Kinetic Energy (k) — The energy inherent in a substance because of its motion, expressed as a function of its velocity and mass, or $MV^2/2$.

Kriging - a geostatistical interpolation procedure for estimating spatial distributions of model inputs from scattered observations.

-L-

Laboratory Blank — An artificial sample, usually distilled water, introduced to a chemical analyzer to observe the response of the instrument to a sample that does not contain the material being measured. The blank can also detect any contamination occurring during laboratory processing of the sample.

Lacustrine — Pertaining to, produced by, or inhabiting a lake.

Lacustrine Deposits — Stratified materials deposited in lake waters and later become exposed either by the lowering of the water level or by the elevation of the land.

Lacustrine Wetlands — According to criteria of the U.S. Fish and Wildlife Service (USFWS), *Lacustrine Wetlands* are greater than 20 acres and have less than 30 percent cover of persistent vegetation. Also see *Wetlands*. [See Appendix D–2 for an explanation of the USFWS Wetland and Deepwater Habitat Classification System and more detailed information on these Systems.]

Lagoon — (1) A shallow lake or pond, especially one connected with a larger body of water. (2) The area of water enclosed by a circular coral reef, or atoll. (3) An area of shallow salt water separated from the sea by sand dunes. (4) A metaphorical term for the ponding area behind a Pleistocene offshore or barrier bar (beaches) that collects fine textured sediments. (5) (Water Quality) Lagoons are scientifically constructed ponds in which sunlight, algae, and oxygen interact to restore water to a quality equal to effluent from a secondary treatment plant.

Lagoon System — (Water Quality) A system of scientifically construction Lagoons or ponds in which sunlight, algae, and oxygen interact to restore water to a quality equal to effluent from a *Secondary Treatment Plant*.

Laminar Flow — A flow in which fluid moves smoothly in streamlines in parallel layers or sheets. The stream lines remain distinct and the flow directions at every point remain unchanged with time. It is characteristic of the movement of ground water. Contrasts with turbulent flow. Synonymous with *Streamline Flow* and *Viscous Flow*.

Landform — (Geography) (1) A discernible natural landscape that exists as a result of wind, water or geological activity, such as a plateau, plain, basin, mountain, etc. (2) A three dimensional part of the land surface, formed of soil, sediment, or rock that is distinctive because of its shape, that is significant for land use or to landscape genesis, that repeats in various landscapes, and that also has a fairly consistent position relative to surrounding landforms.

Landscape — (1) (Geography) All the natural features, such as fields, hills, forests, and water that distinguish one part of the earth's surface from another part. Usually refers to that portion of land or territory which the eye can comprehend in a single view, including all of its natural characteristics. These characteristics are a result not only of natural forces but of human occupancy and use of the land as well. (2) (Ecology) A heterogeneous area composed of a cluster of interacting *Ecosystems* that are repeated in similar form throughout the area. Forest landscapes of the Southwest United States usually range from hundreds to thousands of acres and are the result of geologic, edaphic (soil), climatic, biotic, and human influences.

Land Use — The primary or primary and secondary uses of land, such as cropland, woodland, pastureland, etc. The description of a particular land use should convey the dominant character of a geographic area, and thereby establish the types of activities which are most appropriate and compatible with primary uses.

Langelier Index (LI) — An expression of the ability of water to dissolve or deposit calcium carbonate scale in pipes. The index has important implications in industrial water system where the formation of scale or sludge can cause equipment or process failure. The index is calculated from direct measurements of the following in the water system: pH, alkalinity, calcium concentrations, total dissolved solids, and temperature. A positive value indicates a tendency to form scale, and a negative value means the water will dissolve scale and may be corrosive.

Lateral Moraines — The ridges of *Glacial Till* that mark the sides of a glacier's path. Also see *Moraines*, *Terminal Moraines*, and *Recessional Moraine*.

Lateritic Soil — Land that consist of minerals that are rich in iron and aluminum compounds, other minerals having been removed by *Leaching*. The land is hard and unsuitable for agricultural use.

Leach — (1) To apply water in excess of a crop's needs to flush out salts from the root zone. (2) To remove soluble or other constituents from a medium by the action of a percolating liquid, as in leaching salts from the soil by the application of water.

Leachate — Liquid which has percolated through the ground, such as water seeping through a sanitary landfill, wastes, pesticides, or fertilizers. Leaching may occur in farming areas, feedlots, and landfills, and may result in hazardous substances entering surface water, ground water, or soil.

Leached Layer (Soil) — A soil layer or an entire soil profile from which the soluble materials (CaCO3 and MgCO3 and material more soluble) have been dissolved and washed away by percolating waters.

Leaching — (1) The washing out or flushing of a soluble substance from an insoluble one. (2) The flushing of salts from the soil by the downward percolation of applied water. (3) The process by which soluble materials in the soil, such as salts, nutrients, pesticide chemicals or contaminants, are washed into a lower layer of soil or are dissolved and carried away by water. Also see *Leachate*.

Leakage — (1) (Hydrology) The flow of water from one *Hydrogeologic Unit* to another. This may be natural, as through a somewhat permeable confining layer, or *Anthropogenic*, as through an uncased well. It may also be the natural loss of water from artificial structures, as a result of *Hydrostatic Pressure*. (2) (Dams) The uncontrolled loss of water by flow through a hole or crack.

Leakance - (1) the ratio of the vertical hydraulic conductivity of a confining unit divided by its thickness; (2) the rate of flow across a unit (horizontal) area of a semipervious layer into (or out of) an aquifer under one unit of head difference across this layer. Synonymous with coefficient of leakage.

Leaky Aquifer — An artesian or water table aquifer that loses or gains water through adjacent semipermeable *Confining Units*.

Left Bank — The left-hand bank of a stream viewed when the observer faces downstream.

Lentic — Characterizing aquatic communities found in standing water.

Lentic System — A non-flowing or standing body of fresh water, such as a lake or pond. Compare to a *Lotic System*.

Lentic Waters — Ponds or lakes (standing water).

Levee — (1) A natural or man-made earthen obstruction along the edge of a stream, lake, or river. Also, a long, low embankment usually built to restrain the flow of water out of a river bank and protect land from flooding. If built of concrete or masonry, the structure is usually referred to as a flood wall. The term *Dike* is commonly used to describe embankments that block an area on a reservoir rim that are lower than the top of the main dam. (2) (FEMA) A man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control or divert the flow of water so as to provide protection from temporary flooding.

Levee (Natural) — Bank of sand and silt built by a river during floods, where the *Suspended Load* is deposited in greatest quantity close to the river. The process of developing natural levees tends to raise river banks above the level of the surrounding flood plains. A break in a natural levee is sometimes called a *Crevasse*.

Levee (Manmade) — An embankment, generally constructed on or parallel to the banks of a stream, lake or other body of water, for the purpose of protecting the land side from inundation by flood water or to confine the stream flow to its regular channel.

Limb (Rising or Falling) — The part of the *Hydrograph* in which the discharge is steadily increasing or decreasing.

Lime — Calcium oxide (CaO) used in many water and wastewater treatment operations such as softening, coagulation and phosphorus removal. Also referred to as *Quicklime*.

Limestone — (Geology) A sedimentary rock composed of calcite, or calcium carbonate (CaCO3), and sometimes containing shells and other hard parts of prehistoric water animals and plants. When chemical conditions are right, some calcite crystallizes in sea water and settles to the bottom to form limestone.

Limicolous — Living in mud.

Liming — The application of lime to land, primarily to reduce soil acidity and supply calcium for plant growth. Liming an acid soil to a pH of about 6.5 is desirable to maintain a high degree of availability of most of the nutrient elements required by plants.

Limnetic — Referring to a standing water *Ecosystem* (ponds or lakes); of, relating to, or inhabiting the open water of a body of fresh water, as a limnetic environment or *Limnetic Zone*.

Limnetic Zone — The open water of a pond or lake supporting *Plankton* growth.

Limnology — The branch of *Hydrology* pertaining to the study of freshwater, the aquatic environment and its life; the study of the physical, chemical, hydrological, and biological aspects of fresh water bodies. Related terms include *Limnological*, *Limnologic*, and *Limnologist*.

Limnology Hydrobiologist — A person who undertakes the biological study of bodies of water.

Lineament — (Geology) An essentially rectilinear topographic feature resulting from a fault or zone of faulting. Frequently such areas provide indications of available ground water sources.

Liner — (1) (Water Quality) A low-permeability material, such as clay or high-density polyethylene, used for the bottom and sides of a landfill. The liner retards the escape of *Leachate* from the landfill to the underlying ground water. (2) An insert or sleeve for sewer pipes to prevent leakage or infiltration.

Liquefaction — (1) (General) The act or process of making or becoming liquid; especially the conversion of a solid into a liquid by heat, or of a gas into a liquid by cold or pressure. (2) (Soils) The sudden and spontaneous large decrease of the shearing resistance of a cohesionless soil, caused by a collapse of the structure from shock or other types of strain and associated with a sudden but temporary increase in the pore-fluid pressure resulting in the temporary transformation of the material into a fluid mass.

Lithology — (Geology) (1) The scientific study of rocks, usually with the unaided eye or with little magnification. (2) Loosely, the structure and composition of a rock formation. (3) The description of rocks, especially sedimentary *Clastics* and especially in hand specimen and in outcrop, on the basis of such characteristics as color, structures, mineralogic composition, and grain size.

Littoral — The region along the shore of a non-flowing body of water; corresponds to *Riparian* for a flowing body of water. More specifically, the zone of the sea flood lying between the tide levels.

Littoral Zone — (1) The shallow area near the shore of a non-flowing body of water; that portion of a body of fresh water extending from the shoreline lakeward to the limit of occupancy of rooted plants. (2) A strip of land along the shoreline between the high and low water levels.

Load — The amount of material that a transporting agency, such as a stream, a glacier, or the wind, is actually carrying at a given time. Also, the amount of power delivered to a given point. In this respect:

- [1] ***Base Load*** = The minimum load in a stated period of time.
- [2] ***Firm Load*** = That part of the system load which must be met on demand.
- [3] ***Peak Load*** = Literally, the maximum load in a stated period of time. Sometimes the term peak load is used in a general sense to describe that portion of the load above the base load.

Loam — (1) A soil consisting of a friable mixture of varying proportions of clay, silt, and sand. A soil which has nearly equal proportions of silt, sand and clay. The word is used by gardeners to mean a soil that is rich in organic material, does not compact easily, and drains well after watering. (2) A rich, permeable soil composed of a *Friable* mixture of relatively equal and moderate proportions of clay, silt, and sand particles, and usually containing organic matter (humus) with a minor amount of gravelly material. It has somewhat gritty feel yet is fairly smooth and slightly plastic. Loam may be of residual, fluvial, or *Eolian* origin, and includes many loesses and many of the alluvial deposits of *Flood Plains*, *Alluvial Fans*, and *Deltas*.

Loamy — Said of a soil (such as a clay loam and a loamy sand) whose texture and properties are intermediate between a coarse-textured or sandy soil and a fine-textured or clayey soil.

Loess (Soil) — A fine-grained, yellowish-brown, extremely fertile loam deposited mainly by the wind and found widely in North America, Asia, and Europe. Such soils are highly susceptible to water erosion.

Losing Stream — A stream or reach of a stream that is losing water by seepage into the ground. Also referred to as an *Influent Stream*. Also see *Stream*.

Lunette — A broad, low-lying, typically crescent-shaped mound of sandy or loamy matter that is formed by the wind, especially along the windward side of a lake basin.

Lysimeter — (1) An artificial device for evaluating the *Water Budget* by enclosing a block of soil, often on a scale, with equipment for monitoring inputs and outputs. (2) A field-situated tank or container filled with soil and planted to a crop. Crop consumptive use is measured by weighing or volumetrically monitoring this tank. Also a device for measuring the percolation of water through soils and for determining the soluble constituents removed in the drainage.

-M-

Magma — (Geology) Molten rock found in the mantle, beneath the cruse of the earth. When forced toward the surface, magma cools and solidifies to become *Igneous* rock.

Marine — (1) Of or pertaining to the sea; having to do with the ocean or the things peculiar to the ocean. (2) A system within the *Wetlands and Deepwater Habitat Classification System*. Also see *Deepwater Habitats* and *Wetlands*. [See Appendix D–2 for an explanation of the Wetland and Deepwater Habitat Classification System according to USFWS criteria.]

Marl — A mixture of clays, carbonates of calcium and magnesium, and remnants of shells, forming a loam useful as a fertilizer.

Marsh — A term frequently associated with *Wetlands*. An area of soft, wet, low-lying land, characterized by grassy vegetation that does not accumulate appreciable peat deposits and often forming a transition zone between water and land. A tract of wet or periodically inundated treeless land, usually characterized by grasses, cattails, or other monocotyledons (sedges, lilies, irises, orchids, palms, etc.). Marshes may be either fresh or saltwater, tidal or non-tidal.

Marshland — Treeless land in which the water table is at, above, or just below the surface of the ground; it is dominated by grasses, reeds, sedges, and cattails. These plants typify *Emergent Vegetation*, which has its roots in soil covered or saturated with water and its leaves held above water.

Marsh, Tidal — A low, flat area traversed by interlacing channels and tidal sloughs and periodically inundated by high tides. Vegetation in such areas usually consists of salt-tolerant plants, or *Halophytes*.

Mass Movement — (Geology) The downslope movement of a portion of the land's surface (i.e., a single landslide or the gradual downhill movement of the whole mass of loose earth material) on a slope face. All movement of soil and bedrock materials occurring below the soil surface such as landslips, landflows, rock slides, slumps, etc.

Mathematical Model - a set of mathematical equations expressing the physical system and including simplifying assumptions; (b) the representation of a physical system by mathematical expressions from which the behavior of the system can be deduced with know accuracy.

Maximum Contaminant Level (MCL) — (1) Legally enforceable standards regulating the maximum allowed amount of certain chemicals in drinking water. MDLs must be met by the time water reaches an individual's property. (2) The designation given by the *U.S. Environmental Protection Agency (EPA)* to water quality standards promulgated under the *Safe Drinking Water Act (SDWA)* (Public Law 93–523).

As prescribed by the EPA after research of a contaminant, the MCL is the greatest amount of a contaminant that can be present in drinking water *without* causing a risk to human health. MCLs are set for certain inorganic and organic chemicals, turbidity, coliform bacteria, and certain radioactive materials.

Meander Belt — The zone along a valley floor that encloses a meandering river.

Meander Breadth — The distance between the lines used to define the *Meander Belt*.

Meander Length — The distance in the general course of the meanders between corresponding points of successive meanders of the same phase.

Metamorphic Rock — (Geology) A sedimentary or igneous rock that has been changed by pressure, heat, or chemical action. For example, limestone, a sedimentary rock, is converted to marble, a metamorphic rock.

Metamorphism — A change in the constitution of rock; specifically a pronounced change effected by pressure, heat, and water that results in a more compact and more highly crystalline condition.

Meteoric Water — Ground water derived primarily from precipitation and the atmosphere.

Micrograms per Gram (µg/g) — A unit expressing the concentration of a chemical constituent as the mass (micrograms) of the element per unit mass (gram) of material analyzed.

Micrograms per Liter (µg/l) — A unit expressing the concentration of a chemical constituents in water as the mass (micrograms) of the element per unit volume (liter) of material analyzed. One thousand micrograms per liter is equivalent to one *Milligram per Liter (mg/l)*. This measure is also equivalent to *Parts Per Billion (PPB)*.

Microsiemens per Centimeter (µS/cm) — A unit expressing the amount of electrical conductivity of a solution as measured between opposite faces of a centimeter cube of solution at a specified temperature. Siemens is the International System of Units nomenclature. It is synonymous with mhos and is the reciprocal of resistance measured in ohms.

Micron (µ) — A unit of length equivalent to a micro-meter (µm), or one-millionth of a meter (10^{-6} meter). Micrometer is the preferred term.

Milliequivalents per Liter (MEQ/L) — An expression of the concentration of a material dissolved in water, calculated by dividing the concentration, in milligrams per liter, by the *Equivalent Weight* of the dissolved material. For example, the equivalent weight of aluminum is 9.0. A water concentration of aluminum of 1.8 milligrams per liter equals an aluminum concentration of 0.2 milliequivalent per liter.

Milligrams Per Liter (mg/l) — A unit of the concentration of a constituent in water or wastewater and expresses the concentration of chemical constituents in water as the mass (milligrams) of constituent per unit volume (liter) of water. Concentration of suspended sediment also is expressed in mg/l and is based on the mass of dry sediment per liter of water-sediment mixture. It represents 0.001 gram of a constituent in 1.000 milliliter (ml) of water. It is approximately equal to one part per million (PPM). The term has replaced parts per million in water quality management.

Mine Drainage — Water pumped or flowing from a mine.

Mineral — Any naturally occurring inorganic material with an orderly internal arrangement of atoms and specific physical and chemical properties.

Mineralization — (1) The general process by which elements present in organic compounds are eventually converted into inorganic forms, ultimately to become available for a new cycle of plant growth. (2) The process whereby concentrations of minerals, such as salts, increase in water, often as a natural process resulting from water dissolving minerals found in rocks and soils through which it flows.

Mineral Resource — Known mineral deposits of an area which have present or future utility.

Mineral Soil — Soil composed of predominantly mineral rather than organic materials.

Mining (of an Aquifer) — Withdrawal over a period of time of ground water that exceeds the rate of recharge of the aquifer.

Mining Water Use — Water use for the extraction of minerals occurring naturally including solids, such as coal and ores; liquids, such as crude petroleum; and gases, such as natural gas. Also includes uses associated with quarrying, well operations (*Dewatering*), milling (crushing, screening, washing, flotation, and so forth), and other preparations customarily done at the mine site or as part of a mining activity, such as dust control, maintenance, and wetland restoration. Generally, most of the water used at a mining operation is self-supplied.

Mitigation — (1) (Environmental, General) Actions designed to lessen or reduce adverse impacts; frequently used in the context of environmental assessment. (2) (NEPA) Action taken to avoid, reduce the severity of, or eliminate an adverse impact. Mitigation can include one or more of the following:

[1] avoiding impacts;
[2] minimizing impacts by limiting the degree or magnitude of an action;
[3] rectifying impacts by restoring, rehabilitating, or repairing the affected environment;
[4] reducing or eliminating impacts over time; and
[5] compensating for the impact by replacing or providing substitute resources or environments to offset the loss.

Mixed Boundary – is a linear combination of head and flux at a boundary. An example of a mixed boundary is leakage between a river and an underlying aquifer.

Model — (1) (General) An idealized representation of reality developed to describe, analyze, or understand the behavior of some aspect of it. (2) (Mathematical and Statistical) A simulation, by descriptive, conceptual, statistical, or other means, of a process or thing that is difficult or impossible to observe directly, as in an *Economic Consumption Model* or a *River Flow Model*. A descriptive or conceptual model is one which represents the structure or mechanisms of a model but does not specify the relationships in numerical form. The concept of a (simulation) quantitative model is to approximate reality by means of a quantifiable process such as a mathematical equation or series of equations. In this way the model may be used to simulate various changes in conditions in a "what if" or predictive framework. The fundamental premise of model building is that within some defined bounds of statistical probability a model may be constructed based upon the past behavior of some numeric quantity or variable, or a set of such variables, so as to be able to predict the future behavior of that variable. The actual structure of the model represents the underlying set of assumptions about a phenomenon based on the model builder's view of reality, theoretical underpinnings, proven or probable causal relationships, and deductions and inferences from past observations and experience. To be manageable and useful as a predictive tool, the model must sufficiently simplify the complexities of reality so as to lend itself to some quantifiable structure. However, this simplifying process must not be so extensive as to weaken the model's validity and negate its usefulness as an explanatory and predictive tool.

Model Construction - the process of transforming the conceptual model into a parameterized mathematical form; as parameterization requires assumptions regarding spatial and temporal discretization, model construction requires a-priori selection of computer code.

Model Grid - system of connected nodal points superimposed over the problem domain to spatially discretize the problem domain into cells (finite difference method) or elements (finite element method) for the purpose of numerical modeling.

Modeling - the process of formulating a model of a system or process.

Model Input - the constitutive coefficients, system parameters, forcing terms, auxiliary conditions and program control parameters required to apply a computer code to a particular problem.

Modeling Objectives - the purpose(s) of a model application.

Model Verification - in model application: a) the procedure of determining if a (site-specific) model's accuracy and predictive capability lie within acceptable limits of error by tests independent of the calibration data; b) in model application: using the set of parameter values and boundary conditions from a calibrated model to acceptably approximate a second set of field data measured under similar hydrologic conditions. Also referred to as History Matching.

Molar — A solution containing the indicated number of *Moles* of solute per liter of solution.

Mole — (Chemistry) The mass of a compound in grams numerically equal to its molecular weight. Also, the mass of a compound containing Avogadro's number of molecules.

Molecular Diffusion — The process in which solutes are transported at the microscopic level due to variations in the solute concentrations within the fluid phases. Also see the *Coefficient of Molecular Diffusion*.

Molecular Weight — The sum of the atomic weights of the atoms in a molecule. For example, the molecular weight of water (H2O) is 18, the sum of the atomic weights of two hydrogen atoms (1+1=2) and oxygen (16).

Molecule — A group of atoms held together by chemical bonds. They may be either atoms of a single element (O2) or atoms of different elements that form a compound (H2O). The smallest amount of a compound which has all the properties of the compound.

Monitoring Well — (1) A well used to obtain water quality samples or measure ground water levels. (2) (Water Quality) A well drilled in close proximity to a waste storage or disposal facility, or hazardous waste management facility or *Superfund Site* to check the integrity of the facility or to keep track of leakage of materials into the adjacent ground water.

Monomictic — Lakes or reservoirs which are relatively deep, do not freeze over during the winter, and undergo a single stratification and mixing cycle during the year (usually in the fall).

Moraine — An accumulation of boulders, stones, or other debris carried and deposited by a glacier. Moraines, which can be subdivided into many different types, are deposits of *Glacial Till*. *Lateral*

Moraines are the ridges of till that mark the sides of the glacier's path. *Terminal Moraines* are the material left behind by the farthest advance of the glacier's toe. Each different period of glaciation leaves behind its own moraines. Also see *Recessional Moraine*.

[Ground water] Mounding — Commonly, an outward and upward expansion of the free water table caused by shallow re-injection, percolation below and impoundment, or other surface recharge method (essentially, the reverse of the cone of depression effect created by a pumping well). Mounding can alter ground water flow rates and direction; however, the effects are usually localized and may be temporary, depending upon the frequency and duration of the surface recharge events.

Muck — (1) A moist, sticky mixture, especially of mud and filth. (2) Highly decomposed organic material in which the original plant parts are not recognizable. Muck contains more mineral matter and is usually darker than *Peat*. (3) Earth, rocks, or clay excavated in mining.

Mulch — (1) A substance placed over the soil surface to inhibit weed growth, conserve moisture, and in some cases, prevent heat loss. Examples include straw, wood chips, and leaves. (2) A natural or artificial protective layer of suitable materials, usually of organic matter such as leaves, straw, or peat, placed around plants that aid in soil stabilization, soil moisture conservation, prevention of freezing, and control of weeds, thus providing micro-climatic conditions suitable for germination and growth of selected vegetation.

Mulching — The use of plant residues or other suitable materials on the soil surface, primarily to reduce evaporation of water and erosion of soil.

-N-

Nanograms per Liter (ng/L) — A unit expressing the concentration of chemical constituents in solution as mass (nanograms) of solute per unit volume (liter) of water. One million nanograms per liter is equivalent to 1 milligram per liter (mg/L)

National Environmental Policy Act (NEPA) — A 1970 Act of Congress that requires all federal agencies to incorporate environmental considerations into their decision-making processes. The act requires an *Environmental Impact Statement (EIS)* for any "major federal action significantly affecting the quality of the human environment."

National Pollutant Discharge Elimination System (NPDES) — The program established by the *Clean Water Act (CWA)* that requires all *Point Sources (PS)* of pollution discharging into any "waters of the United States" to obtain a permit issued by the *U.S. Environmental Protection Agency (EPA)* or a state agency authorized by the federal agency. The NPDES permit lists permissible discharges and/or the level of cleanup technology required for wastewater.

National Primary Drinking Water Regulations (NPDWR) — Regulations for public drinking water supply systems that include health-based standards for various contaminants, and monitoring and analysis requirements. Issued by the *U.S. Environmental Protection Agency (EPA)* under authority of the *Safe Drinking Water Act (SDWA)*. While the NPDWR set standards protective of the public health, the *National Secondary Drinking Water Regulations (NSDWR)* set aesthetic standards for drinking water, i.e., color, odor, taste, etc.

National Secondary Drinking Water Regulations (NSDWR) — Regulations governing the operation of public water supply systems under the *Safe Drinking Water Act (SDWA)*. The regulations define secondary maximum contaminant levels, the maximum concentrations of certain substances in drinking water that affect its aesthetic quality. While the NSDWR set aesthetic standards for drinking water, i.e., color, odor, taste, etc., the *National Primary Drinking Water Regulations (NPDWR)* set standards protective of the public health.

Natural Flow — The rate of water movement past a specified point on a natural stream from a drainage area for which there have been no effects caused by stream diversion, storage, import, export, return flow, or change in *Consumptive Use* caused by man-controlled modification to land use. Natural flow rarely occurs in a developed county.

Natural Recharge — The replenishment of ground water storage from naturally-occurring surface water supplies such as precipitation and stream flows. Also see *Artificial* (or *Induced*) *Recharge*, *Incidental Recharge*, and *Perennial Yield*.

(United States) Natural Resources Conservation Service (NRCS) — Formerly known as the *Soil Conservation Service (SCS)*, an agency of the U.S. Department of Agriculture, the Natural Resources Conservation Service (NRCS) had its beginnings with a 1929 emergency act of Congress in response to the famous Dust Bowl when land practices, primarily in the Midwest Farm Belt, caused extensive soil erosion and threatened the food production of the United States. Initially, ten experiment stations were established to work with Land Grant Universities to study soil erosion and ways to prevent it. As a result of these initial efforts, the Soil Erosion Service was established in 1933 to show American farmers new ways of preventing and recovering from soil erosion. In 1935 Congress changed the Soil Erosion Service into the Soil Conservation Service and made it a permanent agency of the U.S. Department of Agriculture. In 1994 the name was change to Natural Resources Conservation Service to denote a broader role of responsibility in natural resource conservation. Presently, the NRCS works in three primary areas: (1) soil and water conservation; (2) resource inventories; and (3) rural community development. These activities are covered under a number of direct NRCS programs, involving only NRCS resources, and NRCS assisted programs, involving the NRCS and at least one other government agency.

Direct NRCS Programs:

[1] Technical Assistance
[2] Great Plains Conservation Program
[3] Watershed Protection, Long-Term Contracts (Public Law 566)
[4] USDA Compliance Plans

NRCS Assisted Programs:

[1] Agriculture Conservation Program
[2] Water Bank Program
[3] Colorado River Salinity Control Program
[4] Conservation Reserve Program
[5] Water Quality Incentive Program
[6] Emergency Conservation Program
[7] Wetlands Reserve Program

Natural Sink — A habitat that serves to trap or immobilize chemicals such as plant nutrients, organic pollutants, or metal ions through natural processes. For example, a river that enters a swamp may carry a substantial amount of dissolved plant nutrients. The natural biological activity of the swamp may remove these nutrients to such an extent that the water exiting the swamp is relatively low in nutrient concentrations. The swamp has then served as a sink to trap the nutrients that are no longer available for subsequent plant growth downstream from the swamp. Also referred to as a *Nutrient Sink*.

Nebraskan — (Geology) Of or relating to one of the glacial stages of the *Pleistocene* epoch which occurred in North America, which consisted of the *Nebraskan* (first stage), *Kansan* (second stage), *Illinoian* (third stage), and *Wisconsin* (fourth stage).

Nephelometer — A device which measures the intensity of light scattered at right angles to its path through a sample. It is used to measure turbidity, and the results are expressed in *Nephelometric Turbidity Units* (NTUs).

Nephelometric — A method of measuring turbidity in a water sample by passing light through the sample and measuring the amount of the light that is deflected.

Nephelometric Turbidity Unit (NTU) — (1) A unit of measure for the turbidity of water resulting from the use of a *Nephelometer* and based on the amount of light that is reflected off the water. (2) The measurement for reporting turbidity that is based on the use of a standard suspension of Formazin. Turbidity measured in NTU uses nephelometric methods that depend on passing specific light of a specific wavelength through the sample. This unit is not identical to the *Jackson Turbidity Unit (JTU).*

Neritic — Of the shallow regions of a lake or ocean that border the land. The term is also used to identify the biota that inhabit the water along the shore of a lake or ocean.

Neritic Zone — The relatively shallow water zone that extends from the high tide market to the edge of the *Continental Shelf*. May also refer to such shallow water regions of lakes.

Neutralization — (1) (Chemistry) A reaction between an acid and a base that yields a salt and water. (2) The equalization of hydrogen and hydroxyl ion concentrations such that the resulting solution is neither acidic nor basic; also, decreasing the acidity or alkalinity of a substance by adding alkaline or acidic materials, respectively.

Neutral Soil — A soil in which the surface layer, at least to normal plow depth, is neither acid nor alkaline in reaction, approximately 7.0 pH.

Nick Point (Bedscarp) — (1) The point at which a stream is actively eroding the streambed to a new base level. (2) An abrupt change in grade in the bottom of a stream channel that moves progressively upstream; the change in grade forms a waterfall. Also, the location where a streambed is actively eroding downward to a new base level.

Nitrates — Nitrates represent a class of chemical compounds having the formula NO3 . Nitrate salts are used as fertilizers to supply a nitrogen source for plant growth. Nitrate additions to surface waters can lead to excessive growth of aquatic plants. The presence of nitrates in ground water occurs from the conversion of nitrogenous matter into nitrates by bacteria and represents the process whereby ammonia in wastewater, for example effluent discharges from septic tank systems, is oxidized to nitrite and then to nitrate by bacterial or chemical reactions. High ground water nitrate levels can cause methemoglobinemia in infants.

Nitrification — The conversion of nitrogenous matter into *Nitrates* by bacteria; the process whereby ammonia in wastewater is oxidized to nitrite and then to nitrate by bacterial or chemical reactions.

Nitrogen — (1) (General) Chemical symbol N, the gaseous, essential element for plant growth, comprising 78 percent of the atmosphere, which is quite inert and unavailable to most plants in its natural form. (2) One of the three primary nutrients in a complete fertilizer and the first one listed in the formulation on a fertilizer label: 10-8-6 (nitrogen, phosphorus, potassium). (3) (Water Quality) A nutrient present in ammonia, nitrate or nitrite or elemental form in water due possibly to *Nonpoint Source (NPS)* pollution or improperly operating wastewater treatment plants.

Nitrogen-Fixing Plants — Plants that can assimilate and fix the free nitrogen of the atmosphere with the aid of bacteria living in the root nodules. Legumes with the associated rhizobium bacteria in the root nodules are the most important nitrogen-fixing plants.

No Action Alternative — Projected baseline condition, or anticipated future condition without a given action being taken. The expected future condition if no action is taken—not necessarily the same as the present condition. The effects of action alternatives are measured against this baseline condition.

Node (Nodal Point) - in a numerical model, a location in the discretized model domain where a dependent variable (hydraulic head) is computed.

Noncohesive Soil — Soil particles that have no natural resistance to being pulled apart at their point of contact, for example, silt, sand, and gravel.

Non-Degradation Policy — An environmental policy which disallows any lowering of naturally occurring quality regardless of preestablished health standards.

Non-Point Source (NPS) Pollution — (1) Pollution discharged over a wide land area, not from one specific location. (2) Water pollution caused by diffuse sources with no discernible distinct point of source, often referred to as runoff or polluted runoff from agriculture, urban areas, mining, construction sites and other sites. These are forms of diffuse pollution caused by sediment, nutrients, organic and toxic substances originating from land use activities, which are carried to lakes and streams by surface runoff. Technically, non-point source pollution, also referred to as *Non-Point Water Pollution*, means any water contamination that does not originate from a "point source," which is designated in the *Clean Water Act (CWA)* as pollution that can be clearly identified as a discharge from a pipe, ditch, or other well-defined source. Non-point source pollution, by contrast, is contamination that occurs when rainwater, snowmelt, or irrigation washes off plowed fields, city streets, or suburban backyards. As this runoff moves across the land surface, it picks up soil particles and pollutants such as nutrients and pesticides. Some of the polluted runoff infiltrates into the soil to contaminate (and recharge) the ground water below. The rest of the runoff deposits the soil and pollutants in rivers, lakes, wetlands, and coastal waters. Originating from numerous small sources, non-point source pollution is widespread, dispersed, and hard to pinpoint. Compared with point source pollution, it is diffuse and difficult to control or prevent. It has been estimated that non-point source pollution accounts for more than one-half of the water pollution in the United States today.

Nonuniform Flow — (Hydraulics) Flow in which the mean velocity or cross-sectional area vary at successive channel cross-sections. If the velocity at a given cross-section is constant with time, it is referred to as *Steady Nonuniform Flow*. If the velocity changes with time at each cross-section, it is known as *Unsteady Nonuniform Flow*.

No-Flow Boundary - model boundary which is a Specified Flux Boundary where the assigned flux is equal to zero. Also see Boundary condition.

Normal Fault — (Geology) A *Fault* in which the hanging wall appears to have moved downward relative to the footwall.

NPDES Permit — A permit issued under the *National Pollutant Discharge Elimination System (NPDES)* for companies discharging pollutants directly into the waters of the United States.

NTU — A unit of measure for the turbidity water based on the amount of light that is reflected off the water. See *Nephelometric Turbidity Unit*.

Numerical Methods - in subsurface fluid flow modeling, a set of procedures used to solve the ground water flow equations in which the applicable partial differential equations are replaced by a set of algebraic equations written in terms of discrete values of state variables (e.g. hydraulic head) at discrete points in space and time. The most commonly used numerical methods in ground water models re the finite-difference method, the finite-element method, the boundary element method and the analytic element method.

Numerical Model - in subsurface fluid flow modeling, a mathematical model that uses numerical methods to solve the governing equations of the applicable problem.

Numerical Solution - an approximate solution of a governing (partial) differential equation derived by replacing the continuous governing equation with a set of equations in discrete points of the model's time and space domains.

-O-

Observation Well — A well used to monitor changes in water levels of an aquifer and to obtain samples for water quality analyses. Also see *Wellhead Protection Program*.

Open or Screened Interval — The length of the unscreened opening or of a well screen through which water enters a well, in feet below land surface.

Open-Pit Mining — The process of removing mineral deposits that are found close enough to the surface so that the construction of tunnels (underground mining) is not necessary. The soil and strata that cover the deposit are removed to gain access to the mineral deposit. The primary environmental concerns related to this technique are the disposition of spoils removed to gain access to the deposit and the scoring of the landscape that remains following the complete removal of the mineral deposit. Erosion and water pollution are also concerns because runoff from the mining area is frequently rich in sediments and minerals which may pollute receiving streams. Furthermore, when the resulting pit extends below the water table, it may necessitate the removal of ground water that infiltrates the mining pit, potentially altering the ground water flow with possible implications on the water table and ground water characteristics. Also referred to as *Strip Mining* or *Surface Mining*. Also see *Acid Mine Drainage*, *Dewater* and *Dewatering*, and *Yellowboy*.

Orogenic — (Geology) Pertaining to the process of mountain-building, especially by the folding of the earth's crust. Also see *Diastrophic* and *Tectonic*.

Osmosis — The selective passage of liquids through a semipermeable membrane in a direction which tends to make concentrations of all substances on one side of the membrane equal to those on the other side. The semipermeable membrane allows the passage of water but prevents the passage of substances dissolved in the water. The water movement is from the more dilute solution toward the more concentrated solution, and will continue until the two solutions are equal in concentration. If pressure is applied to the more concentrated side, the flow of water will reverse, from the concentrated side to the more dilute side, a condition termed *Reverse Osmosis*.

Other Water Use — Water used for such purposes as heating, cooling, irrigation (public-supplied only), lake augmentation, and other nonspecific uses. The water can be obtained from a *Public Water Supply*

System, or may be self supplied.

Outflow, also Outflows — (1) To issue or stream out, in or as if in a flow from a body of water. (2) Process of flowing out; includes all water that leaves a *Hydrologic System*.

Output - in subsurface fluid flow modeling, all information that is produced by the computer code.

Overburden — The earth, rock, and other materials that lie above a desired ore or mineral deposit.

Over Calibration - achieving artificially low residuals by inappropriately adjusting model input parameters without field data to support the adjusted model parameter values.

Overland Flow — (1) Surface runoff. (2) The flow of rainwater or snowmelt over the land surface toward stream channels. (3) (Water Quality) The discharge of wastewater in such a way that it flows over a defined land area prior to entering a receiving stream. The movement over vegetated land fosters the removal of plant nutrients from the wastewater and constitutes a form of *Tertiary Wastewater Treatment*. After it enters a stream, it becomes *Runoff*.

Overturn — (1) The sinking of surface water and rise of bottom water in a lake or sea that results from changes in temperature that commonly occur in spring and fall. (2) One complete cycle of top to bottom mixing of previously stratified water masses. This phenomenon may occur in the spring or fall, or after storms, and results in uniformity of chemical and physical properties of water at all depths. Also referred to as *Turnover*, e.g., *Fall Turnover* and *Spring Turnover*.

Oxbow — An abandoned meander in a river or stream, caused by neck cutoff. Used to describe the U-shaped bend in the river or the land within such a bend of a river.

Oxbow Lake — An abandoned meander isolated from the main stream channel by deposition, and filled with water.

Oxidation (Oxidizing) — (1) A chemical reaction that involves combination with oxygen or the loss of electrons. (2) The process of increasing the positive valence or of decreasing the negative valence of an element or ion. (3) The process by which electrons are removed from atoms or ions, also, reduction. (4) (Water Quality) The addition of oxygen that breaks down organic waste or chemicals such as cyanides, phenols, and organic sulfur compounds in sewage by bacterial and chemical means.

Oxidation-Reduction Potential — The electric potential required to transfer electrons from one compound or element (the *Oxidant*) to another compound (the *Reductant*); used as a qualitative measure of the state of oxidation in water treatment systems.

Oxygen Deficit — (Water Quality) The difference between observed oxygen concentration and the amount that would theoretically be present at 100 percent saturation for existing conditions of temperature and pressure.

Oxygen Demand — The need for molecular oxygen (O2) to meet the needs of biological and chemical processes in water. The amount of molecular oxygen that will dissolve in water is extremely limited; however, the involvement of oxygen in biological and chemical processes in extensive. Consequently, the amount of oxygen dissolved in water becomes a critical environmental constraint on the biota living in the water. The metabolism of large organisms like submerged plants and fish, the microorganisms engaged in decomposition, and spontaneous chemical reactions all require (demand) a portion of a limited resource, molecular oxygen. Also see *Biochemical Oxygen Demand (BOD)*.

Oxygen Depletion — The removal of *Dissolved Oxygen* from a body of water as a result of bacterial metabolism of degradable organic compounds added to the water, typically caused by human activities.

-P-

Palustrine — Pertaining to a *Marsh* or *Wetlands*; wet or marsh habitats.

Palustrine Wetlands — Used in the wetlands classification system by the *U.S. Fish and Wildlife Service (USFWS)* to refer to wetlands that are vegetated-dominated by trees, shrubs, herbaceous plants, mosses or lichens. See *Wetlands (General)*, *Wetlands (COE and EPA)*, *Wetlands (USFWS)*, *Wetlands (NRCS)*, *Wetlands, Palustrine*, and *Wetlands, Benefits*. [See Appendix D–2 for an explanation of the Wetland and Deepwater Habitat Classification System according to U.S. Fish and Wildlife Service (USFWS) criteria and more detailed information of these systems.

Parameter - any of a set of physical properties which determine the characteristics or behavior of a system.

Parameter Identification Model (inverse model) - a computer code for determination of selected unknown parameters and stresses in a ground water system, given that the response of the system to all stresses is known and that information is available regarding certain parameters and stresses.

Partial Penetration — A well constructed in such a way that it draws water directly from a fractional part of the total thickness of the aquifer. The fractional part may be located at the top, the bottom, or anywhere else in the aquifer.

Particle Size — The diameter (usually the intermediate diameter), in millimeters, of suspended sediment or bed material determined by either sieve or other sedimentation methods. The sedimentation-method utilizes the principle of Stokes Law to calculate sediment particle sizes. Sedimentation methods (pipet, bottom-withdrawal tube, visual-accumulation tube, Sedigraph) determine fall diameter of particles in either distilled water (chemically dispersed) or in native water (the river water at the time and point of sampling).

Particle Size Classification — Agrees with recommendations made by the *American Geophysical Union Subcommittee on Sediment Terminology*. The particle size classification is as follows:

[1] ***Clay*** – 0.00024–0.004 millimeters (mm);
[2] ***Silt*** – 0.004–0.062 mm;
[3] ***Sand*** – 0.062–2.0 mm; and
[4] ***Gravel*** – 2.0–64.0 mm.

Partitioning Function - a mathematical relation describing the distribution of a reactive solute between solution and other phases.

Parts Per Billion (PPB) — The number of “parts” by weight of a substance per billion parts of water. Used to measure extremely small concentrations.

Parts Per Million (PPM) — The number of “parts” by weight of a substance per million parts of water. This unit is commonly used to represent pollutant concentrations. Large concentrations are expressed in percentages.

Peak Flow — The maximum instantaneous discharge of a stream or river at a given location. It usually occurs at or near the time of maximum stage.

Pebble — A small stone, especially one worn smooth by erosion. (Geology) A rock fragment between 4 and 64 millimeters (0.16 and 2.51 inches) in diameter, especially one that has been naturally rounded.

Pecelt Number - a relationship between the advective and diffusive components of solute transport expressed as the ratio of the product of the average interstitial velocity, times the characteristic length, divided by the coefficient of molecular diffusion; small values indicate diffusion is the dominant transport process, large values indicate advection dominance.

Pediment — (Geology) (1) A broad, gently sloping rock surface at the base of a steeper slope, often covered with *Alluvium*, formed primarily by erosion. (2) A broad, flat or gently sloping, rock-floored erosion surface or plain of low relief, typically developed by subaerial agents (including running water) in an arid or semiarid region at the base of an abrupt and receding mountain front or plateau escarpment, and underlain by bedrock (occasionally by older alluvial deposits) that may be bare but more often partly mantled with a thin and discontinuous veneer of alluvium derived from the upland masses and in transit across the surface. The longitudinal profile of a pediment is normally slightly concave upward, and its outward form may resemble a bajada (which continues the forward inclination of a pediment). Unlike a *Bajada*, however, which a it closely resembles, a pediment is a surface of erosion whereas a bajada is a surface of deposition. In fact, the top of a bajada often merges with trailing portions of a pediment.

Pedisediment — A layer of sediment, eroded from the shoulder and backslope of an erosional slope, that lies on and is, or was, being transported across a pediment (footslope).

Pedogenic (Pedogenesis) — The process of soil formation. Also see *Pedology*.

Pedology — The scientific study of soils, their origins, characteristics, and uses.

Pelagic — Referring to the open sea at all depths (pelagic animals live in the open sea and are not limited to the ocean bottom).

Pelite — (Geology) A sedimentary rock composed of fine fragments, as of clay or mud.

Peneplain, also Peneplane — (Geology) A nearly flat land surface representing an advanced stage of erosion.

Perched Ground Water — Ground water in a saturated zone of material underlain by a relatively impervious stratum which acts as a barrier to downward flow and which is separated from the main ground water body by a zone of unsaturated material above the main ground water body.

Perched Streams — Perched streams are either *Losing Streams* or *Insulated Streams* that are separated from the underlying ground water by a zone of aeration. Also see *Stream*.

Perched Water Table — The top of a *Zone of Saturation* that bottoms on an impermeable horizon above the level of the general water table in the area. Is generally near the surface, and frequently supplies a hillside spring.

Percolating Waters — Underground waters whose course and boundaries are incapable of determination. Waters which pass through the ground beneath the earth's surface without a definite channel. May be rainwater slowly infiltrating through the soil or water seeping through the banks or the bed of a stream, but these waters have left the flow of the stream so that they no longer may be characterized as a part of the stream flow. It is presumed that ground waters percolate.

Percolation — (1) The movement, under hydrostatic pressure, of water through the interstices of a rock or soil. Also, the movement of water within a porous medium such as soil toward the water table without a definite channel. (2) The entrance of a portion of the streamflow into the channel materials to contribute to ground water replenishment.
(3) Slow seepage of water through a filter.

Percolation, Deep — The amount of water that passes below the root zone of the crop or vegetation.

Percolation Rate — The rate, usually expressed as a velocity, at which water moves through saturated granular material. Also applies to quantity per unit of time of such movement and has been used erroneously to designate *Infiltration Rate* or *Infiltration Capacity*.

Percolation Test — (1) A procedure to measure the drainage characteristics of the soil on a lot. Such tests are required in the proper design of septic tank drainfields. (2) A soil test to determine if soil will take sufficient water seepage for use of a septic tank.

Perennial Stream — A stream that flows from source to mouth throughout the year. Also see *Stream*.

Perennial Yield (Ground Water) — The amount of usable water of a ground water reservoir that can be withdrawn and consumed economically each year for an indefinite period of time. It cannot exceed the sum of the *Natural Recharge*, the *Artificial* (or *Induced*) *Recharge*, and the *Incidental Recharge* without causing depletion of the ground water reservoir. Also referred to as *Safe Yield*.

Perforation of Wells — Holes in the casing of wells which allow water to flow into the well.

Perlite, also Pearlite — A natural volcanic glass similar to obsidian but having distinctive concentric cracks and a relatively high water content. In a fluffy heat-expanded form perlite is used as a lightweight aggregated, in fire-resistant insulation, and in soil for potted plants.

Permanent Hardness — Water hardness that cannot be reduced or removed by heating the water, a reflection of the presence of dissolved calcium, magnesium, iron and other divalent metal ions. These ions will react to form insoluble precipitates.

Permeability — (1) The capacity of soil, sediment, or porous rock to transmit water; the property of soil or rock that allows passage of water through it. (2) For a rock or an earth material, the ability to transmit fluids; the rate at which liquids pass through soil or other materials in a specified direction. It is measured by the rate at which a fluid of standard viscosity can move through a material in a given interval of time under a given *Hydraulic Gradient*. Permeability for underground water is sometimes expressed numerically as the number of gallons per day that will flow through a cross section of 1 square foot, at 60EF, under a hydraulic gradient of 100 percent. Permeability is equal to velocity of flow divided by hydraulic gradient. The following permeability terms apply:

[1] ***Very Slow*** – less than 0.05 inch per hour;
[2] ***Slow*** – 0.05 to 0.20 inch per hour;
[3] ***Moderately Slow*** – 0.20 to 0.80 inch per hour;
[4] ***Moderate*** – 0.80 to 2.50 inches per hour;
[5] ***Moderately Rapid*** – 2.50 to 5.0 inches per hour;

[6] ***Rapid*** – 5.0 to 10.0 inches per hour; and
[7] ***Very Rapid*** – More than 10.0 inches per hour.

Permeability Coefficient — The rate of flow of water through a unit cross-sectional area under a *Unit Hydraulic Gradient* at the prevailing temperature (*Field Permeability Coefficient*), or adjusted to 15EC (59EF). See *Permeability*, above.

Permeability, Effective — Observed permeability of a porous medium to one fluid phase, under conditions of physical interaction between the phase and other fluid phases present.

Permeability, Intrinsic — (1) Relative ease with which porous medium can transmit a fluid under a potential gradient, as a property of the medium itself. (2) Property of a medium expressing the relative ease with which fluids can pass through.

Permeability Soil — The quality of a soil horizon that enables water or air to move through it. The permeability of a soil may be limited by the presence of one nearly impermeable horizon even though the others are permeable.

Permeable — Having pores or openings that permit liquids or gasses to pass through.

pH (Hydrogen Ion Concentration, or Potential of Hydrogen) — (1) A convenient method of expressing the acidity or basicity of a solution in terms of the logarithm of the reciprocal (or negative logarithm) of the hydrogen ion concentration. The pH scale runs from 0 to 14; a pH value of 7.0 indicates a neutral solution. Values above 7.0 pH indicate basicity (basic or alkaline solutions); those below 7.0 pH indicate acidity (acidic solutions). Natural waters usually have a pH between 6.5 and 8.5. Because the units are derived from common logarithms, a difference of one pH unit indicates a tenfold (10^1) difference in acidity; similarly, a difference of two units indicates a hundredfold (10^2) difference in acidity. The term originally derived from "potential of hydrogen," or hydrogen power. (2) A term indicating the hydrogen ion concentration of a solution, i.e., a measure of the solution's acidity. The term (from French, pouvoir hydrogène, or literally, "hydrogen power") is defined as the negative logarithm of the concentration of H+ ions (protons): pH = –log10 [H^+], where [H^+] is the concentration of H^+ ions in moles per liter (see *Mole*). Because H^+ ions associate with water molecules to form hydronium ($H3O^+$) ions (see *Acid* and *Base*), pH also is often expressed in terms of the concentration of hydronium ions. In pure water at 22° C (72° F),$H3O^+$ and hydroxyl (OH^-) ions exist in equal quantities; the concentration of each is 0.107 moles/liter. Consequently, the pH of pure water is –log (0.107), which equals log 107, or 7. If an acid is added to water, however, an excess of $H3O^+$ ions is formed; their concentration can range between 0.106 and 0.10 moles/liter, depending on the strength and amount of the acid. Therefore, acid solutions have a pH ranging from 6 (for a weak acid) to 1 (for a strong acid). Inversely, a basic solution has a low concentration of $H3O^+$ ions and an excess of OH^- ions, and the pH ranges from 8 (for a weak base) to 14 (for a strong base). The presence and concentration of many dissolved chemical constituents found in water are, in part, influenced by the hydrogen-ion activity of water. Biological processes including growth, distribution of organisms, and toxicity of the water to organisms are also influenced, in part, by the hydrogen-ion activity of water.

Phreatic — Of or relating to ground water.

Phreatic Line — The line marking the upper surface of the *Zone of Saturation* in the soil.

Phreatic Surface — A term equivalent to the *Ground water Surface* or the *Water Table*; the free surface of ground water at atmospheric pressure.

Phreatic Water — Synonymous with the *Zone of Saturation*.

Physical Weathering — The breaking down of parent rock into bits and pieces by exposure to temperature changes and the physical action of moving ice and water, growing roots, and human activities such as farming and construction. Compare to Chemical Weathering.

Picocurie (PC, pCi) — One trillionth (1×10^{-12}) of the amount of radioactivity represented by a curie (Ci). A curie is the amount of radioactivity that yields 3.7×10^{10} radioactive disintegrations per second. A picocurie yields 2.22 dpm (disintegrations per minute).

Piedmont — (1) An area, plain, slope, glacier, or other feature at the base of a mountain, for example, a foothill or a *Bajada*. In the United States, the Piedmont (region) is a plateau extending from New Jersey to Alabama and lying east of the Appalachian Mountains. (2) Lying or formed at the base of a mountain or mountain range; for example, a piedmont terrace or a piedmont pediment.

Piedmont Slope — A major physiographic part of an *Intermontane Basin* that comprises all of the constructional and erosional, major and component landforms from the basin floor to the mountain front and on into alluvium-filled mountain valleys.

Piezometer — (1) An instrument used to measure pressure head in a conduit, tank, soil, etc. It usually consists of a small pipe or tube tapped into the side of the container, so that the inside end is flush with, and normal to, the water face of the container and is connected with a manometer pressure gage, mercury or water column, or other device for indicating pressure head. (2) An instrument for measuring pore water pressure within soil, rock, or concrete. (3) Also, an instrument for measuring the compressibility of liquids.

Piezometer (Open Well) — A well structure or tube which allows the level of saturation within a dam to be measured.

Piezometric Head — Synonymous with *Hydraulic Head*, which is now commonly used.

Piezometric Surface — An imaginary surface that everywhere coincides with the static level of the water in the aquifer. This term is now generally considered to be obsolete, being replaced by the term *Potentiometric Surface*.

Piping — (1) The progressive development of erosion of a dam structure by seepage, appearing downstream of the dam as a hole or seam discharging water that contains soil particles. (2) The process by which water forces an opening around or through a supposedly sealed structure, such as a check dam or levee. As water flows through, the opening usually grows larger and the water carries away sediment or levee material. Also referred to as *Internal Erosion*.

Pirate Stream — One of two streams in adjacent valleys that has been able to deepen its valley more rapidly than the other, has extended its valley headward until it has breached the divide between them, and has captured the upper portion of the neighboring stream.

Plain — (1) Level or gently rolling land, usually below 2,000 feet (610 meters) in elevation. (2) A flat, undulating, or even rolling area, larger or smaller, that includes few prominent hills or valleys, that usually is at low elevation in reference to surrounding areas, and that may have considerable overall slope and local relief.

Plateau — A level, elevated land area, usually between 2,000 and 6,000 feet (610–1,830 meters) in elevation.

Pleistocene — (Geology) Of, belonging to, or designating the geologic time, rock series, and sedimentary deposits of the earlier of the two epochs of the Quaternary Period. This epoch was characterized by the alternate appearance and recession of northern glaciation and the appearance of the progenitors of human beings. Also commonly referred to as the *Ice Age*, the Pleistocene covered a period of time from about 2 million years ago to 10,000 years ago and immediately preceded the Holocene Epoch, or the period from 10,000 years ago to the present. The late Pleistocene is generally considered to be the Wisconsinan Age (North America), which extended from about 300,000 years ago to 10,000 years ago and the beginning of the Holocene.

Pliocene — (Geology) The epoch immediately preceding the *Pleistocene* which lasted for about 10 million years' duration from about 12 million years ago to about 2 millions years ago.

Plugging — The act or process of stopping the flow of water, oil, or gas into or out of a formation through a borehole or well penetrating that formation.

Pluvial — (1) Of having to do with rain; rainy. (2) To flow, pour, or fill. (3) (Geology) Formed or caused by the action of rain, as a pluvial deposit. (4) (Geology) More specifically, the two or more Wisconsin stages, of the late *Pleistocene* age (epoch), when the western United States waterbasins were filled with lakes. The *Early Pluvial* period consisted of periods of high humidity so remote as to have left no clear-cut shore features; the *Postpluvial* period represented a period of desiccation following the last high lake stage.

Pluvial Lake — A lake formed during a pluvial (rainy) period.

Pluvial Period — A period of increased rainfall and decreased evaporation, which prevailed in nonglaciated areas during the time of ice advance elsewhere.

Pluvious — Characterized by heavy rainfall; rainy.

Pocosin — An upland swamp of shallow water of the coastal plain of the Southeast United States; a "Dismal", as used in the southern United States.

Point Bar — A bank on the inside of a meander bend that has built up due to sediment deposition opposite a pool.

Point Discharge — The instantaneous rate of discharge, in contrast to the mean rate for an interval of time.

Point Source (PS) — (1) A stationary or clearly identifiable source of a large individual water or air pollution emission, generally of an industrial nature. (2) Any discernible, confined, or discrete conveyance from which pollutants are or may be discharged, including (but not limited to) pipes, ditches, channels, tunnels, conduits, wells, containers, rolling stock, concentrated animal feeding operations, or vessels. Point source is also legally and more precisely defined in federal regulations. Contrast with *Non-Point Source (NPS) Pollution*.

Point Source (PS) Pollution — (1) Pollution originating from any discrete source. (2) Pollutants discharged from any distinct, identifiable point or source, including pipes, ditches, channels, sewers, tunnels, wells, containers of various types, concentrated animal-feeding operations, or floating craft. Also referred to as *Point Source of Pollution*. Also see *Non-Point Source (NPS) Pollution*.

Pore Pressure — Pressure exerted by fluid in the void space of soil or rock; the interstitial (pore) movement of water that may take place through a dam, its foundation, or its abutments.

Pore Space — That portion of rock or soil not occupied by solid mineral matter and which may be occupied by ground water.

Porosity — Most generally, porosity is the property of containing openings or interstices. In rock or soil, it is the ratio (usually expressed as a percentage) of the volume of openings in the material to the bulk volume of the material. With respect to water, porosity is a measure of the water-bearing capacity of a formation. However, with respect to water extraction and movement, it is not just the total magnitude of porosity that is important, but the size of the voids and the extent to which they are interconnected, as the pores in a formation may be open, or interconnected, or closed and isolated. For example, clay may have a very high porosity with respect to potential water content, but it constitutes a poor medium as an aquifer. More important in this respect are a formation's *Effective Porosity* (defined below) and its *Specific Retention*.

Porosity, Effective — The amount of interconnected pore space in a material available for fluid transmission; expressed as a percentage of the total volume occupied by the interconnecting interstices. Porosity may be primary, formed during deposition or cementation of the material, or secondary, formed after deposition or cementation, such as fractures.

Porous — A condition which allows liquids to pass through.

Postprocessing - using computer programs to analyze, display and store results of model simulations.

Potential — (1) (Hydrology and Hydraulics) Any of several scalar variables, each involving energy as a function of position or condition; of relevance here is the fluid potential of ground water. (2) (Water Quality) A water quality issue or problem identified by a river authority as being a potential problem, or a problem without current supporting data.

Potential Drop — Difference in total head between two *Equipotential Lines*.

Potential Evapotranspiration — (1) The maximum quantity of water capable of being evaporated from the soil and transpired from the vegetation of a specified region in a given time interval under existing climatic conditions, expressed as depth of water. (2) The water loss that will occur if at not time there is a deficiency of water in the soil for use by vegetation.

Potential Yield (or Well Capacity) — The maximum rate at which a well will yield water under a stipulated set of conditions, such as a given drawdown, pump, and motor or engine size. Well capacity may be expressed in terms of gallons per minute, cubic feet per second, or other similar units.

Potentiometric Surface — A surface which represents the static head of ground water in tightly cased wells that tap a water-bearing rock unit (i.e., aquifer). In relation to an aquifer, the potentiometric surface is defined by the levels to which water will rise in tightly cased wells. If the head varies significantly with depth in the aquifer, then there may be more than one potentiometric surface. The *Water Table* is a particular potentiometric surface for an *Unconfined Aquifer*. This term has generally replaced the term *Piezometric Surface*.

Precipitant — An agent added to a liquid mixture to encourage the formation of solid materials that will settle from the mixture. For example, alum (aluminum sulfate) is added to sewage to promote the formation of *Floc,* which facilitates the removal of organic materials from the wastewater.

Precipitate — A solid which forms from a liquid suspension as a result of a chemical reaction. The material (floc) is insoluble in water and will settle out over time.

Preprocessing - using computer programs to assist in preparing data sets for use with generic simulation codes; may include grid generation, parameter allocation, control parameter selection, and data file formatting.

Pressure Head — The relative pressure (excess over atmospheric pressure) divided by the unit weight of water; expressed in units of height.

Primacy — (1) Term used to denote that individual states have been delegated the authority to implement the requirements, as prescribed by the *U.S. Environmental Protection Agency (EPA)*, of the *Safe Drinking Water Act (SDWA)* and amendments thereto. (2) Primary enforcement responsibility for administration and enforcement of the primary drinking water regulations and related requirements applicable to public water systems within a state.

Primary Drinking Water Standards — Enforceable standards related directly to the safety of drinking water; set by the U.S. Environmental Protection Agency (EPA).

Primary Standards — (Water Quality) Standards set by the *U.S. Environmental Protection Agency (EPA)* for the maximum amount of pollutants that can be present in air and water without adverse health effects on humans. The primary standards for drinking water are set for 20 materials, ranging from arsenic to fluoride and from pesticides to radionuclides. Compare to *Secondary Standards*.

Farmland, Prime — As defined in the *Farmland Protection Policy Act of 1981*: Land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is available for these uses (urban areas are not included). It has the soil quality, growing season, and moisture supply needed for the economic production of sustained high yields of crops when treated and managed (including water management) according to acceptable farming methods. Prime farmland includes land that is being used currently to produce livestock and timber, but it excludes land committed to urban development or water storage.

Principal Spillway — Allows discharge of water from a reservoir when the water level exceeds the top of the spillway. Principal spillways are used to allow small inflows to be released from the reservoir. Also see *Spillway*.

Propylitic — (Geology) A type of *Hydrothermal* alteration characterized by the formation of calcite, chlorite, epidote, serpentine, quartz, pyrite, and iron oxides.

Provenance — For sediment, the source area or source bedrock or source sediment.

Public Law 92–500 (PL 92–500) — The *Water Pollution Control Act* of 1972 which set goals and timetables for attaining water quality standards. See *Water Pollution Control Act*.

Public Law 93–523 (PL 93–523) — The *Safe Drinking Water Act (SDWA)* of 1974 which established primary and secondary quality standards for drinking water. See *Safe Drinking Water Act (SDWA).*

Public Scoping — The process of soliciting public comments on the issues to be examined in environmental documents such as an *Environmental Impact Statement (EIS)* or water planning documents. The process can be carried out by public meetings, soliciting written comments, or both. The identification of issues, alternatives, impacts, mitigation and/or monitoring all may be addressed during the scoping process.

Pump — A device which moves, compresses, or alters the pressure of a fluid, such as water or air, being conveyed through a natural or artificial channel.

Pumping Test — A test that is conducted to determine aquifer or well characteristics. More specifically, a test made by pumping a well for a period of time and observing the change in *Hydraulic Head* in the aquifer. A pump test may be used to determine the capacity of the well and the hydraulic characteristics of the aquifer. Also referred to as *Aquifer Test*.

Purge — To force a gas through a water sample to liberate volatile chemicals or other gases from the water so their level can be measured.

-Q-

Qualitative Analysis — (Data Analysis) The examination or analysis of a phenomenon to determine its qualitative characteristics versus its quantitative characteristics, i.e., characteristics for which precise numerical identification are not appropriate. Also see *Quantitative Analysis*.

Quantitative Analysis — (Data Analysis) The examination of phenomena using actual observed data with an intention to explain historical behavior and/or predict the future behavior of some phenomenon. Also see *Qualitative Analysis*.

Quartz — (Geology) The most common rock-forming mineral. It is made up of silicon dioxide (SiO2). Quartz crystals may be glassy or opaque (milky quartz) and exist in a variety of colors including white, rose, smoky gray, and purple.

Quartzite — (Geology) A hard *Metamorphic Rock* made up of interlocking quartz grains that have been cemented by silica.

Quaternary Period — (Geology) A period consisting of approximately the last 2 million years of earth history, encompassing both the *Pleistocene* and the *Holocene* epochs.

Quicklime — Another term for lime, or calcium oxide (CaO), used in many water and wastewater treatment operations such as softening, coagulation, and phosphorus removal.

-R-

Radial Drainage — An arrangement of stream courses in which the streams radiate outward in all directions from a central zone or inward from all directions to a central area.

Radial Flow — The flow of water in an aquifer toward a vertically oriented well.

Radioisotope — Isotopic forms of an element that exhibit radioactivity. Isotopes are varieties of a chemical element that differ in atomic weight, but are very nearly alike in chemical properties. The difference arises because the atoms of the isotopic forms of an element differ in the number of neutrons in the nucleus. For example, ordinary chlorine is a mixture of isotopes having atomic weights of 35 and 37, and the natural mixture has an atomic weight of about 35.543. Many of the elements similarly exist as mixtures of isotopes, and a great many new isotopes have been produced in the operation of nuclear devices such as the cyclotron. There are 275 isotopes of the 81 stable elements, in addition to more than 800 radioactive isotopes.

Radionuclides — Radioactive chemicals that are usually naturally occurring and found in drinking water. Typical radionuclides for which the *U.S. Environmental Protection Agency (EPA)* has established *Maximum Contaminant Levels (MCLs)* as part of its enforcement of the *Safe Drinking Water Act (SDWA)* include radium 226 and 228, gross alpha particle activity, and beta particle activity.

Radius of Influence — The radial distance from the center of a well bore to the point where there is no lowering of the water table or *Potentiometric Surface* (the edge of its *Cone of Depression*).

Radon — A radioactive element, chemical symbol Rn, atomic number 86, and atomic weight 222 (Radon–222). Radon is a colorless, tasteless, odorless, naturally-occurring inert gas derived from the natural breakdown (i.e., radioactive decay) of three radioactive isotopes: uranium–238, uranium–235, and thorium–232. These isotopes are typically found in igneous and metamorphic rocks, such as granite and gneiss, and in sedimentary rocks such as organic-rich black shale, phosphatic rock, and coal. Uranium–238 is the most common parent of radon gas because it comprises more than 99 percent of uranium and thorium isotopes found on earth. Radon–222, one of the most common radioactive daughter elements of uranium–238 decay has a relatively short half-life of only 3.8 days. Consequently, radon–222 is relatively unstable and more likely to decay and emit radiation at any particular moment. Daughter isotopes of radon–222 have an even shorter half-life, resulting in a cascade or “burst” of radiation from radon and its daughter products. Radon occurs in ground water, but not in surface water due to its high volatility. In ground water, radon will stay in solution until the pressure on the ground water is decreased. Due to its short half-life and the slow rate of natural ground water flow, radon in ground water typically cannot migrate far from its source. Radon is relatively easy to remove from water; several effective options for the treatment of radon in water include storage, adsorption on *Granular Activated Carbon (GAC)*, and aeration. It has been proposed that radon provides about one-half of the radiation to which the average American is exposed. The chemically inert gas enters homes through soil, water, and building materials. The threat is not uniformly distributed across the United States. An important source of personal exposure to radon appears to be drinking water obtained from wells. The threat comes from the inhalation of the gas released from water during showering, bathing, cooking, and other water uses. Ingestion of water does not appear to present a threat.

Rain — (1) The liquid form of precipitation. (2) Water falling to earth in drops that have been condensed from moisture in the atmosphere. Generally larger than 0.02 inches (0.05 cm) in diameter and which fall in still air at velocities usually greater than 10 feet (3.0 meters) per second.

Rapid Drawdown — Lowering the elevation of water against a bank faster than the bank can drain, leaving a pressure imbalance that may cause the bank to fail.

Ravine — (1) A deep, narrow valley or gorge in the earth’s surface worn by running water. (2) A small narrow steep-sided valley that is larger than a gully and smaller than a canyon and that is usually worn by running water.

Reach (of River) — (1) Most generally, any specified length of a stream, channel, or conveyance. (2) A length of channel which is uniform in its discharge depth, area, and slope; a relatively homogeneous length of stream having a similar sequence of characteristics. (3) A length of channel for which a single gage affords a satisfactory measure of the stage and discharge. (4) The length of a river between two gaging stations.

Reaction Path Modeling - a simulation approach to studying the chemical evolution of a (natural) system.

Readily Water-Soluble Substances — In water pollution, chemicals that are soluble in water at a concentration equal to or greater than one milligram per liter (mg/l).

Reaeration — (1) Absorption of oxygen into water from the atmosphere. The rate of reaeration is proportional to the oxygen deficit. (2) Introduction of air into the lower layers of a reservoir. As the air bubbles form and rise through the water, the oxygen dissolves into the water and replenishes the dissolved oxygen. The rising bubbles also cause the lower waters to rise to the surface where they take on more oxygen from the atmosphere.

Reaeration (of Streams) — The natural process by which flowing stream water is mixed with the atmosphere, resulting in the addition of *Dissolved Oxygen* to the water.

Reasonable Pump Lift — A determination of the rate and volume of water to be pumped from an aquifer. The reasonable pump lift (rate of withdrawal) would include consideration of:

[1] water quality in the aquifer or the basin, including sea water intrusion, base of fresh water, and lateral or vertical migration of contaminants;
[2] the ground water management program;
[3] the thickness of the aquifer;
[4] the depth of existing wells;
[5] the capital cost of new wells;
[6] the net cash flow; and
[7] the total amount of ground water that can be extracted during one water year by the total number of existing wells.

Recarbonation (Recarbonization) — (Water Quality) The process of introducing carbon dioxide as a final stage in the lime-soda ash softening process. This lowers the pH and converts carbonates to bicarbonates, thereby stabilizing the solution against precipitates of carbonates.

Receiving Waters — (1) Rivers, lakes, oceans, or other water courses or bodies of water that receive waters from another source. (2) (Water Quality) Bodies of water that receive treated or untreated effluent discharges.

Recessional Moraine — *Glacial Till* occurring as ridges where the front of a retreating glacier temporarily held a fixed position. Also see *Moraines*, *Lateral Moraines*, and *Terminal Moraines*.

Recession Hydrograph (Curve) — A *Hydrograph* which shows the decreasing rate of runoff following a period of rain or snowmelt. Since *Direct Runoff* and *Base Runoff* recede at different rates, separate curves, called direct runoff recession curves, are generally drawn. Use of the term *Depletion Curve* in the sense of base runoff recession is not recommended.

Recharge (Hydrologic) — (1) The downward movement of water through soil to ground water. (2) The process by which water is added to the *Zone of Saturation*. (3) The introduction of surface or ground water to ground water storage such as an aquifer. Recharge or replenishment of ground water supplies consists of three (3) types:

[1] ***Natural Recharge*** which consists of precipitation or other natural surface flows making their way into ground water supplies;
[2] ***Artificial or Induced Recharge*** which includes actions by man specifically designed to increase supplies in a ground water reservoirs through various methods such as water spreading

(flooding), ditches, and pumping techniques; and

[3] ***Incidental Recharge*** which consists of actions, such as irrigation and water diversion, which add to ground water supplies but are intended for other purposes. Recharge may also refer to the amount of water so added.

Recharge Area (Ground water) — (1) The land area over which precipitation infiltrates into soil and percolates downward to replenish an aquifer. (2) The area in which water reaches the *Zone of Saturation* by surface infiltration. Infiltration moves downward into the deeper parts of an aquifer in a recharge area. Also referred to as a *Recharge Zone*.

Recharge, Artificial — The designed (as opposed to the natural or incidental) replenishment of ground water storage from surface water supplies. There exist five (5) common techniques to effect artificial recharge of a ground water basin:

[1] ***Water Spreading*** consisting of the basin method, stream-channel method, ditch method, and flooding method, all of which tend to divert surface water supplies to effect underground infiltration;

[2] ***Recharge Pits*** designed to take advantage of permeable soil or rock formations;

[3] ***Recharge Wells*** which work directly opposite of pumping wells although have limited scope and are better used for deep, confined aquifers;

[4] ***Induced Recharge*** which results from pumping wells near surface supplies thereby inducing higher discharge towards the well; and

[5] ***Wastewater Disposal*** which includes the use of secondary treatment wastewater in combination with spreading techniques, recharge pits, and recharge wells to reintroduce the water to deep aquifers thereby both increasing the available ground water supply and also further improving the quality of the wastewater.

Recharge Basin — A surface facility, often a large pond, used to increase the infiltration of surface water into a ground water basin.

Recharge Boundary — An aquifer system boundary that adds water to the aquifer. Streams and lakes are typical recharge boundaries.

Recharge, Incidental — Ground water recharge (infiltration) that occurs as a result of human activities unrelated to a recharge project, for example, irrigation and water diversion (unlined canals). Also see *Artificial* (or *Induced*) *Recharge*, *Natural Recharge*, and *Perennial Yield*.

Recharge, Natural — The replenishment of ground water storage from naturally-occurring surface water supplies such as precipitation and stream flows. Also see *Artificial* (or *Induced*) *Recharge*, *Incidental Recharge*, and *Perennial Yield*.

Recharge Rate — The quantity of water per unit of time that replenishes or refills an aquifer.

Recharge Well — Used in conjunction with artificial or induced ground water recharge techniques, the recharge well works directly opposite of pumping wells to induce surface water into the ground water system. Based on the nature of the soil and rock being recharged, the use of recharge wells typically have limited scope and are better employed for recharging deep, confined aquifers. Also see *Injection*.

Recharge Zone — A land area into which water can infiltrate into an *Aquifer* relatively easily. The infiltration replenishes the aquifer. The location is also referred to as a *Recharge Area*.

Reclamation — (1) The process of land treatment that minimizes water degradation, air pollution, damage to aquatic or wildlife habitat, flooding, erosion, and other adverse effects from surface mining operations including adverse surface effects incidental to underground mines, so that mine lands are reclaimed to a usable condition which is readily adaptable for alternate land uses and creates no danger to public health or safety. The process may extend to affected land surrounding mining lands, and may require backfilling, grading, resoiling, revegetation, soil compaction, stabilization, and other measures. (2) May also apply to other land uses and land types, for example, the reclaiming of waste, desert, marshy or submerged land for cultivation, preservation, reuse, etc.

Recommended Maximum Contaminant Level (RMCL) — The maximum level of a contaminant in drinking water at which no known or anticipated adverse affect on human health would occur, and that includes an adequate margin of safety. Recommended levels are nonenforceable health goals. Also see *Maximum Contaminant Level (MCL)*.

Recorder, Steam Flow — A mechanical apparatus which records a continuous record of a water level or other hydrologic factors such as water temperature, flow rates, etc.

Recording Gage — A *Gage* which provides a continuous recording of the parameter being monitored. For example, see *Stream Gaging*.

Recoverable Ground Water — The amount of water which may be physically and economically withdrawn from the ground water reservoir.

Recovery — The process by which the decline of an endangered or threatened species is arrested or reversed, and threats to its survival are neutralized, so that its long-term survival in nature can be ensured.

Reference Wetland — A wetland within a relatively homogeneous biogeographic region that is representative of a specific hydrogeomorphic wetland type.

Regime — "Regime theory" is a theory of the formation of channels in material carried by the stream. Used in this sense, the word "regime" applies only to streams that take at least part of their boundaries from their transported load and part of their transported load from their boundaries, carrying out the process at different places and times in any one stream in a balanced or alternating manner that prevents unlimited growth or removal of boundaries. A stream, river, or canal of this type is called a "regime stream, river, or canal." A regime channel is said to be "in regime" when it has achieved average equilibrium; that is, the average values of the quantities that constitute regime do not show a definite trend over a considerable period, generally, approximately a decade. In unspecialized use, "regime" and "regimen" are synonymous.

Regimen of a Stream — The system or order characteristic of a stream, i.e., its habits with respect to velocity and volume, form and changes in channel, capacity to transport sediment, and amount of material supplied for transportation. The term is also applied to a stream which has reached an equilibrium between corrosion and deposition or, in other words, to a graded stream.

Regulatory Floodplain — (1) That portion of the floodplain subject to floodplain regulations (usually the floodplain inundated by the one-percent chance flood). (2) Flood hazard area within which a community regulates development, including new construction, the repair of substantially damaged buildings, and substantial improvements to existing buildings. In communities participating in the *National Flood Insurance Program (NFIP)*, the regulatory floodplain must include at least the area inundated by the *Base Flood*, also referred to as the *Special Flood Hazard Area (SFHA)*.

Regulatory Floodway — (1) The channel and that portion of the adjacent land area that is required through regulations to pass flood flows without increasing the water surface elevation more than a designated hight. (2) As adopted into a community's floodplain management ordinance, is defined by the *Federal Emergency Management Agency (FEMA)* as the stream channel plus that portion of the overbanks that must be kept free from encroachment in order to discharge the 1-percent annual chance flood without increasing flood levels by more than 1 foot (some states specify a smaller allowable increase). The intention of the floodway is not to preclude development. Rather, it is intended to assist communities in prudently and soundly managing floodplain development and prevent additional damages to other property owners. The community is responsible for prohibiting encroachments, including fill, new construction, and substantial improvements, within the floodway unless it has been demonstrated through hydrologic and hydraulic analyses that the proposed encroachment will not increase flood levels within the community. In areas that fall within the 1-percent annual chance floodplain, but are outside the floodway (termed the floodway fringe), development will, by definition, cause no more than a 1-foot increase in the 1-percent annual chance water-surface elevation. Floodplain management through the use of the floodway concept is effective because it allows communities to develop in flood-prone areas if they so choose, but limits the future increases of flood hazards to no more than 1 foot.

Remediation — (Environmental) Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a Superfund site.

Remnant — A remaining part of some larger landform or of a land surface that has been dissected or partially buried.

Remote Sensing — The measurement or acquisition of information of some property of an object or phenomenon by a recording device that is not in physical or intimate contact with the object or phenomenon under study. Also, the utilization at a distance (as from aircraft, spacecraft, satellites, or ships) of any device and its attendant display for gathering information pertinent to the environment, such as measurements of force fields, electromagnetic radiation, infrared sensing, land use, water bodies, etc. Such systems typically employ devices such as cameras, lasers, radio frequency receivers, radar systems, infrared detectors, sonar seismographs, gravimeters, magnetometers, and scintillation counters.

Replenishment — The act of replenishing an aquifer, usually through artificial recharge, to offset excess ground water pumping.

Residual - the difference between the model-computed and field-measured values of a variable, such as hydraulic head or ground water flow rate, at a specific time and location.

Retardation Factor - is used to simulate the resistance of the contamination to move through the ground water aquifer. A factor of one (1) represents the least resistance while increasing values show increasing resistance.

Retention — That part of the precipitation falling on a drainage area that does not escape as a surface streamflow, during a given period.

Retention Basin — A permanent lake or pond used to slow stormwater runoff. Also see *Detention Basin*.

Retention Storage — Water retained in the capillary pores of the soil, not free to move by gravity, and in large part available to plants.

Retention Time — The interval of time that some waste, fluid or other material is in a treatment facility or process unit.

Return Flow — (1) The amount of water that reaches a ground or surface water source after release from the point of use and thus becomes available for further use. (2) That part of a diverted flow which is not consumptively used and returns to its original source or another body of water. (3) (Irrigation) Drainage water from irrigated farmlands that re-enters the water system to be used further downstream. Such waters may contain dissolved salts or other materials that have been leached out of the upper layers of the soil.

Reverse Osmosis — (1) (Desalination) Refers to the process of removing salts from water using a membrane. With reverse osmosis, the product water passes through a fine membrane that the salts are unable to pass through, while the salt waste (brine) is removed and disposed. This process differs from electrodialysis, where the salts are extracted from the feedwater by using a membrane with an electrical current to separate the ions. The positive ions go through one membrane, while the negative ions flow through a different membrane, leaving the end product of freshwater. (2) (Water Quality) An advanced method of water or wastewater treatment that relies on a *Semipermeable Membrane* to separate waters from pollutants. An external force is used to reverse the normal osmotic process resulting in the solvent moving from a solution of higher concentration to one of lower concentration.

Revetment — (1) A facing of stone, bags, blocks, pavement, concrete, or sandbags, or other materials, used to protect a bank of earth from erosion. (2) A retaining wall. (3) A structure built along the coast to prevent erosion and other damage by wave action; similar to a sea wall.

Reynolds Number [Re or 1] — A dimensionless number used as an index of fluid flow characteristics in a pipe, duct, or around an obstacle. The expression for fluid flow in a pipe or duct is equal to:

$$U = (V \text{ x } d \text{ x } \tilde{n})/\mu$$

where: V is the fluid velocity; d is the pipe or duct diameter; $\tilde{n}$ is the fluid density; and μ is the fluid dynamic viscosity.

For fluid flow around a particle it takes the form:

$$U = (dp \text{ x } vr \text{ x } \tilde{n})/\mu$$

where: dp is the particle diameter; vr is the velocity of the particle relative to the fluid; $\tilde{n}$ is the fluid density; and μ is the fluid viscosity.

For fluid flow in a pipe or duct, a Reynolds number below about 2,100 is considered to be streamline, smooth, or *Laminar Flow*; above 4,000 the flow is turbulent; 2,100–4,000 is a transition zone. For the flow of fluid around a particle, a Reynolds number less than 1.0 is considered laminar flow and as the value increases above 1.0 turbulence increases. The difference between the conditions for laminar flow around particles and in pipes is explained by the impact of inertial forces as the fluid flows around a particle compared to the straight flow in a pipe or duct.

Ridge Lines — Points of higher ground that separate two adjacent streams or *Watersheds*. Also referred to as *Divides*.

Ridgeline Remnant — A narrow ridge with a fully rounded crest that is accordant with the crests of similar nearby ridges. Together these accordant crests approximately mark the position of a preexisting land surface that has been destroyed by dissection.

Riffle — (1) A shallow rapids, usually located at the corssover in a meander of the active channel. (2) Shallow rapids in an open stream, where the water surface is broken into waves by obstructions such as shoals or sandbars wholly or partly submerged beneath the water surface. (3) Also, a stretch of choppy water caused by such a shoal or sandbar; a rapid; a shallow part of the stream.

Rift — A shallow or rocky place in a stream, forming either a ford or a rapid.

"Right of Free Capture" — The idea or concept that the water under a person's land belongs to that person and they are free to capture and use as much as they want. Also called the "law of the biggest pump." Does not apply where both surface water and ground water are regulated. Also referred to as the "Right of Capture."

Rill, also Rille — (1) A small brook; a rivulet. Also small, water-formed ridges that generally may be smoothed by normal tilling methods. (2) A small, intermittent watercourse with steep sides; usually only several centimeters deep; caused by waterborne soil erosion.

Rill Erosion — (1) Removal of soil by running water with formation of shallow channels that can be smoothed out completely by normal tillage. (2) Removal of soil particles from a bank slope by surface runoff moving through relatively small channels. The water collecting from these small channels may then concentrate into a larger channel downhill to form the start of a gully.

Rime — (1) A coating of ice, as on grass and trees, formed when extremely cold water droplets freeze almost instantly on a cold surface. (2) A white frost of congealed dew or vapor. An accumulation of granular ice tufts on the windward sides of exposed objects, particularly on grass and trees, slightly resembling *Hoarfrost,* but formed only from undercooled fog or cloud and always built out directly against the wind.

Riparian — Pertaining to the banks of a river, stream, waterway, or other, typically, flowing body of water as well as to plant and animal communities along such bodies of water. This term is also commonly used for other bodies of water, e.g., ponds, lakes, etc., although *Littoral* is the more precise term for such stationary bodies of water. Also refers to the legal doctrine (*Riparian Doctrine* and *Riparian Water Rights*) that says a property owner along the banks of a surface water body has the primary right to withdraw water for reasonable use. Also see *Riverine*.

Riparian Areas (Habitat) — (1) Land areas directly influenced by a body of water. Usually such areas have visible vegetation or physical characteristics showing this water influence. Stream sides, lake borders, and marshes are typical riparian areas. Generally refers to such areas along flowing bodies of water. The term *Littoral* is generally used to denote such areas along non-flowing bodies of water. (2) (USFWS) Plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent *Lotic* and *Lentic* water bodies (rivers, streams, lakes, or drainage ways). Riparian areas have one or both of the following characteristics: (a) distinctively different vegetative species than adjacent areas, and (b) species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian areas are usually transitional between *Wetlands* and *Uplands*.

Riparian Ecosystem — A transitional ecosystem located between aquatic (usually *Riverine*) and terrestrial (upland) environments. Riparian ecosystems are identified by distinctive soil characteristics and vegetation communities that require free water.

Riparian Habitat — Areas adjacent to rivers and streams with a high density, diversity, and productivity of plant and animal species relative to nearby uplands.

Riparian Land — (1) Land situated along the bank of a stream or other, generally flowing bodies of water. (2) Land so situation with respect to a body of water that, because of such location, the possessor of the land is entitled to the benefits incident to the use of the water.

Riparian Rights — (1) Water rights based on the ownership of land bordering a river or waterway. (2) A concept of water law under which authorization to use water in a stream is based on ownership of the land adjacent to the stream and is normally not lost if not used. (3) The rights of the owners of lands on the banks of watercourses, relating to the water, its use, ownership of soil under the stream, accretion, etc. The term is generally defined as the right which every person through whose land a natural watercourse runs has to the benefit of the stream as it passes through his land for all useful purposes to which it may be applied. Such rights include those such as hunting, fishing, boating, sailing, irrigating, and growing and harvesting wild rice, which rights extend over lakes and wetlands. See *Riparian Doctrine*. Also see *Riparian Water Rights*.

Riparian Vegetation — Plants adapted to moist growing conditions found along waterways and shorelines. They are frequently important to wildlife habitat because of their greater density and succulence.

Riparian Water — Water which is below the highest line of normal flow of the river or stream, as distinguished from flood water.

Riparian Zone — (1) Areas adjacent to a stream that are saturated by ground water or intermittently inundated by surface water at a frequency and duration sufficient to support the prevalence of vegetation typically adapted for life in saturated soil. (2) The transition area between the aquatic ecosystem and the nearby, upland terrestrial ecosystem. Zones are identified by soil characteristics and/or plant communities and include the wet areas in and near streams, ponds, lakes, springs and other surface waters. Also see *Riparian Areas*.

Rip Rap (also Riprap) — A facing layer (protective cover) of stones placed to prevent erosion or the sloughing off of a structure or embankment. A layer of man-made hard, durable material for bank protection and stabilization usually consisting of rock or stone. On steeper inclines, the stones may be secured with wire on some form of link fencing material. Also, a layer of large stones, broken rock, or precast blocks placed in random fashion on the upstream slope of an *Embankment Dam*, on a reservoir shore, or on the sides of a channel as a protection against waves, ice action, and flowing water. Very large rip rap is sometimes referred to as *Armoring*.

Ripple — (1) To form or display little undulations or waves on the surface, as disturbed water does. (2) To flow with such undulations or waves on the surface.

Ripple Mark — One of a series of small ridges produced especially on sand by the action of wind, a current of water, or waves.

Riser — A vertical pipe as for water.

Rising Limb — The increasing portion of the storm *Hydrograph*. Contrast to *Falling Limb*.

River — A natural stream of water of considerable volume, larger than a brook or creek. A river has its stages of development, youth, maturity, and old age. In its earliest stages a river system drains its basin imperfectly; as valleys are deepened, the drainage becomes more perfect, so that in maturity the total drainage area is large and the rate of erosion high. The final stage is reached when wide flats have developed and the bordering lands have been brought low.

River Banks — (1) The boundaries which confine the water to its channel throughout the entire width when the stream is carrying its maximum quantity of water. (2) The portion of the channel cross section that restricts lateral movement of water at normal discharges. Banks often have a gradient steeper than 45 degrees and exhibit a distinct break in slope from the stream bed.

River Basin — (1) A term used to designate the area drained by a river and its tributaries. (2) The are from which water drains to a single point; in a natural basin, the drainage area contributing flow to a given point on a stream.

River Channels — Natural or artificial open conduits which continuously or periodically contain moving water, or which forms a connection between two bodies of water.

Riverine — (1) Relating to, formed by, or resembling a river including tributaries, streams, brooks, etc. (2) Pertaining to or formed by a river; situated or living along the banks of a river, for example, a "riverine ore deposit." Also see *Riparian*.

Riverine (Systems) — Open-water habitats. Typically include all open water areas that occur within a defined channel of a stream as well as along perennial and intermittent stretches of streams and along some major dry washes. In some cases, riverine systems are bounded by *Palustrine Wetlands* that develop in the floodplain on either side of the defined channel. The riverine system and the adjacent palustrine wetlands are often referred to as *Riparian Habitat*. Also see *Wetlands* and *Wetlands, Paulustrine*. [See Appendix D–2 for an explanation of the Wetland and Deepwater Habitat Classification System and more detailed information on these Systems.]

River Reach — Any defined length of a river.

Rivers, Classifications — Classifications of waterways included in the *National Wild and Scenic Rivers System* are as follows:

[1] ***Recreational Rivers*** — Rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shoreline, and that may have undergone some impoundment or diversion in the past.

[2] ***Scenic Rivers*** — Rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive, and shorelines largely undeveloped but accessible in places by roads.

[3] ***Wild Rivers*** — Rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted.

River Stage — The elevation of the water surface at a specified station above some arbitrary zero datum (level).

Riverwash — Barren alluvial land, usually coarse-textured, exposed along streams at low water, and subject to shifting during normal high water.

Rivulet — A small stream or brook; a streamlet.

Roche Moutonnée — An elongated mound of bedrock worn smooth and rounded by glacial abrasion.

Rock Flour — Finely ground rock particles produced by glacial abrasion. Also referred to as *Glacier Meal*.

Roil — To make a liquid cloudy, muddy, or unsettled by stirring up the sediment.

Roily — Water of a liquid that is turbid, muddy, agitated or disturbed.

Roughness — A term used by hydraulic engineers and hydrologists designating a measurement or estimate of the resistance that streambed materials, vegetation, and other physical components contribute to the flow of water in the stream channel and floodplain. It is commonly measured as the Manning's roughness coefficient.

Roughness Coefficient — (Hydraulics) A factor in velocity and discharge formulas representing the effect of channel roughness on energy losses in flowing water.

Routing (Hydraulics) — (1) The derivation of an outflow *Hydrograph* of a stream from known values of upstream inflow, using the wave velocity and/or the storage equation. (2) A technique used to compute the effect of channel storage and translation on the shape and movement of a flood wave through a river reach.

Rugosity — A term used to indicate the degree of roughness of a test-well caused by drilling and subsequent washouts. In some wells, rugosity is caused by the intersection of fractures with the test well and may be an indication of secondary *Porosity* development and possible zones of increased *Transmissivity*.

Run — (1) To flow, especially in a steady stream. (2) A pipe or channel through which something, i.e., water, flows. (3) A fall or slide, as of sand or mud. (4) The migration of fish, especially in order to spawn; a group or school of fish ascending a river in order to spawn, i.e., the seasonal upstream migration of *Anadromous* fish. (5) (Irrigation) The distance of gravity flow from the point of release to the end of the area to be watered. (6) (Nautical) To sail or steer before the wind or on an indicated course. (7) (Geology) A vein or seam, as of ore or rock.

Runnel — (1) A rivulet; a brook. (2) A narrow channel or course, as for water.

Runoff — (1) That portion of precipitation that moves from the land to surface water bodies. (2) That portion of precipitation which is not intercepted by vegetation, absorbed by the land surface or evaporated, and thus flows overland into a depression, stream lake or ocean (runoff called "immediate subsurface runoff" also takes place in the upper layers of the soil). (3) That part of the precipitation, snow melt, or irrigation water that appears in uncontrolled surface streams, rivers, drains or sewers. It is the same as streamflow unaffected by artificial diversions, imports, storage, or other works of man in or on the stream channels. Runoff may be classified according to speed of appearance after rainfall or melting snow as direct runoff or base runoff, and according to source as surface runoff, storm interflow, or ground-water runoff. (4) The total discharge described in (1), above, during a specified period of time. (5) Also defined as the depth to which a drainage area would be covered if all of the runoff for a given period of time were uniformly distributed over it.

Meteorological Factors Affecting Runoff:

- [1] Type of precipitation (rain, snow, sleet, etc.);
- [2] Rainfall intensity;
- [3] Rainfall amount;
- [4] Rainfall duration;
- [5] Distribution of rainfall over the drainage basin;
- [6] Direction of storm movement;
- [7] Antecedent precipitation and resulting soil moisture; and
- [8] Other meteorological and climatic conditions which affect evapotranspiration such as temperature, wind, relative humidity, and season.

Physical Basic Characteristics Affecting Runoff:

- [1] Land use;
- [2] Vegetation;
- [3] Soil type;

[4] Drainage area;
[5] Basin shape;
[6] Elevation;
[7] Slope;
[8] Topography;
[9] Direction of orientation;
[10] Drainage network patterns; and
[11] Ponds, lakes, reservoirs, sinks, etc. in the basin which prevent or alter runoff from continuing downstream.

Runoff Curve Number — A rainfall-runoff parameter commonly used in the U.S. Department of Agriculture, *Natural Resources Conservation Service (NRCS)*, formerly the *Soil Conservation Service (SCS)*, hydrologic procedures. The larger the runoff curve number, the greater the percentage of rainfall that will appear as runoff. The runoff curve number is a function of soil type, land use, and land management practices.

Runoff Cycle — That portion of the *Hydrologic Cycle* between incident precipitation over land areas and its subsequent discharge through stream channels or *Evapotranspiration*.

Runoff, Direct — The runoff entering stream channels most immediately after rainfall or snowmelt. It consists of surface runoff plus interflow and forms the bulk of the *Hydrograph* of a flood. Direct runoff plus *Base Runoff* compose the entire flood hydrograph.

Runoff, Ground Water — That part of the runoff which has passed into the ground, has become ground water, and has been discharged into a stream channel as spring or seepage water. Also referred to as *Base Runoff* or *Base Flow*.

Runoff, Surface — (1) That part of the runoff which travels over the soil surface to the nearest stream channel. (2) That part of the runoff of a drainage basin that has not passed beneath the surface since precipitation. Surface runoff is not the same as direct runoff.

Runs — An area of swiftly flowing water, without surface agitation or waves, which approximates uniform flow and in which the slope of the water surface is roughly parallel to the overall gradient of the stream reach.

-S-

Safe Drinking Water Act [SDWA] (Public Law 93–523) — An amendment to the *Public Health Service Act* which established primary and secondary quality standards for drinking water. The SDWA was passed in 1976 to protect public health by establishing uniform drinking water standards for the nation. In 1986 SDWA Amendments were passed that mandated the *U.S. Environmental Protection Agency (EPA)* to establish standards for 83 drinking water contaminants by 1992 and identify an additional 25 contaminants for regulation every 3 years thereafter.

Safe Yield — (1) The rate at which water can be withdrawn from supply, source, or an aquifer over a period of years without causing eventual depletion or contamination of the supply. (2) A rate of extraction that does not deplete the basin over time. (3) (Ground water) The amount of water that can be withdrawn from an aquifer without producing an undesired effect. (4) (Surface Water) The amount of water than can be withdrawn or released from a reservoir on an ongoing basis with an acceptably small risk of supply interruption (i.e., reducing the reservoir storage to zero.) More commonly referred to a

Perennial Yield and *Sustained Yield*. Generally consists of the rate of *Natural Recharge*, *Artificial* (or *Induced*) *Recharge,* and *Incidental Recharge*.

Saline/Poor Quality Aquifer — An aquifer containing water that is high in total dissolved solids, and is unacceptable for use as drinking water.

Saline Water — Water containing dissolved solids; generally referring to solid contents in excess of 1,000 parts per million (ppm) *Total Dissolved Solids (TDS)*. The *U.S. Geological Survey (USGS)* classifies the degree of salinity of these more mineralized bodies of water as follows:
[1] ***Slightly Saline*** — 1,000–3,000 ppm;
[2] ***Moderately Saline*** — 3,000–10,000 ppm;
[3] ***Very Saline*** — 10,000–35,000 ppm; and
[4] ***Brine*** — More than 35,000 ppm.

Salinity — (1) The concentration of dissolved salts in water or soil water. Salinity may be expressed in terms of a concentration or as an electrical conductivity. When describing salinity influenced by seawater, salinity often refers to the concentration of chlorides in the water. (2) The relative concentration of salts, usually sodium chloride, in a given water sample. It is usually expressed in terms of the number of parts per thousand (‰) or parts per million (ppm) of chloride (Cl). Although the measurement takes into account all of the dissolved salts, sodium chloride (NaCl) normally constitutes the primary salt being measured. Salinity can harm many plants, causing leaves to scorch and turn yellow and stunting plant growth. As a reference, the salinity of seawater is approximately 35‰ or 35,000 ppm. See *Salts* for comparative salt concentrations in water. Also see *Total Dissolved Solids*.
Salinity Intrusion — The movement of salt water into a body of fresh water. It can occur in either surface water or ground water bodies.

Salinization — The accumulation of salts in soil to the extent that plant growth is inhibited. This is a common problem when crops are irrigated in arid regions; much of the water evaporates and salts accumulated in the soil.

Salt — (1) Most generally, all the minerals dissolved in water. (2) A chemical class of ionic compounds formed by the combination of an acid and a base. Most salts are the result of a reaction between a metal and one or more nonmetals. See *Salts*, below.

Salt-Water Intrusion — The invasion of a body of fresh water by a body of salt water, due to its greater density. It can occur either in surface or ground-water bodies. The term is applied to the flooding of freshwater marshes by seawater, the migration of seawater up rivers and navigation channels, and the movement of seawater into freshwater aquifers along coastal regions.

Sand — Composed predominantly of coarse-grained mineral sediments with diameters larger than 0.074 mm (0.0029 inch) and smaller than 2 mm (0.079 inch) in diameter.

Sandbar — A ridge of sand built up by currents, especially in a river or in coastal waters.

Sandstone Aquifer — The type of aquifer supplying ground water to large parts of the United States upper Middle West, Appalachia, and Texas. The water-bearing formation is often contained by shale strata, and the water has high levels of iron and magnesium.

Sandy Soil — Soils that have comparatively large particles that are rounded rather than flattened. Compared to clay soils, sandy soils contain much more soil and air, drain well, and warm quickly. They also dry out quickly, which necessitates more frequent watering that washes out valuable nutrients. Also referred to as “light” soil.

Saturated — (1) Generally, filled to capacity; having absorbed all that can be taken up; soaked through with moisture. (2) (Hydrologic) A condition often used in reference to soils in which all voids or pore spaces between soil particles are filled with water. (3) (Chemistry) Describes a solution in its most concentrated state in which dissolved material can remain in solution under given conditions of temperature, pressure, etc.

Saturated Flow — The liquid flow of water in soils that occurs when the soil pores in the wettest part of the soil are completely filled with water and the direction of flow is from the wettest zone of higher potential to one of lower potential.

Saturated Soils — Soils that have absorbed, to the maximum extent possible, water from rainfall or snowmelt. Any further precipitation on saturated soils will result in surface runoff with down-gradient affects on flooding and erosion.

Saturated Thickness (Aquifer) — The thickness of the portion of the aquifer in which all pores, or voids, are filled with water. In a *Confined Aquifer*, this is generally the aquifer thickness. In an *Unconfined Aquifer,* this is the distance between the water table and the base of the aquifer.

Saturated Zone — (1) The part of a water bearing layer of rock or soil in which all spaces, large or small, are filled with water. (2) The zone in the earth’s crust, extending from the water table downward, in which all open pore spaces in the soil or rock are filled with water at greater than atmospheric pressure. A termed used synonymously with the *Zone of Saturation*. Also referred to as *Phreatic Zone*.

Saturation — The condition of a liquid when it has taken into solution the maximum possible quantity of a given substance at a given temperature and pressure.

Saturation Point — That point at which a soil or an aquifer will no longer absorb any amount of water without losing an equal amount.

Saturation, Zone of — The zone below the *Water Table* in which all pore spaces are filled with ground water. The water table is the top of the zone of saturation in an unconfined aquifer. Also referred to as the *Phreatic Zone*.

Scarify — In land *Restoration* activities, to stir the surface of the ground with an implement in preparation for replanting.

Scarp — (1) A line of cliffs produced by faulting or by erosion. The term is an abbreviated form of *Escarpment*, and the two terms commonly have the same meaning, although “scarp” is more often applied to cliffs formed by faulting. (2) A relatively steep and straight, cliff-like face or slope of considerable linear extent, breaking the general continuity of the land by separating level or gently sloping surfaces lying at different levels, as along the margin of a plateau, mesa, terrace, or bench.

Scenic Rivers — A classification under the national *Wild and Scenic Rivers Act* to include those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads. The following represents restrictions applying to such designated rivers:

(1) ***Timber Production*** – A wide range of silvicultural practices could be allowed if such practices are carried on so that there is no substantial adverse effect on the river and its immediate environment. The river area should be maintained in its near natural environment.

Timber outside the boundary but within the visual scene area should be managed and harvested in a way that provides special emphasis on visual quality.

(2) ***Water Supply*** – All water supply dams and major diversions are prohibited.

(3) ***Hydroelectric Power*** – No development of hydroelectric power facilities would be allowed.

(4) ***Flood Control*** – Flood control dams and levees would be prohibited.

(5) ***Mining*** – Subject to regulations (i.e., 36 CFR 228) that the Secretaries of Agricultural and Interior may prescribe to protect the values of rivers included in the national system. New mining claims and mineral leases could be allowed and existing operations allowed to continue. However, mineral activity must be conducted in a way that minimizes surface disturbances, sedimentation and pollution, and visual impairment.

(6) ***Road Construction*** – Roads may occasionally bridge the river area and short stretches of conspicuous or longer stretches on inconspicuous and well screened roads or screened railroads could be allowed. Consideration will be given to the type of use for which roads are constructed and the type of use that will occur in the river area.

(7) ***Agriculture*** – A wider range of agricultural uses is permitted to the extent currently practices. Row crops are not considered as an intrusion of the 'largely primitive" nature of scenic corridors if there is not a substantial adverse effect on the natural-like appearance of the river area.

(8) ***Recreational Development*** – Larger scale public use facilities, such as moderate size campgrounds, public information centers, and administrative headquarters are allowed if such structures are screened from the river. Modest and unobtrusive marinas also can be allowed.

(9) ***Structures*** – Any concentrations of habitations are limited to relatively short reaches of the river corridor. New structures that would have a direct and adverse effect on river values would not be allowed.

(10) ***Utilities*** – New transmission lines, gas lines, water lines, etc., are discouraged. Where no reasonable alternative exists, additional or new facilities should be restricted to existing right-of-way. Where new rights-of-ways are indicated, the scenic, recreation, and fish and wildlife values must be evaluated in the selection of the site.

(11) ***Motorized Travel*** – Motorized travel on land or water may be permitted, prohibited or restricted to protect the river values. Also see *Wild and Scenic Rivers Act*, *Wild Rivers*, and *Recreational Rivers*.

Scour — (1) To clear, dig, or remove by or as if by a powerful current of water. (2) The erosive action of running water in streams, which excavates and carries away material from the bed and banks. Scour may occur in both earth and solid rock material. (3) The powerful and concentrating clearing and digging action of flowing air or water, especially the downward erosion by stream water in sweeping away mud and silt on the outside curve of a bend, or during time of flood. (4) A place in a stream bed swept (scoured) by running water, generally leaving a gravel bottom. (5) The process by which flood waters remove soil around objects that obstruct flow, such as the foundation walls of a house.

S–Curve — The mass curve corresponding to a *Unit Hydrograph* or a distribution graph.

(Well) Seal — (Hydraulics) The watertight seal established in the annular space between the outermost water well casing and the drill hole to prevent the inflow and movement of surface water or shallow ground water, or to prevent the outflow or movement of water under artesian pressures. The term also includes a *Sanitary Seal*.

Seasonal or Intermittent Streams — Streams which flow only at certain times of the year when it receives water from springs, rainfall, or from surface sources such as melting snow. Also see *Stream*.

Seasonal Wetlands — Wetland areas flooded or taking on the characteristics of a wetland only during specific periods of the year or seasons. Also see *Wetlands* and *Prairie Potholes*.

Secchi Depth — A relatively crude measurement of the turbidity (cloudiness) of surface water. The depth at which a *Secchi Disc (Disk)*, which is about 10–12 inches in diameter and on which is a black and white pattern, can no longer be seen.

Secchi Disc (Disk) — A circular plate, generally about 10–12 inches (25.4–30.5 cm) in diameter, used to measure the transparency or clarity of water by noting the greatest depth at which it can be visually detected. Its primary use is in the study of lakes. Also see *Secchi Depth*.

Secondary Drinking Water Regulations — Non-enforceable regulations applying to public water systems and specifying the maximum contamination levels that, in the judgement of the *U.S. Environmental Protection Agency (EPA)*, are required to protect the public welfare. These regulations apply to any contaminants that may adversely affect the odor or appearance of such water and consequently may cause people served by the system to discontinue its use. Term may be used synonymously with *Secondary Drinking Water Standards*.

Secondary Drinking Water Standards — Non-enforceable standards related to the aesthetic quality of drinking water such as those relating to taste and odor; generally set by the *U.S. Environmental Protection Agency (EPA)* or state water-quality enforcement agencies based on EPA guidance. Term may be used synonymously with *Secondary Drinking Water Regulations*.

Secondary Maximum Contaminant Level (SMCL) — The maximum concentration or level of certain water contaminants in public water supplies set by the *U.S. Environmental Protection Agency (EPA)* to protect the public welfare. The secondary levels are written to address aesthetic considerations such as taste, odor, and color or water, rather than health standards. Also see *Primary Drinking Water Standards*, *Maximum Contaminant Level (MCL)*, and *Maximum Contaminant Level Goal (MCLG)*.

Secondary Porosity — The porosity that results from fractures and solution channels.

Section 404 Permit — The *Wetland* dredge and fill permit issued under regulations written to conform to *Section 404* of the *Clean Water Act (CWA)*. The permit is actually granted by the *U.S. Army Crops of Engineers (COE)*.

Sediment — (1) Soil particles that have been transported from their natural location by wind or water action; particles of sand, soil, and minerals that are washed from the land and settle on the bottoms of wetlands and other aquatic habitats. (2) The soil material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by erosion (by air, water, gravity, or ice) and has come to rest on the earth's surface. (3) Solid material that is transported by, suspended in, or deposited from water. It originates mostly from disintegrated rocks; it also includes chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics, and cause of the occurrence of sediment in streams are influenced by environmental factors. Some major factors are degree of slope, length of slope, soil characteristics, land usage, and quantity and intensity of precipitation. (4) In the singular, the word is usually applied to material in suspension in water or recently deposited from suspension. In the plural the word is applied to all kinds of deposits from the waters of streams, lakes, or seas, and in a more general sense to deposits of wind and ice. Such deposits that have been consolidated are generally called sedimentary rocks. (5) Fragmental or clastic mineral particles derived from soil, alluvial, and rock materials by processes of erosion, and transported by water, wind, ice, and gravity. A special kind of sediment is generated by precipitation of solids from solution (i.e., calcium carbonate, iron oxides). Excluded from the definition are vegetation, wood, bacterial and algal slimes, extraneous lightweight artificially made substances such as trash, plastics, flue ash, dyes, and semisolids.

Sediment Control — The control of movement of sediment on the land, in a stream or into a reservoir by means of manmade structures; such as debris dams, wing dams, or channelization; land management techniques, or natural processes.

Sediment Load — (1) The soil particles transported through a channel by stream flow. (2) The total sediment, including bedload plus suspended sediment load, is the sediment being moved by flowing water in a stream at a specified cross section.

Sediment Load, Total — Also referred to as the total load, a term that refers to the total sediment (bed load plus suspended-sediment load) that is in transport. The term needs to be qualified, however, such as "annual suspended-sediment load" or "sand-size suspended-sediment load," and so on. It is not synonymous with total sediment discharge.

Sediment Storage — The accumulation, in a reservoir, of sediment that would normally be carried downstream without the project.

Sedimentary Rock — (Geology) Rock formed of sediment, especially from mechanical, chemical, or organic processes, and specifically: (1) clastic rock, such as conglomerate, sandstone, and shale, formed of fragments of other rock transported from their sources and deposited in water; and (2) rocks formed by precipitation from solution, as rock salt and gypsum, or from secretions of organisms, such as most limestone. Many sedimentary rocks show distinct layering, which is the result of different types of sediment being deposited in succession. Also see *Igneous Rock* and *Metamorphic Rock*.

Sedimentation — (1) Strictly, the act or process of depositing sediment from suspension in water. Broadly, all the processes whereby particles of rock material are accumulated to form sedimentary deposits. Sedimentation, as commonly used, involves not only aqueous but also glacial, aeolian, and organic agents. (2) (Water Quality) Letting solids settle out of wastewater by gravity during treatment.

Sediments — Soil, sand, and minerals washed from the land into water, usually after rain. They pile up in reservoirs, rivers, and harbors, destroying fish and wildlife habitat, and clouding the water so that sunlight cannot reach aquatic plants. Careless farming, mining, and building activities will expose sediment materials, allowing them to wash off the land after rainfall.

Seep — (1) To pass slowly through small openings or pores; ooze. (2) Ground water emerging on the face of a stream bank. (3) An area which slowly passes water out of the ground to the surface, or where water moves slowly from surface bodies to ground water bodies, as from canals and ditches into the underlying ground water table. (4) An area of minor ground water outflow onto the land surface or into a stream channel or other water body. Flows are usually too small to be a spring.

Seepage — (1) The passage of water or other fluid through a porpus medium, such as the passage of water through an earth embankment or masonry wall. (2) Ground water emerging on the face of a stream bank. (3) The slow movement of water through small cracks, pores, *Interstices,* etc., of a material into or out of a body of surface or subsurface water. (4) The *Interstitial* movement of water that may take place through a dam, its foundation, or its *Abutments*. (5) The loss of water by infiltration into the soil from a canal, ditches, laterals, watercourse, reservoir, storage facilities, or other body of water, or from a field. Seepage is generally expressed as flow volume per unit of time. During the process of priming (a field during initial irrigation), the loss is called *Absorption Loss*.

Seepage Face - a physical boundary segment of a ground water system along which ground water discharges and which is present when a water table surface ends at the downstream external boundary of a flow domain; along this boundary segment, of which the location of the upper end is a-priori unknown, water pressure equals atmospheric pressure and hydraulic head equals elevation head. Commonly referred to as "seeps" or "springs".

Seeps — Ground water/surface water connections caused by river or stream erosion into a near-surface aquifer.

Semi-Analytical Model - a mathematical model in which complex analytical solutions are evaluated using approximate techniques, resulting in a solution discrete in either the space or time domain.

Semiaquatic — Adapted for living or growing in or near water; not entirely aquatic.

Semiarid — A term applied to regions or climates where moisture is normally greater than under arid conditions but still definitely limits the growth of most crops. Dryland farming methods or irrigation generally are required for crop production. The upper limit of average annual precipitation in the cool semiarid regions is as low as 15 inches (38.1 cm). Whereas in tropical regions it is as high as 45 or 50 inches (114.3 or 127.0 cm).

Semiconfined (Aquifer) — An aquifer that has a "leaky" confining unit and displays characteristics of both confined and unconfined aquifers, typically evidencing low permeability through which recharge and discharge can still occur. Also see *Leaky Aquifer*.

Semipermeable — (1) Partially permeable. (2) Allowing passage of certain, especially small, molecules or ions but action as a barrier to others. Used of biological and synthetic membranes.

Senile — (Geology) Worn away nearly to the base level, as at the end of an erosion cycle.

Sensitivity - the variation in the value of one or more output variables (such as hydraulic heads) or quantities calculated from the output variables (such as ground water flow rates) due to changes in the value of one or more inputs to a ground water flow model (such as hydraulic properties or boundary conditions).

Sensitivity Analysis - a procedure based on systematic variation of model input values (1) to identify those model input elements that cause the most significant variations in model output; and (2) to quantitatively evaluate the impact of uncertainty in model input on the degree of calibration and on the model's predictive capability.

Settleable Solids — Most generally, all solids in a liquid that can be removed by stilling the liquid. In the *Imhoff* cone test, the volume of matter in a one-liter sample that settles to the bottom of the cone in one hour. (Water Quality) Bits of debris, sediment, or other solids that are heavy enough to sink when a liquid waste is allowed to stand in a pond or tank. Also see *Settling Chamber* and *Settling Pond*.

Settling Pond — (Water Quality) An open *Lagoon* into which wastewater contaminated with solid pollutants is placed and allowed to stand. The solid pollutants suspended in the water sink to the bottom of the lagoon and the liquid is allowed to overflow out of the enclosure.

Shaft — A vertical or inclined opening of uniform and limited cross section made for finding or mining ore, raising water, or ventilating underground workings (as in a cave).

Shallow Well — A well with a pumping head of 20 feet or less, permitting use of a suction pump.

Sheet — (Geology) A broad, relatively thin deposit or layer of *Igneous* or *Sedimentary Rock*.

Sheet Erosion — (1) The removal of thin, fairly uniform layer of soil or materials from the land surface by the action of rainfall and runoff water. (2) The removal by surface runoff of a fairly uniform layer of soil from a bank slope from *Sheet Flow* or runoff that flows over the ground surface as a thin, even layer not concentrated in a channel.

Sheet Flow — An overland flow or downslope movement of water taking the form of a thin, continuous film over relatively smooth soil or rock surfaces and not concentrated into channels larger than rills.

Significant Hydrologic Resources (SHR) — Generally refers to either federally significant resources, e.g., wetlands, which meet federal definitions and guidelines, or regionally designated significant resources which do not meet such federal definitions or guidelines, e.g., stream and riparian environments, playas, spring fed stands of riparian vegetation, and other wetland areas.

Silica — (Geology) Silicon dioxide (SiO2). It occurs in crystalline (quartz), amorphous (opal), or impure (silica sand) forms.

Sill — (1) A submerged ridge at relatively shallow depth separating the basins of two bodies of water. (2) A horizontal beam forming the bottom of the entrance to a lock. (3) Also, a low, submerged dam-like structure built to control riverbed scour and current speeds. (4) (Geology) An intrusive body of igneous rock of approximately uniform thickness and relatively thin compared with its lateral extent, which has been emplaced parallel to the bedding or schistosity of the intruded rocks.

Silt — (1) Sedimentary particles smaller than sand particles, but larger than clay particles. (2) An intermediate soil textural class consisting of particles between 0.05 and 0.002 millimeters in diameter.

Siltation — The deposition of finely divided soil and rock particles upon the bottom of stream and river beds and in reservoirs.

Simulation - in ground water modeling, one complete execution of a ground water modeling computer program, including input and output. Simulation is sometimes also used broadly to refer to the process of modeling in general.

Sink — (1) Generally, a dry or intermittently dry lakebed in the lowest spot of a closed valley; a depression in the land surface, especially one having a central playa or saline lake with no outlet. Salt contents are generally quite high. The term sink is interchangeable with the term *Playa*. Also see *Natural Sink*. (2) (Environmental) A place in the environment where a compound or material collects.

Sinkhole — A depression in the earth's surface caused by dissolving of underlying limestone, salt, or gypsum. Drainage is provided through underground channels which may be enlarged by the collapse of a cavern roof. Also see *Karst*.

Sinuous (Stream) — Characterized by many curves or turns; winding.

Site Characterization - (1) a general term applied to the investigation activities at a specific location that examines natural phenomena and human-induced conditions important to the resolution of environmental, safety and water resource issues; (2) means the program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of a particular site relevant to the program. Site characterization includes geophysical testing, borings, surface excavations, excavation of exploratory shafts, limited subsurface lateral excavations and borings and in situ testing at depth needed to determine the suitability of the site.

Slickensides — (Geology) A smooth striated polished surface produced on rock by movement along a fault.

Slope — The side of a hill or mountain, the inclined face of a cutting, canal or embankment or an inclination from the horizontal. In the United States, it is measured as the ratio of the number of units of horizontal distance to the number of corresponding units of vertical distance. The term is expressed as a percent when the slope is gentle, in which cast the term *Gradient* is also used.

Slough — (1) A place of deep mud or mire; a wet or marshy place as a swamp or marshland creek. Also a side channel or inlet as from a river; ordinarily found on or at the edge of the flood plain or a river; a *Bayou*. (2) (Localized) In the Mississippi Valley and in California, a tide flat or bottom-land creek. (3) (Sewage Disposal) Of a filter, to cast off a thin film of scum or a mass of bacterial growth or fungus. (4) Also *Slue*. A stagnant swamp, marsh, bog, or pond, especially as part of a bayou, and inlet, or a backwater.

Sloughing (or Sloughing Off) — Movement of a mass of soil down a bank into the channel (also called *Slumping*). Sloughing is similar to a landslide.

Soda Ash — (Water Quality) Also known as *Sodium Carbonate*, typically of chemical symbol Na2CO3, a salt of strong alkaline taste used in making glass, soap, paper, chemical reagents and to remove non-carbonate hardness from water.

Sodicity (of Soils) — A measure of the excess sodium in a soil which imparts a poor physical condition to the soil. *Sodic Soils* are generally impermeable to water, which makes it difficult to germinate crops.

Sodium Adsorption Ratio (SAR) — An expression of relative activity of sodium ions in exchange reactions with soil, indicating the sodium or alkali hazard to soil. It is calculated from the expression:

$$SAR = (Na)/[(Ca + Mg)/2]^{1/2}$$

where all quantities are expressed in milliequivalents per liter (meg/L). It is a particularly important measure in waters used for irrigation purposes. Waters range in respect to sodium hazard from those which can be used for irrigation on almost all soils to those which are generally unsatisfactory for irrigation.

Sodium Bicarbonate — (Wastewater Treatment) A white crystalline salt, NaHCO2, less soluble than *Sodium Carbonate* and having only a slight alkaline taste. Used as a *Coagulant Aid* in the neutralization process of wastewater treatment plants, it promotes more rapid settling, increases the efficiency of the coagulation process and extends the pH range to a level at which *Alum* (aluminum sulfate), a common inorganic coagulant, is effective.

Sodium Carbonate — (Water Quality) Any carbonate of sodium, typically Na2CO3, a salt of strong alkaline taste, found in nature, as in soda lakes, but more often made artificially and used extensively in making glass, soap, paper, chemical reagents and in the softening of water. Also referred to as *Soda Ash*.

Soft Water — Water that contains low concentrations of metal ions such as calcium and magnesium. This type of water does not precipitate soaps and detergents. Compare to *Hard Water*.

Soil — The meaning of this term varies depending on the field of consideration: (1) *Pedology* — the earth materials which have been so modified and acted upon by physical, chemical, and biological agents that it will support rooted plants; (2) *Engineering Geology* — the layer of incoherent rock material that nearly everywhere forms the surface of the land and rests on *Bedrock*, also called *Regolith*; (3) Ecology — A dynamic natural body on the surface of the earth in which plants grow, composed of mineral and organic materials and living forms.

Soil Classification — — The systematic arrangement of soils into groups or categories on the basis of their characteristics. Broad groupings are made on the basis of general characteristics and subdivisions on the basis of more detailed differences in specific properties. *Soil Taxonomy* is the study of soil classification systems. For a description of soil classifications, see *Land Capability Classes*.

Soil Creep — The slow mass movement of soil materials down slopes primarily under the influence of gravity, but facilitated by saturation with water and/or by alternating freezing and thawing.

Soil Erodibility — An indicator of a soil's susceptibility to raindrop impact, runoff, and other erosive processes.

Soil Erosion — The detachment and movement of soil from the land surface by wind or water.

Soil Moisture (Soil Water) — Water diffused in the upper part of the *Unsaturated Zone* (*Zone of Aeration*) of the soil, from which water is discharged by the *Transpiration* of plants, by *Evaporation*, or *Interflow*. Also referred to as *Soil Moisture Content* or *Available Water Content (AWC)*.

Solubility — The relative capacity of a substance to serve as a solute. Sugar has a high solubility in water, whereas gold has a low solubility in water.
Solum — The top two soil layers, composed of the topsoil (*A–Horizon*) and the subsoil (*B–Horizon*, or layer of leached material deposition). The solum excludes the parent material layer (*C–Horizon*). Also referred to as the *Zone of Eluviation*. Also see *Soil Profile*.

Solute — (1) Any material which is dissolved in another, such as salt dissolved in water. (2) Any substance that is
dissolved in water.

Solute Transport — The movement of dissolved substances through a *Hydrogeologic Unit*.

Solute Transport Model — Mathematical model used to predict the movement of solutes (generally contaminants) in an aquifer through time.

Solution — A homogeneous mixture of a solute in a solvent. For example, when sugar (the solute) is dissolved in water (the solvent), the molecules that comprise the sugar crystal are separated from one another and dispersed throughout the liquid medium.

Solution Channel — Tubular or planar channel formed by solution in carbonate-rock terrains, usually along joints and bedding planes.

Source - a process, or a feature from which, water, vapor, NAPL, solute or heat is added to the ground water or vadose zone flow system.

Source of Contaminants - the physical location (and spatial extent) of the source contaminating the aquifer; in order to model fate and transport of a contaminant, the characteristics of the contaminant source must be known or assumed.

Source Loading - the rate at which a contaminant is entering the ground water system at a specific source.

Specific Capacity (of a Well) — In ground water hydrology, the ratio of the discharge or yield of a well, usually measured in gallons per minute per foot, to drawdown after a period of sustained pumping.

Specific Conductance — A measure of the ability of water to conduct an electrical current as measured using a 1–cm cell and expressed in units of electrical conductance, i.e., siemens or microsiemens (µS or µmho) at 25 EC. Specific conductance is related to the type and concentration of ions in solution and can be used for approximating the total dissolved solids (TDS) content of water by testing its capacity to carry an electrical current. Commonly, the concentration of dissolved solids (in milligrams per liter, mg/L) is from 55 to 75 percent of the specific conductances (in microsiemens, µS). This relation is not constant from stream to stream, and it may vary in the same source with changes in the composition of the water. For comparison, the specific conductance of sea water is approximately 50,000 µS, which is equivalent to a TDS concentration of about 35,000 milligrams per liter (mg/l). (Water Quality) Specific conductance is used in ground water monitoring as an indication of the presence of ions of chemical substances that may have been released by a leaking landfill or other waste storage or disposal facility. A higher specific conductance in water drawn from *Downgradient Wells* when compared to *Upgradient Wells* indicates possible contamination from the facility.

Specific Discharge (Specific Flux) — For ground water, the rate of discharge per unit area, measured at right angles to the direction of flow.

Specific Drawdown — The drawdown in a well per unit discharge.

Specific Gravity (SG or SP GR) — (1) The ratio of the density of a substance to the density of some substance (as pure water) taken as a standard when both densities are obtained by weighing in air. (2) The ratio of the mass of a solid or liquid to the mass of an equal volume of distilled water at 4EC (39EF) or of a gas to an equal volume of air or hydrogen under prescribed conditions of temperature and pressure. Relative to water, the specific gravity (SG) is given by:

SG = ñ/ñw

where ñ is the density (weight per unit volume) of the unknown substance and ñw is the density of water. The parameter has no units and is frequently used to determine the concentration of a *Solution*.

Specific Storage — The volume of water removed or added within the unit volume of an aquifer per unit change in head.

Specific Yield (of an Aquifer) — The volume of water available per unit volume of aquifer, if drawn by gravity. Specific yield is expressed as a percent. For example, if 0.2 cubic meter of water will drain from 1 cubic meter of aquifer sand, the specific yield is 20 percent.

Specific Yield (Ground Water) — The ratio of the volume of water that a rock will yield by gravity, after being saturated, to its own volume, expressed as a percentage.

Specified Flux Boundary - model boundary condition in which the ground water flux is specified; also called fixed or prescribed flux, or Neumann boundary condition.

Specified Head Boundary (Constant Head) - a model boundary at which the hydraulic head is specified; also called fixed or prescribed head, or Dirichlet boundary condition.

Spit — (1) A narrow point of land extending into a body of water. (2) A brief, scattered fall of rain or snow.

Spring (Water) — (1) A concentrated discharge of ground water coming out at the surface as flowing water; a place where the water table crops out at the surface of the ground and where water flows out more or less continuously. (2) A place where ground water flows naturally from a rock or the soil into the land surface or into a body of surface water. Its occurrence depends on the nature and relationship of rocks, especially permeable and impermeable strata, on the position of the water table, and on the topography.

Spring, Cold — A spring whose water has a temperature appreciably below the mean annual atmospheric temperature in the area.

Spring, Hot — A thermal spring whose temperature is above that of the human body.

Spring Overturn — A physical phenomenon that may take place in a lake or similar body of water during the early spring, most frequently in lakes located in temperate zones where the winter temperatures are low enough to result in freezing of the lake surface. The sequence of events leading to spring overturn include: (1) the melting of ice cover; (2) the warming of surface waters; (3) density changes in surface waters producing convection currents from top to bottom; (4) circulation of the total water volume by wind action; and (5) vertical temperature equality. The overturn results in a uniformity of the physical and chemical properties of the entire water mass. Also see *Fall Overturn*. Also referred to as *Spring Turnover*.

Static Head — The difference in elevation in feet between the water surface of the body of water being pumped and the centerline of the discharge pipe at the point of release. It is the lift measured in feet.

Static Level (Ground Water) — The level of water in a nonpumping or nonflowing well. For the purpose of computing the drawdown, it generally is the water level immediately before pumping begins.

Static Lift — The vertical distance between source and discharge water levels in a pump installation.

Static Pressure — The pressure exerted by a still liquid or gas, especially water or air.

Static Water Depth — (Hydraulics) For a water well, the vertical distance from the centerline of the pump discharge down to the surface level of the free pool while no water is being drawn from the pool or water table.

Static Water Level — (1) The elevation or level of the water table in a well when the pump is not operating. (2) The level or elevation to which water would rise in a tube connected to an *Artesian Aquifer* or basin in a conduit under pressure.

Steady Flow — Flow in which the rate remains constant with respect to time at a given cross-section.

Steady State — (1) State of balance in a *Hydrologic System* where little or no change in hydraulic head occurs through time. (2) In a system with a flow-through of material (e.g., water) or energy, the equilibrium condition in which the flow in equals the flow out.

Stewardship — (Ecology) (1) Caring for land and associated resources and maintaining healthy ecosystems for future generations. (2) Administrative and/or custodial actions taken to preserve and protect the *Natural Resources*, particularly the plant (*Flora*) and animal (*Fauna*) life, of an area or *Ecosystem*.

Stochastic Hydrology — That branch of *Hydrology* involving the manipulation of statistical characteristics of hydrologic variables with the aim of solving hydrologic problems, using the stochastic properties of the events.

Stochastic Process — (Statistics) A process in which the dependent variable is random (so that the prediction of its values depends on a set of underlying probabilities) and the outcomes at any instant is not known with certainty. A process is said to be stochastic when its future cannot be predicted exactly from its past; describing an event or process that involves random chance or probability. A stochastic relationship is assumed to be inexact and therefore involves a *Disturbance (or Error) Term* which is used to account for the unexplainable portion of the relationship. Consequently, a simple (stochastic) functional relationship shows that for any time period, *t* (where *t*=1, 2, ..., n), the relationship between the dependent (*Endogenous*) variable, Y, and the independent (*Exogenous*) variable, X, may be written as:

Yt = á + â Xt + åt

where: Y represents the dependent variable of variable to be explained; t represents time periods of observation (i.e., t=1,2,...,n); á (*alpha*) represents the constant term (without a time reference); â (*beta*, also a constant term without a time reference) represents the coefficient of the independent variable, X; X represents the independent, or explanatory variable; and å (*epsilon*), the error term, represents the value of the unexplained disturbance term.

Storage — (1) Water artificially impounded in surface or underground reservoirs for future use. (2) Water naturally detained in a drainage basin, such as ground water, channel storage, and depression storage. The term *Drainage Basin Storage*, or simply *Basin Storage*, is sometimes used to refer collectively to the amount of water in natural storage in a drainage basin. (3) (Water Quality) The temporary holding of waste pending treatment or disposal, as in containers, tanks, waste piles, and surface impoundments.

Storage, Specific (Ground Water) — The amount of water released from or taken into storage per unit volume of a porous medium per unit change in head.

Storativity — The volume of water that a permeable unit, i.e., aquifer, will absorb or expel from storage per unit surface area per unit change in head. In an unconfined aquifer, the storativity value is equal to the *Specific Yield*. The specific yield of the aquifer can be used to estimate the time between when pumping begins and equilibrium ground water conditions are reached.

Strata — (Geology) Distinct horizontal layers in geological deposits. Each layer may differ from adjacent layers in terms of texture, grain size, chemical composition, or other geological criteria. The term is also applied to layering of other material such as the atmosphere.

Stratification — The arrangement of a body of water, such as a lake, into two or more horizontal layers of differing characteristics, such as temperature, density, etc. Also applies to other substances such as soil and snow, etc.

Stratigraphy — (1) The branch of geology which treats the formation, composition, sequence and correlation of the layered rocks as parts of the earth's crust. (2) The branch of geology that deals with the definition and description of major and minor natural divisions of rocks (mainly sedimentary, but not excluding igneous and metamorphic) available for study in outcrop or from subsurface, and with the interpretation of their significance in geologic history. It involves interpretation of features of rock strata in terms of their origin, occurrence, environment, thickness, lithology, composition, fossil content, age, history, paleogeographic conditions, relation to organic evolution, and relation to other geologic concepts. (3) The arrangement of strata, especially as to geographic position and chronological order of sequence.

Stratum — A horizontal layer or section.

Stream — A general term for a body of flowing water; natural water course containing water at least part of the year. In *Hydrology*, the term is generally applied to the water flowing in a natural channel as distinct from a canal. More generally, as in the term *Stream Gaging*, it is applied to the water flowing in any channel, natural or artificial. Some classifications of streams include, *in relation to time*:

- [1] ***Ephemeral Streams*** — Streams which flow only in direct response to precipitation and whose channel is at all times above the water table.
- [2] ***Intermittent or Seasonal Streams*** — Streams which flow only at certain times of the year when it receives water from springs, rainfall, or from surface sources such as melting snow.
- [3] ***Perennial Streams*** — Streams which flow continuously.And, *in relation to ground water*:
- [4] ***Gaining Streams*** — Streams or a reach of a stream that receive water from the zone of saturation. Also referred to as an *Effluent Stream*.
- [5] ***Insulated Streams*** — Streams or a reach of a stream that neither contribute water to the zone of saturation nor receive water from it. Such streams are separated from the zones of saturation by an impermeable bed.
- [6] ***Losing Streams*** — Streams or a reach of a stream that contribute water to the zone of saturation. Also referred to as an *Influent Stream*.
- [7] ***Perched Streams*** — Perched streams are either losing streams or insulated streams that are separated from the underlying ground water by a zone of aeration.

Stream Capture — The process whereby a stream rapidly eroding headward cuts into the divide separating it from another drainage basin, and provides an outlet for a section of a stream in the adjoining valley. The lower portion of the partially diverted stream is called a *Beheaded Stream*. Also referred to as *Stream Piracy*.

Stream Channel — The bed where a natural stream of water runs or may run; the long narrow depression shaped by the concentrated flow of a stream and covered continuously or periodically by water.

Stream, Effluent — A stream or reach of a stream fed by ground water. It is also referred to as a *Gaining Stream*. See *Stream*.

Stream, Ephemeral — A stream that flows only in response to precipitation. See *Stream*.

Streamflow — The discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word streamflow uniquely describes the discharge in a surface stream course. Streamflow is a more general term than "runoff" as streamflow may be applied to discharge whether or not its is affected by diversion or regulation.

Streamflow Depletion — The amount of water that annually flows into a valley or onto a particular land area minus the amount that flows out of the valley or away from the particular land area. It is also the amount of water taken from a stream.

Streamflow Regulation — The artificial manipulation of the flow of a stream.

Stream Gradient — A general slope or rate of change in vertical elevation per unit of horizontal distance of the water surface of a flowing stream.

Stream, Influent — A stream that contributes water to the *Zone of Saturation*. Also referred to as a *Losing Stream*. See *Stream*.

Stream, Intermittent — A stream that flows only part of the time or through only part of its reach. See *Stream*.

Streamlet — A small stream.

Stream Load — All the material transported by a stream or river either as visible sediment (*Bed Load* and *Suspended Load*) or in solution (*Dissolved Load*).

Stream Order — (1) Designation of stream segments within a drainage basin; a system of numbering streams according to sequence of tributary size. The smallest perennial tributary is designated as order 1, the junction of two first-order streams produces a stream segment of order 2, etc. (2) A method of numbering streams as part of a drainage basin network as adopted by the *U.S. Geological Survey (USGS)*. The smallest unbranched mapped tributary is a first-order stream, the stream receiving the tributary is a second-order stream, and so on, with the main stream always of the highest order. It is usually necessary to specify the scale of the map used, as a first-order stream on a 1:62,500 map may be a third-order stream on a 1:12,000 map. Tributaries which have no branches are designated as of the first order, streams which receive only first-order tributaries are of the second order, larger branches which receive only first-order and second-order tributaries are designated third order, and so on, the main stream being always of the highest order.

Stream, Perennial — A stream that flows continuously. See *Stream*.

Stream Piracy — The process whereby a stream rapidly eroding headward cuts into the divide separating it from another drainage basin, and provides an outlet for a section of a stream in the adjoining valley. The lower portion of the partially diverted stream is called a *Beheaded Stream*. Also referred to as *Stream Capture*.

Stream Reach — The continuous portion of a stream channel and adjoining floodplain from one selected point to another, usually measured along the *Thalweg* of the channel.

Stream Segment — (Water Planning) Surface waters of an approved planning area exhibiting common biological, chemical, hydrological, natural, and physical characteristics and processes. Segments will normally exhibit common reactions to external stresses, for example, discharge or pollutants.

Stream Terrace — (1) A surface representing remnants of a stream's channel or flood plain when the stream was flowing at a higher level. Subsequent downward cutting by the stream leaves remnants of the old channel or flood plain standing as a terrace above the present level of the stream. (2) A transversely level erosional remnant of a former axial stream or major desert stream floodplain that slopes in the same direction as the adjacent, incised stream, and is underlain by well sorted and stratified sand and gravel or by loamy or clayey sediments.

Stream, Underground — A subsurface stream which has all the characteristics of a water-course on the surface — a definite channel with bed and banks, a definite stream of water, and a definite source(s) of supply.

Strip Mining — The process of removing mineral deposits that are found close enough to the surface so that the construction of tunnels (underground mining) is not necessary. The soil and strata that cover the deposit are removed to gain access to the mineral deposit. The primary environmental concerns related to this technique are the disposition of spoils removed to gain access to the deposit and the scoring of the landscape that remains following the complete removal of the mineral deposit. Water pollution is also a concern because runoff from the mining area is frequently rich in sediments and minerals. Furthermore, such operations sometimes necessitate the removal of ground water that infiltrates the mining pit, consequently altering the ground water flow with potential implications on the water table and aquifer characteristics. Also referred to as *Open-Pit Mining* or *Surface Mining*.

Subsequent Stream — A tributary stream flowing along beds of less erosional resistance, parallel to beds of greater resistance. Its course is determined subsequent to the uplift that brought the more resistant beds within its sphere of erosion.

Subsidence — (1) The sinking of the land surface due to a number of factors, of which ground water extraction is one. (2) A sinking of a large area of the earth's crust. Typically this may result from the over-pumping of a basin's water table and the inability of the soils to re-absorb water from natural or artificial injection. Also frequently results from overdrafts of the aquifer and its inability to fully recharge, a process termed *Aquifer Compaction*.

Subsoil — Soil material underlying the surface soil.

Superfund Law (Comprehensive Environmental Response, Compensation, and Liability Act — CERCLA) — This statute, originally enacted in 1980 and substantially modified in 1986, establishes the *U.S. Environmental Protection Agency's (EPA)* authority for emergency response and cleanup of hazardous substances that have been spilled, improperly disposed of, or released into the environment. The primary responsibility for response and cleanup is on the generators or disposers of the hazardous substances, with a backup federal response using a trust fund provision.

Superfund List — A list of the hazardous waste disposal sites most in need of cleanup. The list is updated annually by the *U.S. Environmental Protection Agency (EPA)* based primarily on how a site scores using the *Hazard Ranking System*. Also referred to as the *National Priorities List (NPL)*.

Superfund Site — A hazardous waste landfill on the *National Priorities List (NPL)* (also referred to as the *Superfund List*) being cleaned up by the responsible parties or using proceeds from the *Hazardous Substances Superfund*.

Superimposed Stream — A stream whose present course was established on young rocks burying an old surface. With uplift, this course was maintained as the stream cut down through the young rocks to and into the old surface.

Superposition Principle - the addition or subtraction of two or more different solutions of a governing linear partial differential equation (PDE) to obtain a composite solution of the PDE. As an example, the superposition of drawdown caused by a pumping well on a regional, nonpumping potentiometric surface.

Surface Casing — The well pipe inserted as a lining nearest to the surface of the ground to protect the well from near-surface sources of contamination.

Surface Impoundment — (Water Quality) The treatment, storage, or disposal of liquid hazardous wastes, such as in tanks, ponds, pits, or lagoons. An indented area in the land's surface for such storage and treatment.

Surface Mining — The process of removing mineral deposits that are found close enough to the surface so that the construction of tunnels (underground mining) is not necessary. The soil and strata that cover the deposit are removed to gain access to the mineral deposit. The primary environmental concerns related to this technique are the disposition of spoils removed to gain access to the deposit and the scoring of the landscape that remains following the complete removal of the mineral deposit. Water pollution is also a concern because runoff from the mining area is frequently rich in sediments and minerals. Furthermore, such operations sometimes necessitate the removal of ground water that infiltrates the mining pit, consequently altering the ground water flow with potential implications on the water table and aquifer characteristics. Also referred to as *Open-Pit Mining* or *Strip Mining*. Also see *Dewatering*.

Surface Mining Control and Reclamation Act — An act passed in 1977 requiring that mine operators take measures to avoid acid or other toxic mine drainage. To correct existing acid drainage problems, the section of the law dealing with abandoned mine land states that land and water affected by mining that took place before 1977 can be cleaned up with fees paid by coal operators into the *Abandoned Mine Reclamation Fund*. About 90 percent of existing stream damage in the United States is from underground coal mining that took place before 1977. The federal enforcement agency is the U.S. Department of the Interior, Bureau of Mines, Office of Surface Mining Reclamation and Enforcement (OSM).

Surface Runoff — That part of the runoff which travels over the soil surface to the nearest stream channel. It is also defined as that part of the runoff of a drainage basin that has not passed beneath the surface since precipitation. Also applies to snowmelt or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions. In terms of surface water quality, surface runoff may constitute a major transporter of *Non-Point Source (NPS) Pollution*. The term is misused when applied in the sense of *Direct Runoff*. Also see *Runoff*, *Direct Runoff*, *Overland Flow*, *Ground-Water Runoff*, and *Surface Water*.

Surface Water — (1) An open body of water such as a stream, lake, or reservoir. (2) Water that remains on the earth's surface; all waters whose surface is naturally exposed to the atmosphere, for example, rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc., and all springs, wells, or other collectors directly influenced by surface water. (3) A source of drinking water that originates in rivers, lakes and run-off from melting snow. It is either drawn directly from a river or captured behind dams and stored in reservoirs. Also see *Ground Water Under the Direct Influence (UDI) of Surface Water*.

Suspended Sediment — Very fine soil particles which remain in suspension in water for a considerable period of time without contact with the bottom. Such material remains in suspension due to the upward components of turbulence and currents and/or by *Colloidal Suspension*.

Suspended Solids (SS) — Solids which are not in true solution and which can be removed by filtration. Such suspended solids usually contribute directly to turbidity. Defined in waste management, these are small particles of solid pollutants that resist separation by conventional methods. Suspended solids (along with *Biochemical Oxygen Demand — BOD*) is a measurement of water quality and an indicator of treatment plant efficiency. Also see *Suspended Particulate Matter*.

Suspended, Total — The total amount of a given constituent in the part of a representative suspended-sediment sample that is retained on a 0.45-micrometer membrane filter. This term is used only when the analytical procedure assures measurement of at least 95 percent of the constituent determined.

Knowledge of the expected form of the constituent in the sample, as well as the analytical methodology used, is required to determine when the results should be reported as "suspended, total". Determinations of "suspended, total" constituents are made either by analyzing portions of the material collected on the filter or, more commonly, by the difference, based on
determinations of (1) dissolved and (2) total concentrations of the constituent.

Sustained Yield — (1) (General) Achievement and maintenance, in perpetuity, of a high-level annual or regular periodic output or harvest of the various renewable land and water resources. (2) (Hydrology) The amount of water that may be removed (say, through ground water pumping) from an hydrographic area during a period of time without affecting future yields. Under such conditions, sustained yield is approximately equal to annual recharge. Contrast with *Ground water Mining*. (3) (Ecology) The perpetual output of a renewable resource, achieved and maintained at a given management intensity, without impairment of the productivity of the land.

Swale — (1) A slight depression, sometimes swampy, in the midst of generally level land. (2) A shallow depression in an undulating ground moraine due to uneven glacial deposition. (3) A long, narrow, generally shallow, trough-like depression between tow beach ridges, and aligned roughly parallel to the coastline. (4) A piece of meadow, often a slight depression or valley, as in a plain or moor, marshy and rank with vegetation. Swales usually carry flows only during or immediately after rainfall or snowmelt events. Swales vary in size from small conveyances providing drainage along roadways and behind or between buildings to larger waterways.

Swamp — A term frequently associated with *Wetlands*. Wet, spongy land; low saturated ground, and ground that is covered intermittently with standing water, sometimes inundated and characteristically dominated by trees or shrubs, but without appreciable peat deposits. Swamps may be fresh or salt water and tidal or non-tidal. It differs from a *Bog* in not having an acid substratum.

Sweet (Water) — Water that is pleasing to the senses; agreeable and not saline or polluted; drinkable; *Potable*. Also see *Freshwater*.

-T-

Tacking — The binding of *Mulch* fibers by mixing them with an adhesive chemical compound during land *Restoration* projects.

Tafoni — Natural cavities in rocks formed by weathering.

Tailings — The waste material remaining after metal is extracted from ore.

TDS (Total Dissolved Solids) — All the solids (usually mineral salts) that are dissolved in water. Used to evaluate water quality.

Technology-Based Standards — (EPA) Effluent limitations applicable to direct and indirect sources which are developed on a category-by-category basis using statutory factors, not including water-quality effects.

Temperature Gradient — The rate of change of temperature with increase in height or decrease in depth.

Temperature Inversion — A surface cooling at the earth's surface which sometimes leads to an increase in temperature with altitude.

Temperature Regulation — The processes through which an organism's temperature is adjusted to certain metabolic requirements or conditions in its environment. For example, the act of human perspiration promotes surface skin evaporation which cools the body.

Temperature Scale — The temperature scale adopted by a 1960 international conference was based on a fixed temperature point, the *Triple Point* of water, at which the solid, liquid, and gas are in equilibrium. The temperature of 273.16 K (Kelvin) was assigned to this point. The freezing point of water was designated as 273.15 K, equaling exactly 0° on the *Celsius Temperature Scale*. The Celsius scale, which is identical to the *Centigrade Temperature Scale*, is named for the 18th-century Swedish astronomer Anders Celsius, who first proposed the use of a scale in which the interval between the freezing and boiling points of water is divided into 100 degrees. By international agreement, the term Celsius has officially replaced Centigrade.

Terminal Moraine — Constitutes the material (*Glacial Till*) left behind by the farthest advance of a Glacier's toe. Each different period of glaciation leaves behind its own uniquely developed moraines.
Terminus — Refers to the location of water's final destination, as in the terminus of a river system being a *Terminal Lake*.

Terrace — (1) (Erosion and Irrigation) An embankment or combination of an embankment and channel constructed across a slope to control erosion by diverting and temporarily storing surface runoff instead of permitting it to flow uninterrupted down the slope. Outlets may be soil infiltration only, vegetated waterways, tile outlets, or combinations thereof. (2) (Geological) An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide. (3) Also, a *Berm* or discontinuous segments of a berm, in a valley at some height above the *Flood Plain*, representing a former abandoned flood plain of the stream.

Terracing — A series of levels on a hillside, one above the other; dikes built along the contour of sloping farm land that hold runoff and sediment to reduce erosion. Hillside farming on terraces greatly reduces water erosion of soil.

Test Hole (Test-Well) — (Hydraulics) A well hole drilled for experimental or exploratory purposes.

Texture — Refers to relative proportions of clay, silt, and sand in soil.

Thalweg – (Geology) 1**.** The line defining the lowest points along the length of a river bed or valley. 2. A subterranean stream.

Thatch — Dead stems that build up beneath certain ground covers and lawn grasses, sometimes becoming so thick and compressed as to impede infiltration by water.

Thermal Gradient — A temperature difference between two areas.

Threatened Species — Any plant or animal species likely to become an "endangered" species within the foreseeable future throughout all of a significant area of its range or natural habitat; identified by the Secretary of the Interior as "threatened", in accordance with the 1973 *Endangered Species Act (ESA)*.

Till (Glacial) — Till is the mixture of rocks, boulders, and soil picked up by a moving *Glacier* and carried along the path of the ice advance. The glacier deposits this till along its path — on the sides of the ice sheet, at the toe of the glacier when it recedes, and across valley floors when the ice sheet melts. These till deposits are akin to the footprint of a glacier and are used to track the movement of glaciers. These till deposits can be good sources of ground water, if they do not contain significant amounts of impermeable clays. Also see *Moraines*, *Lateral Moraines*, and *Terminal Moraines*.

Tilth — (1) The general physical condition of soil as it relates to agriculture use. (2) Land used for agriculture, as opposed to pasture or forest.

Titrant — A solution of known strength or concentration; used in *Titration*.

Titration — (Chemistry) (1) A method, or the process, of determining the strength of a solution, or the concentration of a substance in solution, in terms of the smallest amount of it required to bring about a given effect in reaction with another known solution or substance, as in the neutralization of an acid by a base. (2) A process whereby a solution of known strength (the *Titrant*) is added to a certain volume of treated sample containing an indicator. A color change shows when the reaction is complete (the end point).

Titrator — An instrument, usually a calibrated cylinder (tube-form), used in *Titration* to measure the amount of *Titrant* being added to the sample.

Toe — (1) The downstream edge at the base of a dam. (2) The break in slope at the foot of a stream bank where the bank meets the bed. (3) The line of a natural or fill slope where it intersects the natural ground. (4) The lowest edge of a backslope of a cut where it intersects the roadbed or bench.

Topographic Maps — Maps with lines showing equal elevation or a region's relief; also showing natural and man-made surface features, including hills, valleys, rivers, and lakes; and man-made features such as canals, bridges, roads, cities, etc.

Total Carbon (TC) — (Water Quality) A measure of the amount of carbon-containing compounds in water. The measure includes both organic and inorganic forms of carbon as well as compounds that are soluble and insoluble. The typical laboratory analysis involves the conversion of all forms of carbon to carbon dioxide and the subsequent measurement of the carbon dioxide produced. The parameter represents an estimate of the strength of wastewater and the potential damage that an effluent can cause in a receiving stream or other body of water as a result of the removal of *Dissolved Oxygen* from the water. The measurement of total carbon requires less sample, is more rapid, and yields more reproducible results than the measurement of either the *Chemical Oxygen Demand (COD)* or the *Biochemical Oxygen Demand (BOD)*. Also see *Total Organic Carbon (TOC)*.

Total Constituent — The total amount of a given constituent in a representative suspended-sediment sample, regardless of the constituent's physical or chemical form. This term is used only when the analytical procedure assures measurement of at least 95 percent of the constituent present in both the dissolved and suspended phases of the sample. A knowledge of the expected form of the constituent in the sample, as well as the analytical methodology used, is required to judge when the results should be reported as "total". (Not that the word "total" serves a double meaning here, first indicating that the sample consists of a suspended-sediment mixture and second that the analytical method determined all of the constituent in the sample.)

Total Discharge — The quantity of a given constituent, measured as dry mass or volume, that passes a stream cross section per unit of time. When referring to constituents other than water, this term needs to be qualified, such as "total sediment discharge", "total chloride discharge", etc.

Total Dissolved Solids (TDS) — (Water Quality) A measure of the amount of material dissolved in water (mostly inorganic salts). Typically aggregates of carbonates, bicarbonates, chlorides, sulfates, phosphates, nitrates, etc. of calcium, magnesium, manganese, sodium, potassium, and other cations which form salts. The inorganic salts are measured by filtering a water sample to remove any suspended particulate material, evaporating the water, and weighing the solids that remain. An important use of the measure involves the examination of the quality of drinking water. Water that has a high content of inorganic material frequently has taste problems and/or water hardness problems. As an example, water that contains an excessive amount of dissolved salt (sodium chloride) is not suitable for drinking. High TDS solutions have the capability of changing the chemical nature of water. High TDS concentrations exert varying degrees of osmotic pressures and often become lethal to the biological inhabitants of an aquatic environment. The common and synonymously used term for TDS is "salt". Usually expressed in milligrams per liter. Also see *Hard Water* and *Salinity*.

Total Hardness — The total dissolved salts in water, expressed as total parts of dissolved salts in a million parts of water. Also see *Hard Water*.

Total Head — Energy contained by fluid because of its pressure, velocity, and elevation, usually expressed in feet of fluid (foot-pounds per pound).

Total Inorganic Carbon (TIC) — (Water Quality) The total amount of inorganic salts of carbonates and bicarbonates present in water without regard as to whether the salts are in suspended particulate form or dissolved. Water that contains an excessive amount of these salts is considered to be *Hard Water*. The dissolved materials interfere with the functioning of soaps and detergents and can form adherent scale in boilers, pipes, and steam equipment.

Total Inorganic Nitrogen (TIN) — A measure of the total *Nitrate*, *Nitrite*, and *Ammonia* concentrations of a body of water, typically measured in milligrams per liter (mg/l) or micrograms per liter (µg/l). From the point of view of a planktonic algae, nitrate, nitrite, and ammonia are all very suitable sources of nitrogen for growth. Also see *Carlson's Trophic State Index (TSI)*.

Total Inorganic Phosphate (TIP) — A measure of the concentration of usable phosphorus (soluble *Phosphates*) contained in a body of water. Soluble phosphates readily contribute to algae growth in water. Also see *Carlson's Trophic State Index (TSI)*.

Total Kjeldahl Nitrogen (TKN) — The total concentration of nitrogen in a sample present as ammonia or bound in organic compounds.

Total Load — All of a constituent in transport. When referring to sediment, it includes suspended load plus bed load.

Total Maximum Daily Load (TMDL) — (Water Quality) The maximum quantity of a particular water pollutant that can be discharged into a body of water without violating a water quality standard. The amount of pollutant is set by the *U.S. Environmental Protection Agency (EPA)* when it determines that existing, *Technology-Based* effluent standards on the water pollution sources in the area will not achieve one or more *Ambient Water Quality Standards*. The process results in the allocation of the TMDL to the various *Point Sources (PS)* of pollutants in the area.

Total Organic Carbon (TOC) — (Water Quality) A measure of the amount of organic materials suspended or dissolved in water. The measure is very similar to the assay of the total carbon content; however, samples are acidified prior to analysis to remove the inorganic salts of *Carbonates* and *Bicarbonates*. The assay of total organic carbon represents an estimation of the strength of wastewater and the potential damage that an effluent can cause in a receiving body of water as a result of the removal of *Dissolved Oxygen* from the water. The measurement of total organic carbon requires less sample, is more rapid, and yields more reproducible results than the measurement of either the *Chemical Oxygen Demand (COD)* or the *Biochemical Oxygen Demand (BOD)*. As a pollution indicator, this method is more reliable than the assay of *Total Carbon (TC)* when the wastewater contains high amounts of total inorganic carbon as well.

Total Recoverable Constituent — The amount of a given constituent that is in solution after a representative suspended-sediment sample has been digested by a method (usually using a dilute acid solution) that results in dissolution of only readily soluble substances. Complete dissolution of all particulate matter is not achieved by the digestion treatment, and thus the determination represents something less than the "total" amount (that is, less than 95 percent) of the constituent present in the dissolved and suspended phases of the sample. To achieve comparability of analytical data, equivalent digestion procedures are required of all laboratories performing such analyses because different digestion procedures are likely to produce different analytical results.

Total Solids (TS) — (Water Quality) A measure of the amount of material that is either dissolved or suspended in a water sample, obtained by allowing a known volume to evaporate and then weighing the remaining residue. Total solids equals the sum of the measurements of *Total Dissolved Solids (TDS)* and *Total Suspended Solids (TSS)*.

Total Suspended Solids (TSS) — (Water Quality) Solids, found in waste water or in a stream, which can be removed by filtration. The origin of suspended matter may be man-made wastes or natural sources such as silt. Compare to *Total Dissolved Solids (TDS)*.

Toxicity Characteristic Leaching Procedure (TCLP) — A test that measures the mobility of organic and inorganic chemical contaminants in wastes. The test, designed by the *U.S. Environmental Protection Agency (EPA)*, produces an estimate of the potential for *Leachate* formation by a waste if it is placed in the ground. If the TCLP is applied to a solid waste sample and the extract leached from the waste or the solid waste sample itself contains concentrations of specified materials exceeding allowable levels, the waste is defined as a *Hazardous Waste*, meeting the toxicity characteristic.

Toxic Materials — Any liquid, gaseous, or solid substance or substances in a concentration which, when applied to, discharged to, or deposited in water or another medium may exert a poisonous effect detrimental to people or to the propagation, cultivation, or conservation of animals, or other aquatic life.

Trace Elements — Elements essential to plant or animal life but required only in small amounts, such as the trace amounts of manganese, zinc, iron, molybdenum, cobalt, and copper.

Trace Metals — A general term for metals found in small quantities (less than 1 milligram per liter — mg/l) in water, usually due to their insolubility.

Transient Conditions - a condition in which system inputs and outputs are not in equilibrium so that there is a net change in the system with time.

Transient Flow - a condition that occurs when at any location in a ground water or vadose zone flow system the magnitude and/or direction of the specific discharge changes with time.

Transmissibility (Ground Water) — The capacity of a rock to transmit water under pressure. The coefficient of transmissibility is the rate of flow of water, at the prevailing water temperature, in gallons per day, through a vertical strip of the aquifer one foot wide, extending the full saturated height of the aquifer under a hydraulic gradient of 100 percent. A *Hydraulic Gradient* of 100 percent means a one foot drop in head in one foot of flow distance.

Transmissivity, also Coefficient of Transmissivity (ô) — The ability of an aquifer to transmit water. The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit *Hydraulic Gradient*. It is equal to an integration of the hydraulic conductivities across the saturated part of the aquifer perpendicular to the flow paths. Also, the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. Transmissivity values are given in gallons per minute through a vertical section of an aquifer 1 foot wide and extending the full saturated height of an aquifer under a hydraulic gradient of one in the *English Engineering System*; in the *Standard International System*, transmissivity is given in cubic meters per day through a vertical section of an aquifer 1 meter wide and extending the full saturated height of an aquifer under hydraulic gradient of one. It is a function of properties of the liquid, the porous media, and the thickness of the porous media. Also see *Coefficient of Transmissivity*.

Trellis Pattern — A roughly rectilinear arrangement of stream courses in a pattern reminiscent of a garden trellis, developed in a region where rocks of differing resistance to erosion have been folded, beveled, and uplifted.

Turbid — (1) Having the lees or sediment disturbed; roiled; cloudy. (2) Not clear or translucent; clouded, muddy; dull; impure; polluted. Also see *Turbidity*.

Turbidimeter — A device used to measure the degree of turbidity, or the density of suspended solids in a sample.

Turbidity — (1) A measure of the reduced transparency of water due to suspended material which carries water quality implications. The term “turbid” is applied to waters containing suspended matter that interferes with the passage of light through the water or in which visual depth is restricted. The turbidity may be caused by a wide variety of suspended materials, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton and other microscopic organisms and similar substances. Turbidity in water has public health implications due to the possibilities of pathogenic bacteria encased in the particles and thus escaping disinfection processes. Turbidity interferes with water treatment (filtration), and affects aquatic life. Excessive amounts of turbidity also make water aesthetically objectionable. The degree of the turbidity of water is measured by a *Turbidimeter*. (2) The collective optical properties of a water sample that cause light to be scattered and absorbed rather than transmitted in straight lines; the higher the intensity of scattered light, the higher the turbidity. Turbidity is expressed in nephelometric turbidity units (NTU) or Formazin turbidity units (FTU) depending on the method and equipment used.

Turbidity Current — A current in which a limited volume of turbid or muddy water moves relative to surrounding water because of its greater density.

Turnover, Spring — A physical phenomenon that may take place in a lake or similar body of water during the early spring, most frequently in lakes located in temperate zones where the winter temperatures are low enough to result in freezing of the lake surface. The sequence of events leading to spring overturn include: (1) the melting of ice cover; (2) the warming of surface waters; (3) density changes in surface waters producing convection currents from top to bottom; (4) circulation of the total water volume by wind action; and (5) vertical temperature equality. The overturn results in a uniformity of the physical and chemical properties of the entire water mass. Also referred to as *Spring Overturn*. Also see *Fall Overturn*.

-U-

Unbiased Sample — (Statistics) A sample is said to be unbiased if its behavior and characteristics are representative of the total *Population*.

Unconfined — Conditions in which the upper surface of the *Zone of Saturation* forms a water table under atmospheric pressure.

Unconfined Aquifer — An aquifer containing water that is not under pressure; the water level in a well is the same as the water table outside the well. An unconfined aquifer made up of loose material, such as sand or gravel, that has not undergone lithification (settling). In an unconfined aquifer the upper boundary is the top of the *Zone of Saturation* (water table).

Unconsolidated Deposits (Sediment) — Sediment not cemented together; may consist of sand, silt, clay, and organic material.

Unconsolidated Formation — Natural earth formations that have not been turned to stone, such as alluvium, soil, gravel, clay, sand and overburden.

Underflow — (1) (Surface and Ground water) The downstream flow of water through the permeable deposits underlying a stream. (2) (Water Quality) The slurry of concentrated solids or *Sludge* that is removed from the bottom of a *Settling Tank*, *Clarifier*, or *Thickener*. (3) Submerged gravity-driven flows which occur when inflows to a water body are denser than the ambient water. The inflow subsequently plunges and continues as a distinct flow which can be envisioned as a submerged stream. Underflows, also called *Density Current*, are known to form intermittently on coastal continental shelves, in reservoirs and at effluent discharge sites.

Underground Water — Water below the surface of the ground. Also referred to as *Ground water*, *Ground Water*, *Subsurface Water*, and *Subterranean Water*.

Unimpaired Flow — The flow past a specified point on a natural stream that is unaffected by stream diversion, storage, import, export, return flow, or change in use caused by modifications in land use.

Unit Hydrograph — (1) The *Hydrograph* of direct runoff from a storm uniformly distributed over the drainage basin during a specified unit of time; the hydrograph is reduced in vertical scale to correspond to a volume of runoff from the drainage basin of one inch. (2) The hydrograph of surface runoff (not including ground water runoff) on a given basin due to an effective rain falling for a unit of time.

Unsaturated Flow — Movement of water in a porous medium in which the pore spaces are not filled with water and the direction of flow is from the wetter zone of higher potential to one of lower potential.

Unsaturated Zone — (1) The portion of the soil profile which contains both air and water. Water in this zone cannot enter a well. (2) The subsurface zone between the water table (*Zone of Saturation*) and the land surface where some of the spaces between the soil particles are filled with air. It includes the root zone, intermediate zone, and capillary fringe. The pore spaces contain water, as well as air and other gases at less than atmospheric pressure. Saturated bodies, such as *Perched Ground Water,* may exist in the unsaturated zone, and water pressure within these bodies may be greater than atmospheric. Also referred to as the *Vadose Zone* or, less frequently, the *Zone of Aeration*.

Unsteady Flow — Flow that is changing with respect to time.

Upgradient Well — A ground water monitoring well, such as those required at facilities that treat, store, or dispose of hazardous waste using surface impoundments or landfills, that allows sampling and analysis of ground water that is upstream from the facility, before the ground water is possibly affected by any escaping contaminants. The results of the analyses are used for comparison to the results of ground water sampled from *Downgradient Wells*.

Uplands — (1) The ground above a floodplain; that zone sufficiently above and/or away from transported waters as to be dependent upon local precipitation for its water supplies. (2) Land which is neither a *Wetland* nor covered with water.

Uplift — (Hydraulics) The upward pressure of water on the base of a structure or the upward pressure in the pores of a material, i.e., *Interstitial Pressure*.

Upstream — Toward the source or upper part of a stream; against the current. In relation to water rights, the term refers to water uses or locations that affect water quality or quantity of downstream water uses or locations.

Usable Storage Capacity — The available storage capacity plus the remaining ground water storage within a reasonable pump lift. Specific yield of the sediments is used in calculating estimates of usable storage capacity.

-V-

Vadose — Of, relating to, or being water that is located in the *Zone of Aeration* in the earth's crust above the ground water level.

Vadose Zone — The subsurface zone between the water table (*Zone of Saturation*) and the land surface where some of the spaces between the soil particles are filled with air. Also referred to as the *Unsaturated Zone* or, less frequently, the *Zone of Aeration*.

Vadose Water — Water occurring in the *Unsaturated Zone* (*Vadose Zone*) between the land surface and the water table.

Vale — A valley, often coursed by a stream; a dale.

Valley — (1) An area of land that is lower than the land on either side of it. (2) An elongated depression cut by stream erosion and associated water erosion on its sideslopes (stream valley). Also used in the vernacular for *Intermontane* and *Intramontane Basins*. Also see *U-Shaped Valleys* and *V-Shaped Valleys*.

Velocity, Average Interstitial (õ) — The average rate of ground-water flow in interstices, expressed as the product of *Hydraulic Conductivity* and *Hydraulic Gradient* divided by the *Effective Porosity*. It is synonymous with *Average Linear Ground-Water Velocity* or *Effective Velocity*.

Velocity Head — Energy contained by fluid because of its velocity; usually expressed in feet of fluid (foot-pounds per pound).

Velocity (of Water in a Stream) — Rate of motion of a stream measured in terms of the distance its water travels in a unit of time, usually expressed in feet per second.

Venturi — A short tube with a constricted throat used to determine fluid pressures and velocities by measurement of differential pressures generated at the throat as a fluid traverses the tube.

Venturi Effect — The increase in the velocity of a fluid stream as it passes through a constriction in a channel, pipe, or duct. Calculated by the *Continuity Equation*, or

$$Q = VA$$

where Q is the volumetric flow rate, A is the Area of flow, and V is the fluid velocity. Because Q does not change, as A gets smaller then V must increase.

Venturi Meter — A meter, developed by Clemens Herschel, for measuring flow of water or other fluids through closed conduits or pipes. It consists of a venturi tube and one of several forms of flow registering devices.

Venturi Tube — A closed conduit that gradually contracts to a throat, causing a pressure head by which the velocity through the throat may be determined.

Vernal Pools — (1) *Wetlands* that occur in shallow basins that are generally underlain by an impervious subsoil layer (e.g., a clay pan or hard pan) or bedrock outcrop, which produces a seasonally perched water table. (2) A type of *Wetland* in which water is present for only part of the year, usually during the wet or rainy seasons (e.g., spring). Also referred to as *Temporary Wetland*.

Viscosity (ç) — A measure of the resistance of a fluid to flow. For liquids, viscosity increases with decreasing temperature. For gases, viscosity increases with increasing temperature. Expressed as mass per length-time (e.g., kilograms per meter-second). A common viscosity unit is the *Poise*. One poise equals 1.0 gram per centimeter-second. Also referred to as *Dynamic Viscosity*.

Void — The pore space or other openings in rock. The openings can be very small to cave size and are filled with water below the *Water Table*.

Void Ratio — Ratio of volume of intergranular voids to volume of solid material in a sediment or sedimentary rock.

Voids — A general term for pore spaces or other openings in rock.

V-Shaped Valleys — Valleys typically eroded by stream action. *U-Shaped Valleys*, by contrast, are characteristic of glacial erosion.

-W-

Wash — (1) To carry, erode, remove, or destroy by the action of moving water. To be carried away, removed, or drawn by the action of water. Removal or erosion of soil by the action of moving water. (2) A deposit of recently eroded debris. (3) Low or marshy ground washed by tidal waters. A stretch of shallow water. (4) (Western United States) The dry bed of a stream, particularly a watercourse associated with an alluvial fan, stream, or river channel. Washes are often associated with arid environments and are characterized by large, high energy discharges with high bed-material load transport. Washes are often intermittent and their beds sparsely vegetated. (5) Loose or eroded surface material (such as gravel, sand, silt) collected, transported, and deposited by running water, as on the lower slopes of a mountain range, especially coarse alluvium. (6) Turbulence in air or water caused by the motion or action of an oar, propeller, jet, or airfoil.

Water (H2O) — The liquid that descends from the clouds in rain and which forms streams, lakes, and seas, and is a major constituent of all living matter. Pure water consists of *Hydrogen* (11.188 percent by weight) and *Oxygen* (88.812 percent by weight) in the proportion of two atoms of hydrogen to one of oxygen (H2O), and is an odorless, tasteless, transparent liquid which is very slightly compressible. It has a slightly blue color which is observable only in thick layers of the liquid. At its maximum density, 39.2EF (or 4EC), it is the standard for specific gravities, one cubic centimeter weighing one gram. Water's weight per gallon (at 15EC or 59EF) is 8.337 pounds (3.772 kilograms). It is also the standard for specific heats. Its own specific heat is very great. It freezes at 32EF (0EC) and boils at 212EF (100EC) under atmospheric pressure at sea level. Pure water is an extremely poor conductor of electric current, although many *Aqueous* (water-based) solutions are conductors. Water is the most important of solvents, dissolving many gases, liquids, and solids. Natural waters of the earth, as those of springs, rivers, or the oceans, contain more or less dissolved matter, which is mostly removed by distillation. Rain water is nearly pure. Water is important chemically as a solvent and dissociating agent, as a catalytic agent, and often as one of the substances taking part in a chemical reaction. Ordinary water, described above, is a mixture of molecules containing hydrogen of atomic weight 1, with a small proportion (about 0.015 per cent) of molecules containing hydrogen of atomic weight 2. This later kind of water, termed *Heavy Water* or *Deuterium Oxide*, D2O, can be separated by fractional electrolysis or distillation and in other ways and is used as a moderator in certain nuclear reactors.

Water Audit — A procedure that combines flow measurements and listening surveys (leak detection) in an attempt to give a reasonably accurate accounting of all water entering and leaving a system.

Water Balance — (1) A measure of the amount of water entering and the amount of water leaving a system. Also referred to as *Hydrologic Budget*. Also see *Hydrologic Equation*. (2) The ratio between the water assimilated into the body and that lost from the body; also, the condition of the body when this ratio approximates unity.

Water Color — One of the most immediately apparent attributes of many natural waters and one that, together with visual clarity, strongly influences human aesthetic perception and recreational use. Color of waters is a guide to their composition, and remote sensing of water color is increasingly being used to infer water quality, particularly suspended solids and phytoplankton concentrations. The color of water, with water considered a translucent (i.e., not transparent) material, is commonly associated with transmitted light, for example, the color seen by a diver beneath the water's surface. However, the color of natural waters as observed from above is that associated with the upwelling light field that results from back scattering of sunlight illuminating the water volume. In this manner, the color of natural waters can be objectively specified using their spectral *Reflectance*, where the reflectance is defined as the ratio of the upwelling light to incident (downwelling) light.

Water Policy — Those actions governing the management, administration, and procedures used to implement and direct a formal *Water Planning* process by which water rights, water uses, and water diversions are evaluated, ranked, and allocated on the basis of specific public policy goals and objectives and designated, either by legislative mandate, regulation, or fiat, *Preferred Uses*. Similar in scope and purpose to water planning, a water policy approach to water planning is also inherently concerned with various aspects of water resource development, transport, water treatment, allocation among various competing uses, conservation, waste-water treatment, re-use, and disposal. However, unique to the water policy approach is that water-related actions are specifically governed by pre-determined, publicly-approved water-related stipulations such as environmental impacts, quality of life values, *"Highest and Best Use"* concepts and criteria, water quality standards, conservation issues, industry sector water allocations, economic diversity goals, etc. To effect such a policy approach to water planning, a *Public Scoping* process is essential to ascertain, quantify, and rank the specific policy goals used to allocate limited water resources among competing uses. Also see *Water Plan*.

Water Pollution — Generally, the presence in water of enough harmful or objectionable material to damage the water's quality. More specifically, pollution shall be construed to mean contamination of any waters such as will create or is likely to create a nuisance or to render such waters harmful, detrimental or injurious to public health, safety or welfare, or to domestic, municipal, commercial, industrial, agricultural, recreational, or other legitimate uses, or to livestock, wild animals, birds, fish or other aquatic life, including but not limited to such contamination by alteration of the physical, chemical or biological properties of such waters, or change in temperature, taste, color or order thereof, or the discharge of any liquid, gaseous, radioactive, solid or other substances into such waters. More simply, it refers to quality levels resulting from man's activities that interfere with or prevent water use or uses.

Water Quality — (1) A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose. (2) The chemical, physical, and biological condition of water related to beneficial use.

Water Quality-Based Limitations — Effluent limitations applied to dischargers when mere technology-based limitations would cause violations of *Water Quality Standards*. Usually applied to dischargers into small streams.

Water Quality-Based Permit — A permit with an effluent limit more stringent than one based on technology performance. Such limits may be necessary to protect the designated use of receiving waters (e.g., drinking, recreation, industrial, irrigation, etc.).

Water Quality Criteria — A specific level or range of levels of water quality necessary for the protection of a water use; levels of water quality expected to render a body of water suitable for its designated use. The criteria are set for individual pollutants and are based on different water uses, such as a public water supply, an aquatic habitat, and industrial supply, or for recreation.

Water Quality Standards — (1) A plan for water quality management containing four major elements: water use; criteria to protect uses; implementation plans, and enforcement plans. An anti-degradation statement is sometimes prepared to protect existing high quality water sources. (2) State-adopted and *U.S. Environmental Protection Agency (EPA)* approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

Water Resources Regions [United States] — A designated natural *Drainage Basin* or *Hydrologic Area* that contains either the drainage area of a major river or the combined drainage areas of two or more rivers. Of the 21 designated water-resources regions, delineated by the *Water Resources Council* in 1970, 18 are in the conterminous United States, and one each are in Alaska, Hawaii, and Puerto Rico. The following represents a listing of U.S. water-resources regions and the states primarily and partly included:

- [1] ***Region 01 — New England Region*** (Maine, New Hampshire, Massachusetts, Connecticut, Rhode Island, and part of Vermont)
- [2] ***Region 02 — Mid-Atlantic Region*** (New York, Pennsylvania, New Jersey, Maryland, Washington D.C., Virginia, and parts of Vermont and West Virginia)
- [3] ***Region 03 — South Atlantic–Gulf Region*** (North Carolina, South Carolina, Georgia, Alabama, Florida, and parts of Virginia and Mississippi)
- [4] ***Region 04 — Great Lakes Region*** (Michigan, and parts of Wisconsin, Indiana, Ohio, and New York)
- [5] ***Region 05 — Ohio Region*** (Indiana, Ohio, West Virginia, Kentucky, and parts of Illinois, Tennessee, Virginia, Pennsylvania, and New York)

[6] ***Region 06 — Tennessee Region*** (Tennessee and parts of Alabama, Georgia, Virginia, and North Carolina)
[7] ***Region 07 — Upper Mississippi Region*** (Minnesota, Wisconsin, Iowa, Illinois, and parts of Missouri and Indiana)
[8] ***Region 08 — Lower Mississippi Region*** (parts of Arkansas, Mississippi, Louisiana, Tennessee, Kentucky, and Missouri)
[9] ***Region 09 — Souris–Red–Rainy Region*** (parts of North Dakota and Minnesota)
[10] ***Region 10 — Missouri Region*** (Montana, Wyoming, North Dakota, South Dakota, Nebraska, and parts of Colorado, Kansas, Missouri, Iowa, and Minnesota)
[11] ***Region 11 — Arkansas–White–Red Region*** (Oklahoma and parts of Colorado, New Mexico, Kansas, Texas, Missouri, Arkansas, and Louisiana)
[12] ***Region 12 — Texas–Gulf Region*** (Texas and parts of New Mexico and Louisiana)
[13] ***Region 13 — Rio Grand Region*** (New Mexico and parts of Texas and Colorado)
[14] ***Region 14 — Upper Colorado Region*** (parts of Utah, Colorado, Wyoming, Arizona, and New Mexico)
[15] ***Region 15 — Lower Colorado Region*** (Arizona and parts of California, Nevada, Utah, and New Mexico)
[16] ***Region 16 — Great Basin Region*** (Nevada and parts of Utah, California, Oregon, Idaho, and Wyoming)
[17] ***Region 17 — Pacific Northwest Region*** (Washington, Oregon, Idaho, and parts of Montana, Wyoming, Nevada, and Utah)
[18] ***Region 18 — California Region*** (California and parts of Oregon and Nevada)
[19] ***Region 19 — Alaska Region*** (Alaska)
[20] ***Region 20 — Hawaii Region*** (Hawaii)
[21] ***Region 21 — Caribbean Region*** (Puerto Rico)

Watershed — (1) An area that, because of topographic slope, contributes water to a specified surface water drainage system, such as a stream or river. An area confined by topographic divides that drains a given stream or river. (2) (Catchment) The natural or disturbed unit of land on which all of the water that falls (or emanates from springs or melts from snowpacks), collects by gravity, and fails to evaporate, runs off via a common outlet. (3) All lands enclosed by a continuous hydrologic drainage divide and lying upslope from a specified point on a stream; a region or area bounded peripherally by a water parting and draining ultimately to a particular water course or body of water. Also referred to as *Water Basin* or *Drainage Basin*. (4) A ridge of relatively high land dividing two areas that are drained by different river systems. Also referred to as *Water Parting*.

Watershed Management — (1) The planned manipulation of one or more factors of the natural or disturbed drainage so as to effect a desired change in or maintain a desired condition of the water resource. (2) The analysis, protection, development, operation or maintenance of the land, vegetation and water resources of a drainage basin for the conservation of all its resources for the benefit of its residents. Watershed management for water production is concerned with the quality and timing of the water which is produced. Also referred to as *Water Management* and *Basin Management*.

Watershed Planning — The formulation of a plan, based on the concept of a *Watershed*, a *Water Basin*, a *Hydrologic Region*, or a *Hydrologic Study Area (HSA)*, with the intent to assess climatological conditions, inventory existing ground and surface water resources, determine current water uses, project future socioeconomic and environmental demands for those resources, and explore feasible water-balancing options, so as to maximize the benefits to the inhabitants of a study area while simultaneously preserving and protecting the region's wildlife, habitat, and environmental conditions.

Watershed Project — A comprehensive program of structural and nonstructural measures to preserve or restore a water shed to good hydrologic condition. These measures may include detention reservoirs, dikes, channels, contour trenches, terraces, furrows, gully plugs, revegetation, and possibly other practices to reduce flood peaks and sediment production.

Watershed Protection — The treatment of watershed lands in accordance with such predetermined objectives as the control of erosion, stream flow, silting floods, and water, forage, or timber yield. Also see *Watershed Planning*.

Watershed Protection Approach (WPA) — A type of pollution management program supported by the *U.S. Environmental Protection Agency (EPA)* as being the most effective mechanism for achieving clean water and healthy, sustainable ecosystems throughout the United States. The WPA is a "placed-based" strategy that integrates water quality management activities within hydrologically defined drainage basins or watersheds as opposed to using conventional, politically-defined boundaries. The WPA allows stakeholders to tailor corrective actions to local concerns within the coordinated framework of a state, Tribal, and national water program. In addition, an emphasis on public participation provides the opportunity to incorporate environmental justice issues into watershed management. Six basic objectives form the general foundations of EPA's watershed protection process:

[1] identifying critical watersheds with EPA and state participation;
[2] clearly defining the problems, general causes, and specific sources of risks and impairments to the watershed;
[3] developing potential pollution prevention and control strategies;
[4] implementing point and nonpoint source controls;

[5] developing scientifically valid and practical indicators for gauging and reducing the risks in the watershed; and
[6] developing ecological criteria that states may use in formulating future watershed protection standards.

Water Table — (1) The surface of a ground water body at which the water is at atmospheric pressure; the upper surface of the ground water reservoir. (2) The upper surface of the *Saturated Zone* that determines the water level in a well in an *Unconfined Aquifer*. (3) The level of ground water; the upper surface of the *Zone of Saturation* for underground water. It is an irregular surface with a slope or shape determined by the quantity of ground water and the permeability of the earth material. In general, it is highest beneath hills and mountains and lowest beneath valleys. Also referred to as *Ground Water Table*.

Water-Table Aquifer — An *Unconfined Aquifer* within which is found the water table.

Water Table, Perched — The surface of a local zone of saturation held above the main body of ground water by an impermeable layer or stratum, usually clay, and separated from the main body of ground water by an unsaturated zone.

Water Use, Types — The use of water may be classified by specific types according to distinctive uses, such as the following:

[1] Commercial Water Use
[2] Domestic Water Use
[3] Hydroelectric Power Water Use
[4] Irrigation Water Use
[5] Livestock Water Use
[6] Mining Water Use
[7] Navigational Water Use
[8] Other Water Use
[9] Public Water Use (same as *Utility Water Use*)

[10] Residential Water Use (same as *Domestic Water Use*)
[11] Rural Water Use
[12] Thermoelectric Power Water Use

Water Well — An excavation where the intended use is for location, acquisition, development, or artificial recharge of ground water.

Water Witch — A person who predicts the presence of underground water with hand-held tools such as forked twigs (*Divining Rod*) or metal rods. The *United States Geological Survey (USGS)* and the National Water Well Association do not advise against using a water witch to search for ground water, but say that there is no scientific basis for the belief in water witchery. Also see *Douse* (also *Dowse* or *Dowsing*).

Water Withdrawal — Water removed from ground water or surface water for use.

Water Yield — Runoff, including ground water outflow that appears in the stream, plus ground water outflow that leaves the basin underground. Water yield is the precipitation minus the *Evapotranspiration*.

Well (Water) — (1) An excavation (pit, hole, tunnel), generally cylindrical in form and often walled in, drilled, dug, driven, bored, or jetted into the ground to such a depth as to penetrate water-yielding geologic material and allow the water to flow or to be pumped to the surface. (2) An artificial excavation put down by any method for the purposes of withdrawing water from the underground aquifers. A bored, drilled, or driven shaft, or a dug hole whose depth is greater than the largest surface dimension and whose purpose is to reach underground water supplies or oil, or to store or bury fluids below ground.

Well Capacity (or Potential Yield) — The maximum rate at which a well will yield water under a stipulated set of conditions, such as a given drawdown, pump, and motor or engine size. Well capacity may be expressed in terms of gallons per minute, cubic feet per second, or other similar units.

Well, Fully Penetrating — A well drilled to the bottom of an aquifer, constructed in such a way that it withdraws water from the entire thickness of the aquifer.

Well Function — The mathematical function by means of which the unsteady drawdown can be computed at a given point in an aquifer at a given time due to a given constant rate of pumping from a well.

Wellhead — (1) The source of a well or stream. (2) A principal source; a *Fountainhead*. (3) The physical structure, facility, or device at the land surface from or through which ground water flows or is pumped from subsurface, water-bearing formations.

Well Interference — The effects of neighboring pumping wells on the discharge and drawdown at a particular pumping well.

Well Logs — A record that is kept during well drilling of the various formations and rock materials and the depths at which they are encountered. Synonymous with *Water Well Report*.

Well Screen — A filtering device used to keep sediment from entering a water well.

Well Stimulation — Cleaning, enlarging, or increasing the pore space of a well used for the *Injection* of fluids into subsurface geological strata.

Well Yield — The volume of water discharged from a well in gallons per minute or cubic meters per day.

Wet Adiabatic Lapse Rate — The rate of temperature decrease as a parcel of air saturated with water rises and the pressure decreases, given by:

ãs = –*dT*/*dz*

where:*dT* is the temperature change;*dz* is the change in altitude; and ãs is the saturated (wet) *Adiabatic Lapse Rate*.

Because moisture is condensing in the rising parcel of air and releasing latent heat, the temperature drop with increasing altitude is less than the (dry) adiabatic lapse rate, or about 0.6EC per 100 meters (3.3EF per 1,000 feet). The rate assumes that there is no exchange of heat between the parcel and the surrounding air by conduction or mixing.

Wetland Banking — A term used to describe actions required to be taken on the part of developers to mitigate and replace the loss of wetlands. Through various federal and state regulations governing land use on wetlands, when impacts to wetlands cannot be avoided or minimized, wetlands must be replaced. The replacement process allows for the creation or restoration of any number of wetlands to provide replacement credit for future wetlands impacts or debits, i.e., reductions in existing wetlands. Wetland banking not only insures successful wetland restoration, but also typically requires that replacement occurs before targeted wetlands are removed, thereby at least temporarily increasing the overall amount of wetlands. Also, wetland banking credits may frequently be sold in an open market arrangement thereby facilitating both more efficient land use planning and habitat preservation. Wetland creation under the wetland banking process also allows planners to target wetland construction in precisely those areas and watersheds which have the greatest need for the benefits of wetlands, e.g., flood storage, water quality improvement, habitat creation or preservation, etc.

Wetland Mitigation — Unlike *Wetland Banking* or *Wetland "Clumping" (Aggregation)*, Wetland Mitigation deals with those actions taken to avoid, minimize, or deter the need to adversely affect existing *Wetlands* and similar habitats. Wetland mitigation deals in three fundamental areas:

[1] ***Avoidance*** — involving a comprehensive evaluation of practicable alternatives to the proposed actions to demonstrate that the least environmentally damaging practicable alternative that satisfies the project purpose has been selected;

[2] ***Minimization*** — where some actions adversely affecting existing wetland areas are unavoidable, then steps must taken to insure that such adverse effects are minimized to every extent possible; and

[3] ***Compensatory Mitigation*** — in the case of extensive or substantive wetland impacts, then alternative actions must be taken in conjunction to the proposed project to insure that new areas are added to existing wetland inventory (banking) and/or that alternative and comparable wetland habitat is created (clumping and aggregation).

Wetland banking and clumping (aggregation) concepts are only involved in the compensatory mitigation stage, and possibly the minimization of impacts stage, when all other actions have failed to prevent substantive impacts on existing wetlands. Also see *Wetland Mitigation Bank*.

Wetland Mitigation Bank — An arrangement whereby private developers buy credits of an acre or so each for the right to drain and build on *Wetlands* on their own property. The practice is generally permitted under *Section 404* of the federal *Clean Water Act (CWA)*, which requires developers to provide an equal amount of *Constructed Wetlands* for each acre of wetland destroyed. As an additional requirement, the mitigating wetlands must be created on land that historically was a wetland at one time or another. Developers are also required to both restore and maintain the mitigating wetlands. In states without enabling legislation for such banks, jurisdiction falls under the authority of the *U.S. Army Corps of Engineers (COE)*.

Wetlands, also Wetland (General) — Wetlands are those areas where water saturation is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the surrounding environment. The identification of wetlands and associated habitats is regulated by complex federal legislation. The *U.S. Environmental Protection Agency (EPA)*, the *U.S. Army Corps of Engineers (COE)*, the (U.S. Department of Agriculture) *Natural Resources Conservation Service (NRCS)* (formerly the *Soil Conservation Service — SCS*), and the (Department of the Interior) *U.S. Fish and Wildlife Service (USFWS)*, have developed definitions of wetlands in response to their regulatory responsibilities. The single feature that all wetlands have in common is a soil or substrate that is saturated with water during at least a part of the growing season. These saturated conditions control the types of plants and animals that live in these areas. Other common names for wetlands are *Sloughs*, *Ponds*, *Swamps*, *Bogs*, and *Marshes*. Basically, all definitions of wetlands require that one or more attributes be met:

[1] ***Wetland Hydrology*** — At some point of time in the growing season the substrate is periodically or permanently saturated with or covered by water;

[2] ***Hydrophytic Vegetation*** — At least periodically, the land supports predominantly water-loving plants such as cattails, rushes, or sedges;

[3] ***Hydric Soils*** — The area contains undrained, wet soil which is anaerobic, or lacks oxygen in the upper levels.

Wetlands (COE and EPA) — (Regulatory) The *U.S. Army Corps of Engineers (COE)* and the *U.S. Environmental Protection Agency (EPA)* have adopted a regulatory definition for administering the Section 404 permit program of the *Clean Water Act (CWA)* as follows: [Wetlands are] those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Wetlands (NRCS) — (Technical) The (U.S. Department of Agriculture) *Natural Resources Conservation Service (NRCS)* (formerly the *Soil Conservation Service — SCS*) uses the following definition for identifying wetlands on agricultural land in assessing farmer eligibility for U.S. Department of Agriculture program benefits under the “Swampbuster” provision of the *Food Security Act (FSA)* of 1985. As amended in 1990, the FSA states that the term “wetland,” except when such term is part of the term “converted wetland,” means land that

[1] has a predominance of hydric soils;

[2] is inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions; and

[3] under normal circumstances does support a prevalence of such vegetation. For purposes of the 1990 amended FSA, and any other act, this term shall not include lands in Alaska identified as having high potential for agricultural development which have a predominance of permafrost soils.

Wetlands (USFWS) — (Regulatory and Environmental) The *U.S. Fish and Wildlife Service (USFWS)* has defined wetlands as follows: Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is covered by shallow water. For purposes of this classification, wetlands must have one or more of the following three attributes:

[1] at least periodically, the land supports predominantly *Hydrophytes* (*Hydrophytic Vegetation*);

[2] the substrate is predominantly undrained *Hydric Soils*; and

[3] the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year (*Wetland Hydrology*).The term wetland includes a variety of areas that fall into one of five categories:

[1] areas with hydrophytes and hydric soils, such as those commonly known as marshes, swamps, and bogs;
[2] areas without hydrophytes but with hydric soils — for example, flats where drastic fluctuation in water level, wave action, turbidity, or high concentration of salts may prevent the growth of hydrophytes;
[3] areas with hydrophytes but nonhydric soils, such as margins of impoundments or excavations where hydrophytes have become established but hydric soils have not yet developed;
[4] areas without soils but with hydrophytes such as the seaweed-covered portion of rocky shores; and
[5] wetlands without soil and without hydrophytes, such as gravel beaches or rocky shores without vegetation. While *Wetlands* and *Deepwater Habitats* are defined separately, the USFWS approach to a definition views these two regimes as a continuum of an ecological classification system, and therefore both must be considered in an ecological approach to classification. The deepwater habitat/wetland classification includes five major systems:
    [1] Marine
    [2] Estuarine
    [3] Riverine
    [4] Lacustrine
    [5] Palustrine The first four of these classifications include both wetland and deepwater habitats, but only the Palustrine System includes only wetland habitats. Wetlands have been found to provide many valuable functions to include ground water recharge and discharge, flood flow alteration, sediment stabilization, sediment and toxicant retention, nutrient removal and/or transformation, diverse wildlife and aquatic habitats, and recreation.

Wetlands, Benefits — Since colonial times, an estimated 54 percent of the total wetland areas in the United States have vanished. In a major study by the U.S. Department of the Interior, *U.S. Fish and Wildlife Service (USFWS)*, during the 20 years from the mid-1950s to the mid-1970s, such losses averaged 458,000 acres each year. More recent studies have clearly demonstrated that wetlands are precious ecological resources that nurture wildlife, purify polluted waters, check the destructive power of floods and storms, and provide a variety of recreational activities. The following constitutes a listing of some of the major benefits of these ecological systems:

[1] ***Waterfowl Breeding*** — Over 12 million ducks nest and breed annually in northern U.S. wetlands. This area, when combined with similar habitats in the Canadian prairies, accounts for 60–70 percent of the continent’s breeding duck population.
[2] ***Habitat for Waterfowl and Other Birds*** — Some 2½ million of the 3 million mallards in the Mississippi Flyway and nearly 100 percent of our 4 million wood ducks spend the winter in flooded bottomland forests and marshlands throughout the south.
[3] ***Biological Diversity and Wildlife Habitat*** — Wetlands provide food and shelter for a great variety of fur-bearing animals and other kinds of wildlife.
[4] ***Habitat for Threatened and Endangered Species*** — At least one-third of the nation’s threatened or endangered species live in wetland areas.
[5] ***Marine Fish and Shellfish Production*** — Roughly two-thirds of our shellfish and important commercial and sport species of marine fish rely on coastal marshes for spawning and nursery grounds.
[6] ***Freshwater Fish*** — Many of the 4½ million acres of open water areas found in our inland wetlands are ideal habitat for such sought-after species as bass, catfish, pike, bluegill, sunfish, and crappie.
[7] ***Timber Production*** — Wetlands, especially bottomland forests, are rich sources of timber.
[8] ***Flood Control*** — Wetlands temporarily store flood waters and thus reduce downstream losses

of life and property.

[9] ***Water Quality*** — Wetlands act as natural water purification mechanisms. They remove silt and filter out and absorb many pollutants such as waterborne chemicals and nutrients.

[10] ***Saltwater Intrusion Control*** — The flow of freshwater through wetlands creates ground water pressure that prevents saltwater from invading public water supplies.

[11] ***Shoreline Stabilization*** — By absorbing wave and storm energy and slowing water currents, wetland vegetation serves as a buffer against shoreline erosion.

[12] ***Reduction of Coastal Storm Damage*** — Coastal marshes and mangrove stands help to blunt the force of major storms.

[13] ***Recreational Opportunities*** — Wetlands offer unspoiled, open space for the aesthetic enjoyment of nature as well as activities such as hiking, fishing, hunting, photography, and environmental education.

[14] ***Ground water Recharge and Discharge*** — Water standing in or slowing moving through wetland areas provides important recharge opportunities to ground waters while water taken from the ground, for example through mine *Dewatering* operations, is frequently released into wetland areas for further treatment of potentially harmful substances.

[15] ***Sediment Stabilization*** — Through their ability to slow the flow of water and the filtering capabilities of associated flora, wetlands provide important functions for the removal and trapping of sediment and other materials in water affecting its *Turbidity* and its levels of *Dissolved* and *Suspended Solids*.

[16] ***Sediment and Toxicant Retention*** — Wetland vegetation inherently provides important functions in the retention and absorption of various dissolved and suspended materials in the waters entering these areas as well as providing for the removal of various chemical and toxic substances as well as some heavy metals.

[17] ***Nutrient Removal and/or Transformation*** — Wetland vegetation readily absorbs for its own use various nitrate and phosphate-based nutrients in the water, thereby increasing *Dissolved Oxygen* levels and the quality of downstream waters.

Wetlands, Constructed — (1) Wetlands constructed by man either as part of a *Wetland Banking*, *Wetland Clumping (Aggregation)*, or *Wetland Mitigation* program, or to achieve some other environmental preservation or restoration program. (2) (Water Quality) Wetlands constructed specifically for the purpose of treating waste water effluent before re-entering a stream or other body of water or being allowed to percolate into the ground water. Also see *Lagoon*.

Wetlands, Jurisdictional — An area that meets the criteria established by the *U.S. Army Corps of Engineers (Corps or COE)* for a *Wetlands* (as set forth in their ***Wetlands Delineation Manual***). Such areas come under the jurisdiction of the Corps of Engineers for permitting certain actions such as dredge and fill operations. See *Wetlands*. [Also see ***Classification of Wetlands and Deepwater Habitats of the United States***, U.S. Department of the Interior, Fish and Wildlife Service (USFWS). Appendix D–2 presents a summarization of this Wetland and Deepwater Habitat Classification System based upon USFWS criteria.]

Wetlands, Palustrine — Wetlands dominated by plants that persist throughout the year or the growing season. These areas are what most people think of when they see the term "wetland", and include marshes, swamps, bogs, and wet meadows. Palustrine wetlands may be dominated by subtidal, permanently and intermittently flood areas (*Rock Bottom*, *Unconsolidated Bottom*, *Aquatic Bed*, and *Unconsolidated Shore*), mosses and lichens (*Moss-Lichen Wetlands*), erect, rooted, herbaceous hydrophytes such as sedges, rushes, grasses, cattails, and bulrushes (*Emergent Wetlands*), woody vegetation less than 6 meters (20 feet) tall (*Scrub-Shrub Wetlands*), or woody vegetation that is 6 meters (20 feet) or taller (*Forested Wetlands*). Palustrine wetlands may occur in the vicinity of springs, seeps, and flowing wells, on the floodplains of streams and creeks, around the shores of some lakes and reservoirs, adjacent to irrigation canals, and in areas influenced by irrigation or irrigation runoff. The following presents a more detailed description of these wetland classes:

[1] ***Rock Bottom*** — The Class Rock Bottom includes all wetlands and deepwater habitats with substrates having an areal cover of stones, boulders, or bedrock 75 percent or greater and vegetative cover of less than 30 percent. Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semipermanently flooded. The rock substrate of the rocky benthic or bottom zone is one of the most important factors in determining the abundance, variety, and distribution of organisms. The stability of the bottom allows a rich assemblage of plants and animals to develop. Rock bottoms are usually high-energy habitats with well-aerated waters.

[2] ***Unconsolidated Bottom*** — The Class Unconsolidated Bottom includes all wetland and deepwater habitats with at least 25 percent cover of particles smaller than stones, and a vegetative cover less than 30 percent. Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semipermanently flooded. Unconsolidated bottoms are characterized by the lack of large stable surfaces for plant and animal attachment. They are usually found in areas with lower energy than rock bottoms, and may be very unstable.

[3] ***Aquatic Bed*** — The Class Aquatic Bed includes wetlands and deepwater habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years. Water regimes include subtidal, irregularly exposed, regularly flooded, permanently flooded, intermittently exposed, semipermanently flooded, and seasonally flooded. Aquatic beds represent a diverse group of plant communities that requires surface water for optimum growth and reproduction. They are best developed in relatively permanent water or under conditions of repeated flooding.

[4] ***Unconsolidated Shore*** — The Class Unconsolidated Shore includes all wetland habitats having three characteristics: (1) unconsolidated substrates with less than 75 percent areal cover of stones, boulders, or bedrock; (2) less than 30 percent areal cover of vegetation other than pioneering plants; and (3) any of the following water regimes: irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artificially flooded. Unconsolidated shores are characterized by substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms such as beaches, bars, and flats, all of which are included in this wetland class.

[5] ***Moss-Lichen Wetlands*** — The Moss-Lichen Wetland Class includes areas where mosses or lichens cover substrates other than rock and where emergents, shrubs, or trees make up less than 30 percent of the areal cover. The only water regime is saturated. Mosses and lichens are important components of the flora in many wetlands, especially in the north, but these plants usually form a ground cover under a dominant layer of trees, shrubs, or emergents. In some instances higher order plants are uncommon and mosses or lichens dominate the flora. Such Moss-Lichen Wetlands are not common, even in the northern United States where they occur most frequently.

[6] ***Emergent Wetlands*** — The Emergent Wetland Class is characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. All water regimes are included except sub-tidal and irregularly exposed. In areas with relatively stable climatic conditions, Emergent Wetlands maintain the same appearance year after year. In other areas, such as the prairies of the central United States, violent climatic fluctuations cause them to revert to an open water phase in some years. Emergent Wetlands are found throughout the United States and occur in all Wetland Classification Systems except the Marine. Emergent Wetlands are known by many names, including marsh, meadow, fen, prairie pothole, slough, and savanna.

[7] ***Scrub-Shrub Wetlands*** — The Class Scrub-Shrub Wetland includes areas dominated by woody vegetation less than 6 meters (20 feet) tall. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions. All water regimes except sub-tidal are included. Scrub-Shrub Wetlands may represent a successional stage leading to Forested Wetland, or they may be relatively stable communities. They occur only in the Estuarine and Palustrine Wetland Systems, but are one of the most widespread classes in the United States. Scrub-Shrub Wetlands are known by many names, such as shrub swamp, shrub carr, and pocosin (dismal).

[8] ***Forested Wetlands*** — The Class Forested Wetland is characterized by woody vegetation that is 6 meters (20 feet) tall or taller. All water regimes are included except sub-tidal. Forested Wetlands are most common in the eastern United States and in those sections of the West where moisture is relatively abundant, particularly along rivers and in the mountains. They occur only in the Palustrine and Estuarine Wetland Systems and normally possess an overstory of trees, an understory of young trees or shrubs, and a herbaceous layer. Forested Wetlands in the Estuarine System, which include the mangrove forests of Florida, Puerto Rico, and the Virgin Islands, are known by such names as swamps, hammocks, heads, and bottoms. These names often occur in combination with species names or plant associations such as cedar swamp or bottomland hardwoods.

Wild and Scenic Rivers (Act) — A national system established under the Wild and Scenic Rivers Act of free-flowing rivers and streams which possess one or more of the following outstanding remarkable values: (1) scenic; (2) recreational; (3) geological; (4) fish and wildlife; (5) historic or cultural; or (6) other values, including biological or ecological. There are three classifications of rivers or river segments – wild, scenic and recreational – with classifications based on the condition of the river and the adjacent lands at the time of the study. The act defines these classifications as follows:

(1) ***Wild River*** – Those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and water unpolluted, representing vestiges of rivers in primitive America;

(2) ***Scenic River*** – Those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads;

(3) ***Recreational River*** – Those rivers or sections of rivers that are readily accessible by road or railroad that may have some development along their shorelines, and that may have undergone some impoundments or diversions in the past. Also see *Wild Rivers*, *Scenic Rivers*, and *Recreational Rivers* for permitted activities and restrictions.

Wild Rivers — A classification under the national *Wild and Scenic Rivers Act* to include those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and water unpolluted, representing vestiges of rivers in primitive America. The following represents restrictions applying to such designated rivers:

(1) ***Timber Production*** – Cutting of trees is not permitted unless needed in association with a primitive recreation experience (i.e., clearing for trails and protection of users) or to protect the environment (i.e., fire control). Timber outside the boundary but within the visual corridors will be managed and harvested in a manner to provide special emphasis to visual quality.

(2) ***Water Supply*** – All water supply dams and major diversions are prohibited.

(3) ***Hydroelectric Power*** – No development of hydroelectric power facilities would be permitted.

(4) ***Flood Control*** – No flood control dams, levees, or other works are allowed in the channel or river corridor. The natural appearance and essentially primitive character of the river areas must be maintained.

(5) ***Mining*** – New mining claims and mineral leases are prohibited within one-quarter mile of the river. Valid claims would not be abrogated. Subject to regulations (i.e., 36 CFR 228) that the Secretaries of Agricultural and Interior may prescribe to protect the rivers included in the National System, other existing mining activity must be conducted in a way that minimizes surface disturbance, sedimentation, and visual impairment. Reasonable access will be permitted.

(6) ***Road Construction*** – No roads or other provisions for overland motorized travel would be permitted within a narrow incised river valley or, if the river valley is broad, within one-quarter mile of the river bank. A few inconspicuous roads leading to the boundary of the river area at the time of the study will not disqualify wild river classification. Also, unobtrusive trail bridges could be allowed.

(7) ***Agriculture*** – Agricultural use is restricted to a limited amount of domestic livestock grazing and hay production to the extent currently practiced. Row crops are prohibited.

(8) ***Recreational Development*** – Major public-use areas, such as large campgrounds, interpretive centers, or administrative headquarters are located outside the wild river area. Simple comfort and convenience facilities, such as fireplaces or shelters may be provided as necessary within the river area. These should harmonized with the surroundings.

(9) ***Structures*** – A few minor existing structures could be allowed assuming such structures are compatible with the essentially primitive and natural values of the viewshed. New structures would not be allowed except in rare instances to achieve management objectives. Structures and activities associated with fisheries enhancement programs could be allowed.

(10) ***Utilities*** – New transmission lines, gas lines, water lines, etc., are discouraged. Where no reasonable alternative exists, additional or new facilities should be restricted to existing right-of-way. Where new rights-of-ways are indicated, the scenic, recreation, and fish and wildlife values must be evaluated in the selection of the site.

(11) ***Motorized Travel*** – Motorized travel on land or water could be permitted, but is generally not compatible with this classification.

Wilderness — Undeveloped land and associated water resources retaining their primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural condition and that (1) generally appears to have been affected primarily by the forces of nature with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) is of sufficient size so as to make practical its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

Wilderness Act — A 1964 Act of Congress which established federal *Wilderness Areas*. As defined under this act, wilderness is undeveloped federal land without permanent improvements or human habitation; is protected and managed so as to preserve its natural conditions; has outstanding opportunities for solitude or primitive recreation; has at least 5,000 acres or is of sufficient size to make practical its condition; and may contain features of scientific, educational, scenic, or historical value as well as ecologic and geologic interest.

Wilderness Area — Land where the effects of man are not apparent. Large tracts of land that are set aside and allowed to develop without the intervention of man. Such activities as the construction of roads, development of recreational facilities, removal of trees, or hunting are prohibited. The 1964 *Wilderness Act* allows the U.S. government to set aside sections within the national forests, national parks, and national wildlife refuges as wilderness areas. Currently there are about 450 such areas within the United States totaling 90 million acres, two-thirds of which are in Alaska.

Wildlife Refuge — An area designated for the protection of wild animals, within which hunting and fishing are either prohibited or strictly controlled.

Wisconsin — (Geology) Of or relating to one of the glacial stages of the *Pleistocene* epoch which occurred in North America, which consisted of the *Nebraskan* (first stage), *Kansan* (second stage), *Illinoian* (third stage), and *Wisconsin* (fourth stage).

Witch — To use a divining rod to find underground water or minerals; *Dowse*.

Withdrawal, Water — Water diverted from the ground or diverted from a surface-water source for use. It may be *Consumptively* or *Nonconsumptively* used, beneficially or nonbeneficially used, or returned in part for reuse.

-X-

Xeric — Describing an organism that requires little moisture or a habitat containing little moisture; dry environmental conditions as compared to *Hydric* (wet environmental conditions) and *Mesic* (moderate environmental conditions).

X–Year Flood — The magnitude of a flood which has a 1-in-*X* chance of being exceeded in any future one-year period. For example, a 2–year flood would have a 1-in-2 (50 percent) chance of exceedence in any one year; a 10–year flood, a 1-in-10 (10 percent) chance; a 100–year flood, a 1-in-100 (1 percent) chance, etc. These values are statistically derived, using past flood records. They are used for many reasons, but especially for engineering drainage and water supply structures. As the occurrence of floods is random in time, there is no guarantee that there will not be two *X*–year floods within a given year. There is also no guarantee that there will be an *X*–year flood in an *X*–year time period, or even in a 2*X* period. Finally, an *X–Year, Y–Duration Rain* will not necessarily produce an *X*–year flood. Storm duration and intensity, antecedent moisture and other conditions can cause *X*–year rains to produce more or less than *X*–year floods. For example, a 100–year, 6–hour rain over a very dry basin may only produce a 2–year flood, whereas a 5–year, 6–hour rain over a saturated or burned basin could cause a 100–year flood. Also see *Hundred Year Flood*.

X–Year, Y–Duration Rain — The magnitude of rainfall which has a 1-in-*X* chance of being exceeded in any future one-year time period with a duration of Y [hours or days]. *X*–year rains must have durations associated with them; e.g., 25–year, 6–hour rain, 50–year, 24–hour rain, 100–year, 10–day rain, etc. These values are statistically derived using past rainfall records. Also referred to as *Rainfall Duration-Frequency*. Also see *X–Year Flood*.

-Y-

Yellowboy — Iron oxide flocculent (clumps of solids in waste or water); usually observed as orange-yellow deposits in surface streams with excess iron content. Characterized by unsightly yellowish precipitates of ferric sulfate and hydroxide and frequently observed in many streams polluted by mine drainage.

Yield — (1) The quantity of water expressed either as a continuous rate of flow (e.g., cubic feet per second – cfs) or as a volume per unit of time (e.g., acre-feet per year – AFY) which can be collected for a given use or uses from surface- or ground-water sources on a watershed. The yield may vary with the use proposed, with the plan of development, and also with economic considerations. (2) Total runoff. (3) The streamflow in a given interval of time derived from a unit area of watershed. It is determined by dividing the observed streamflow at a given location by the drainage area above that location and is usually expressed in cubic feet per second per square mile.

Yield, Average Annual — The average annual supply of water produced by a given stream or water development.

Yield, Firm — The maximum annual supply of a given water development that is expected to be available on demand, with the understanding that lower yields will occur in accordance with a predetermined schedule or probability. Sometimes referred to as *Dependable Yield*.

Yield, Gross (Water) — (1) The available water runoff, both surface and subsurface, prior to use by man's activities, use by phreatophytes, or evaporation from free water surfaces. (2) The estimated or actual available water, both surface and sub-surface, prior to agricultural and phreatophytic use. Generally, this water yield is estimated for a stream or streams at a point above the highest diversion for the main body of irrigated land on a flood plain of a valley.

Yield, Perennial — The amount of usable water of a ground-water reservoir that can be economically withdrawn and consumed each year for an indefinite period of time. It cannot exceed the sum of the *Natural Recharge*, the *Artificial* (or *Induced*) *Recharge*, and the *Incidental Recharge* without causing depletion of the ground water reservoir. Also referred to as *Safe Yield*.

Yield, Safe — With reference to either a surface- or ground-water supply, the rate of diversion or extraction for *Consumptive Use* which can be maintained indefinitely, within the limits of economic feasibility, under specified conditions of water-supply development.

Young — (Geology) Being of an early stage in a geologic cycle. Used of bodies of water and land formations.

-Z-

Zeolite — (1) (Geology) Any of various hydrous silicates that are analogous in composition to the feldspars, occur as secondary minerals in cavities of lavas, and can act as an ion-exchanger. (2) (Chemistry) Also, any of various natural or synthesized silicates of similar structure used especially in water softening and as an adsorbent and catalyst. (3) (Water Quality) A type of ion exchange material used to soften water. Natural zeolites are siliceous compounds which remove calcium and magnesium from hard water and replace them with sodium. Synthetic or organic zeolites are ion exchange materials which remove calcium or magnesium and replace them with either sodium or hydrogen.

Zero Discharge — The goal, in the preamble to the *Clean Water Act (CWA)*, of zero pollutants in water discharges.

Zone of Accumulation — The combination of the *A-Horizon* and the *B-Horizon*.

Zone of Aeration — The comparatively dry soil or rock located between the ground surface and the top of the *Water Table*. A zone immediately below the surface of the ground, in which the openings are partially filled with air, and partially with water trapped by molecular attraction. Generally subdivided into: (a) belt of soil moisture; (b) intermediate belt; and (c) capillary fringe. Also referred to as the *Unsaturated Zone* or the *Vadose Zone*.

Zone of Contribution (ZOC) — The area surrounding a pumping well that encompasses all areas or features that supply ground-water recharge to the well.

Zone of Eluviation — The two uppermost zones in the soil profile, consisting of the *A–Horizon*, from which soluble *Salts* and *Colloids* are leached, and in which organic matter has accumulated and generally constitutes the most fertile soil layer, and the *B–Horizon*, or the lower soil zone which is enriched by the deposition or precipitation of material from the overlying zone, or A–horizon. Also referred to as the *Solum*.

Zone of Influence (ZOI) — (1) (Hydrologic) The area surrounding a pumping well within which the water table or *Potentiometric Surfaces* has been changed due to ground-water withdrawal. (2) (Environmental) The geographic area whose social, economic, and/or environmental conditions is significantly affected by changes in the study area.

Modified after Nevada Division of Water Resources, Department of Conservation and Natural Resources and Michigan Department of Environmental Quality

Appendix B

SUGGESTED MINIMUM REQUIREMENTS FOR PROBABLE HYDROLOGIC CONSEQUENCES (PHC) DETERMINATION

I. IMPACT ANALYSIS
   - A. Presence or absence of acid-forming or other toxic-forming materials that could contaminate surface or ground water
     1. Overburden
        a. Chemical properties (acid/toxic/alkaline potential)
        b. Percentage of potentially acid- and toxic-forming materials relative to alkaline and non-acidic/non-toxic strata
        c. Physical properties (i.e. conductivity of spoil)
     2. Coal processing waste
        a. In pit disposal
        b. Slurry impoundments/pipelines
        c. Refuse piles
     3. Disposal of non-coal waste
     4. Disposal of "imported" material (e.g. CCBs, sediment pond sludge, landfills - solid waste)
     5. Coal-bed methane recovery
   - B. The effect of the proposed operation on sediment yield from the disturbed area during mining and reclamation and after liability release
     1. Identify on-site erosion concerns
     2. Predict sediment yields from mine plan area both during and after control structures are removed
   - C. Short-term and long-term effects of the operation on surface and ground water with regard to total dissolved solids, specific conductivity, total suspended solids, iron, manganese, pH, acidity, alkalinity, water levels/flow and any other parameters pertinent to the area and those included in the baseline testing
     1. Short-term impacts (during mining and reclamation)
        a. Major impacts
        b. Minor impacts
     2. Long-term impacts (post mining and at bond release)
        a. Major impacts
        b. Minor impacts
     3. Impacts lasting beyond reclamation liability period
        a. When do changes cease?
        b. Restoring water table/potentiometric surface
        c. When do concentrations stop increasing?
        d. When does water quality return to ambient?
     4. Differentiate between on-site and off-site impacts
        a. On-site: minimize disturbance to hydrologic balance
        b. Off-site: prevent material damage

- D. Possible impact and effects of mining operations on/from existing surface and underground mines (active and inactive) with regard to water quality/quantity
- E. Hydrologic consequences specific to underground mining
  - 1. Subsidence
    - a. Effects on stream flow and quality
    - b. Effects on ground water (quantity and quality)
  - 2. Mine pools – potential water resource or pollution source?
- F. Possible impacts that may cross political boundaries (i.e. state lines)

II. FINDINGS

- A. Whether adverse impacts may occur to the hydrologic balance (address possible contamination, diminution, or interruption of surface- or ground-water resources in legitimate use)
- B. Whether toxic-forming materials are present that could contaminate surface and/or ground water
- C. Whether proposed operation may contaminate, diminish or interrupt current water uses
- D. Identify impacts from proposed operation on:
  - 1. Sediment yields
  - 2. Acidity, suspended solids, dissolved solids, etc.
  - 3. Flooding or stream flow alteration

Appendix C

SUGGESTED MINIMUM REQUIREMENTS FOR HYDROLOGIC RECLAMATION PLAN (HRP)

III. DESCRIBES PLAN TO MEET PERFORMANCE STANDARDS IN 30 CFR PART 816 INCLUDING 816.41 (HYDROLOGIC BALANCE PROTECTION) AND 816.43 (DIVERSIONS)
  - A. Goal: minimize all hydrologic impacts and prevent material damage outside the permit area

IV. PLAN MUST DESCRIBE PREVENTIVE AND REMEDIAL MEASURES THAT WILL BE USED TO ADDRESS **ALL** POTENTIAL HYDROLOGIC IMPACTS IDENTIFIED IN THE PHC INCLUDING, BUT NOT LIMITED, TO:
  - A. AMD
    1. Identify and isolate or otherwise special handle problematic materials
    2. Contingency for temporary water treatment plan
    3. Perpetual water treatment (deep mines)
  - B. Disposal activities (i.e. coal processing waste, CCBs, non-coal waste, etc.)
  - C. Prevention of additional contributions of suspended solids to stream flow using best technology currently available (BTCA)
    1. Control of surface and subsurface drainage
    2. Restoration of approximate pre-mining recharge capacity
       - a. Ensure wetlands, shallow wells and springs are protected
       - b. Mitigate adverse effects of increased infiltration/recharge, if present
  - D. Protection of rights of present water users by providing a specific plan for replacing existing water supplies should they be contaminated, diminished or destroyed by the proposed operation
  - E. Quantitative criteria:
    1. CWA
    2. Effluent limits
    3. TMDLs
    4. Individual state water quality/quantity requirements
    5. Others

V. SURFACE AND GROUND WATER MONITORING PLANS
  - A. Parameters for both surface water and ground water
  - B. Sampling locations and rationale for selection
  - C. Sampling frequency and protocol
  - D. Reporting
  - E. How data will be used to determine mining effects on the hydrologic balance

Appendix D

SUGGESTED MINIMUM REQUIREMENTS FOR CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA)

VI. INTRODUCTION
- A. Regulatory Basis
- B. Concept of cumulative hydrologic impacts and cumulative impact areas

VII. ELEMENTS OF THE CHIA
- A. Reason for CHIA (new application or significant revision of existing operation)
- B. Cumulative Impact Area (CIA)
  - 1. Definition of a CIA
    - a. The area, including the proposed permit area, within which impacts resulting from the proposed operation may interact with the impacts of all anticipated or existing mining on surface and ground water systems
  - 2. Delineation of working CIA
    - a. Criteria used to include/exclude mining operations of interest
      - (1) First effort – qualitative (tracing watersheds and applying conceptual model of ground water flow)
      - (2) Impact analysis- quantity with model(s) to refine the CIA (Lumb, 1982)
- C. Baseline conditions
  - 1. Surface and ground water quality/quantity
  - 2. Water users and water uses
- D. Identification of hydrologic concerns
  - 1. Surface water
    - a. Changes in flow
    - b. Changes in water chemistry
    - c. Increased sediment load
    - d. Impact on users
  - 2. Ground water
    - a. Aquifer drawdown
    - b. Changes in water chemistry
    - c. Impact on users
- E. Establish material damage criteria
  - 1. Procedure for defining material damage
    - a. Establishing criteria vs. standards vs. thresholds
      - (1) Stress quantitative rather than qualitative (provide an example of both)
    - b. Relation to CWA
    - c. Biologic criteria (biological integrity relative to water quality/quantity)
    - d. Sediment criteria

e. Ground water and surface water criteria (i.e. flow/water level, quality, etc.)
f. Procedure for converting criteria to standards as applicable to guidance document

2. Special cases:
   a. Alluvial valley floor material damage
   b. Subsidence material damage

F. Analyses of cumulative hydrologic impacts
   1. PHC life-of-mine impacts for all potential/existing coal mines within the CIA
   2. Identify other existing/potential sources of impacts within the CIA:
      a. Logging
      b. Reservoir releases
      c. Coal-bed methane extraction
      d. Trans-basin diversion
      e. Gas wells
      f. Injection wells
      g. Community or industrial effects
      h. Agricultural effects
      i. Non-coal mining (e.g. sand/gravel operations, limestone, etc.)

G. Model cumulative effects of mining impacts:
   1. Incorporate non-coal related impacts (if possible)
   2. Develop conceptual model
   3. Decide what significant impacts need to be modeled (surface/ground water flow and quality)
   4. Select model and data to use
   5. Determine model nodes (key points, i.e. intakes, water users, significant non-coal mining impacts, etc.)
   6. Decide on time frames – short or long term, steady state
   7. Decide on seasonal issues (monthly, quarterly, low flow, high flow, etc.)
   8. Run model, calibrate, verify, sensitivity analysis
   9. Interpret results – compare to baseline
   10. Compare to material damage criteria
   11. Make decision to:
       a. Approve
       b. Re-do model
       c. Request operator to:
          (1) Change mine plan
          (2) Clean up adjacent mine
          (3) Approach other mines
          (4) Develop mitigation or remedial measures
       d. Change material damage standards
          (1) Approach state agency to change water quality standards
          (2) Mining company can conduct site-specific studies
          (3) Use alternate standards (i.e. biological)
       e. Disapprove – deny permit

H. Findings

1. Compare predicted impacts to material damage criteria
    a. Are adverse impacts to the hydrologic balance expected due to:
        (1) The planned operations (i.e, mining method, coal processing waste disposal, etc.)?
        (2) Acid- and toxic-forming materials?
        (3) Sediment yields?
        (4) Stream flow alterations?
        (5) Degradation of water quality/quantity
            (a) During mining?
            (b) Post mining?
        (6) Other
2. Mitigation measures
3. Sampling plan
4. Note any special conditions or stipulations that the findings are contingent upon

I. Conclusion (will the addition of the proposed operation to other anticipated or existing mining materially damage the hydrologic balance outside the proposed permit area?)

Appendix E

SUGGESTED MINIMUM REQUIREMENTS FOR POST-MINING HYDROLOGIC ASSESSMENT (PHA)

VIII. BOND RELEASE CONSIDERATIONS
- A. Regulatory Basis (Section 519(b)(2))
- B. Hydrologic Balance – Protection/prevention of Material Damage
  - 1. Post-reclamation
    - a. AMD?
    - b. Recharge capacity?
    - c. Surface water
      - (1) Baseline vs. post-reclamation quality/flow rates – trends?
      - (2) Post-reclamation quality vs. water quality standards – trends?
      - (3) Drainage issues?
      - (4) Problems/water-user complaints? If yes:
        - (a) What were CHIA predictions?
        - (b) Variation in mining technique/practice from approved plan?
        - (c) Mitigation?
    - d. Ground water
      - (1) Baseline vs. post-reclamation quality – trends?
      - (2) Post-reclamation quality vs. water quality standards – trends?
      - (3) Water levels – recharge?
      - (4) Seeps?
      - (5) Problems/well complaints? If yes:
        - (a) What were CHIA predictions?
        - (b) Variation in mining technique/practice from approved plan?
        - (c) Mitigation?
  - 2. Recommendation (should permittee be released from final reclamation liability?)

Appendix F

METHODS OF DETERMINING IMPACTS – PROCESSES AND TOOLS

1. **Databases** – Databases are an excellent resource for determining potential impacts to water resources as a result of coal-mining operations. The most relevant database would include the RAs inventory of surface- and ground-water monitoring records collected from the site and other coal or non-coal mining permits near the area of interest. Another major source of ground-water information could include databases from the state's water well agency that maintains inventories of private wells drilled in the area of interest. Another valuable database would include those records from the appropriate state agency responsible for preparing the water quality inventory report pursuant to Section 305(b) of the Federal Water Pollution Control Act.

   Other sources of water databases include:

   - AgNIC is a database of agricultural information resources including information on water.
   - Agricultural Research Service Water Database is a collection of precipitation and streamflow data from small agricultural watersheds in the United States.
   - APIRS Online: The Aquatic, Wetland, and Invasive Plants Database is "a computerized bibliographic database (Copyright University of Florida, 2000) devoted to freshwater aquatic and wetland plants as well as terrestrial and aquatic invasive plants."
   - AWhere by Mud Springs Geographers, Inc. (www.mudsprings.com) is a workforce Geographic Information System (GIS) software package that requires minimal training and is useful to both the casual and power GIS user. This software moves GIS from the lab into the field and boardroom and can be customized. It features a large library of databases and the ability to model climate data. A free trial is available on the website.
   - ChemFinder--Chemical Searching and Information Integration; a chemical database that provides physical property data and 2D chemical structures; also gives access to "the largest single list of chemical information sites (by at least double the size of the next-largest) that we [ChemFinder] are aware of."
   - Drinking Water Research Information Network (DRINK) "is a portal to information on projects funded or performed by water research organizations, government agencies in the U.S., international research organizations and academic institutions focused on drinking water issues. It is a compilation of drinking water project information from partner organizations that creates a single source of ongoing research."
   - EnviroMapper for Water "is a web-based Geographic Information System (GIS) application that dynamically displays information about bodies of water in the United States. This interactive tool allows you to create customized maps that portray the nation's surface waters along with a collection of environmental data."

- Environmental Fate Data Base -- Purposes of the database: "(1) To allow rapid access to all available fate data on a given chemical without having to resort to expensive, time consuming, and inefficient primary literature searches; (2) To identify critical gaps in the available information to facilitate planning of research needs; and (3) To provide a data source for constructing structure-activity correlations for degradability and transport of chemicals in the environment." For more information, see http://www.syrres.com/esc/efdb_info.htm.
- Enviro-Science e-Print Service provides access to "manuscripts of journal articles and book chapters, conference papers, presentations, posters, and selected technical reports in environmental management science."
- Expertise Directories (International Water Resources Association); search or browse to locate water professionals with various areas of expertise.
- Locate Your Watershed is part of the Environmental Protection Agency's Surf Your Watershed site where you can get various types of information--including an Index of Watershed Indicators--about specific watersheds in the United States.
- National Contaminant Occurrence Database "EPA developed the NCOD to satisfy the statutory requirements set by Congress in the 1996 amendments to the Safe Drinking Water Act (SDWA) to maintain a national drinking water contaminant occurrence database using samples data for both regulated and unregulated contaminants in public water systems. This site provides a listing of water sample analytical data that EPA is currently using and has used in the past for analysis, rulemaking, and rule evaluation. The data have been extensively checked for data quality and analyzed for national representative-ness."
- National Environmental Methods Index provides "a mechanism to compare and contrast the performance and relative cost of analytical, test, and sampling methods for environmental monitoring." The index can be used to compare methods based on analyte, media and performance data. NEMI is a project of the Methods and Data Comparability Board, developed with funding from the U.S. Environmental Protection Agency and the U.S. Geological Survey (USGS).
- National Environmental Publications Information System allows you to "search over 11,000 full text, EPA documents online."
- National Hydrography Dataset (NHD) "is a comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs and wells. Within the NHD, surface water features are combined to form "reaches," which provide the framework for linking water-related data to the NHD surface water drainage network. These linkages enable the analysis and display of these water-related data in upstream and downstream order."
- National Nutrient Database "stores and analyzes nutrient water quality data and serves as an information resource for states, tribes, and others in establishing scientifically defensible numeric nutrient criteria. It contains ambient data from our Legacy STOrage and RETrieval (STORET) data

system, the US Geological Survey's National Stream Quality Accounting Network (NASQAN) data and National Water Quality Assessment (NAWQA) data, and other relevant sources such as universities and states/tribes. The ultimate use of the data is to derive ecoregional waterbody-specific numeric nutrient criteria. We will also use this database to develop ecoregionally representative nutrient criteria for all waterbodies of the United States."

- National Water Quality Standards Database is a U. S. Environmental Protection Agency database "being developed for the purposes of displaying water quality standards (WQS), including designated uses and criteria, for the Nation's surface waters."
- National Wetlands Inventory provides wetlands maps from the U. S. Fish and Wildlife Service.
- National Wetlands Research Center (NWRC) Publications and Information Products is a database of studies and reports from this organization within the USGS. Note: The database may not display properly when using Netscape (8/24/05).
- Publications Warehouse (USGS) "The reports and thematic maps database currently contains more than 67,000 bibliographic citations [as of 1/13/05], including numbered series begun as early as 1882. Citations and online documents are added regularly. Availability of content ranges from full text to bibliographic citation only."
- Safe Drinking Water Query Form provides access to information about Safe Drinking Water Act violations and enforcement history for public water supplies during the last ten years; see Safe Drinking Water Overview for more information.
- STORET "The U.S. Environmental Protection Agency (EPA) maintains two data management systems containing water quality information for the nation's waters: the Legacy Data Center (LDC), and STORET. The LDC contains historical water quality data dating back to the early part of the 20th century and collected up to the end of 1998. STORET contains data collected beginning in 1999, along with older data that has been properly documented and migrated from the LDC. Both systems contain raw biological, chemical, and physical data on surface and ground water collected by federal, state and local agencies, Indian Tribes, volunteer groups, academics, and others. All 50 States, territories, and jurisdictions of the U.S. are represented in these systems."
- StreamStats "is a Web-based tool that allows users to obtain streamflow statistics, drainage-basin characteristics, and other information for user-selected sites on streams. StreamStats users can choose locations of interest from an interactive map and obtain information for these locations." (Data available for three states as of August 24, 2005.)
- USGS National Water Quality Assessment Data Warehouse "enables water resource managers, scientists, and the public to find data about the quality of the water at 2,800 stream sites and 5,000 wells in 46 states, according to the U. S. Geological Survey (USGS)."

- Water and Climate Bibliography; "a comprehensive database of scientific literature pertaining to climate change and freshwater resources worldwide."
- WATERS (Watershed Assessment, Tracking & Environmental ResultS), from the U. S. Environmental Protection Agency, "unites water quality information that was previously available only from several independent and unconnected databases." See http://www.epa.gov/waters/about/index.html for more information.
- WaterWeb Links Database; links to water-related Web sites searchable by keyword(s), geographic location or language.

2. Data Interpretation – Input data and utilize the Office of Surface Mining (OSM) software to interpret the overburden analyses and/or the surface water and ground water data.

3. Graphs - Useful tools for the applicant and the regulatory authority to determine trends (i.e. fluctuating water levels, water quality quantity, etc.). A variety of useful graphs can be generated by OSM software.

4. Software and Training - computer software can be extremely useful for modeling purposes. The applicant and the regulatory authority should consider using OSM's wide array of the latest software that is tailored for SMCRA-related hydrologic concerns, namely:

Office of Surface Mining's National Technical Training Program (NTTP) Courses (http://www.tips.osmre.gov/training/tips_html/links_nttp.asp):

Acid-Forming Materials: Fundamentals and Applications - This course is designed to provide participants with basic information on the characteristics of potentially acid forming material, their oxidation and production of acid mine drainage/related aquatic toxic materials and extremely acid materials, and potential for mitigation of these impacts.

Acid-Forming Materials: Principles and Processes - This course provides participants with information to upgrade their technical skills and current thinking in the critical aspects of the formation, weathering, and effects of acid forming materials in hydrologic and soil plant systems.

Acid-Forming Materials: Planning and Prevention - This workshop provides participants with information to enhance their knowledge and technical skills in planning mitigation of acid-forming materials impacts in hydrologic and soil and plant systems.

Forensic Hydrology – This course will serve to apply the knowledge gained from other NTTP hydrology, geology, and mining courses taken by the target audience. The course will concentrate on application of field investigative techniques, data collection, data and information analysis and interpretation, report structuring, and litigation preparation. At a minimum the course will address investigations of ground and surface water impacts that occurred as a result of mining. The underlying theme to this course is the philosophical and practical approaches to hydrologic investigations from start to finish. The course is not designed to teach basic hydrogeologic information, report writing, basic instrument use, or background in mining which are taught in other NTTP classes**.**

NEPA Procedures - This course provides training for State and Federal staff involved in Federal mine plan and Federal permit review in the procedures for complying with and drafting environmental documents required by National Environmental Policy Act (NEPA) and other appropriate environmental laws, regulations, and executive orders.

Permit Findings Workshop - This course is a workshop designed to assist regulatory personnel in preparing permit findings that are technically and legally sufficient and appropriately documented so-as to be able to withstand legal challenge and public scrutiny. This course is intended to provide a process orientation and an awareness raising approach or methodology to permit findings.

Permitting Hydrology – This course emphasizes reviewing probable hydrologic consequences determinations, defining material damage, and preparing cumulative hydrologic impact assessments.

Quantitative HydroGeology - This hands-on course will review the underlying assumptions and theories of aquifer characterization and the practical utilization of hydrogeologic principles to understand and analyze ground water movement. The course is intended to be a refresher on hydrogeology and to provide exposure to application of these principles in analysis and investigation of ground water questions. The course will look at confined, unconfined, leaky, and fractured aquifers. Students will work examples applying these principles to coal mining and reclamation-related problems.

Surface and Ground water Hydrology - This course provides participants with information on the basic effects of surface coal mine operations on surface and ground water hydrology.

Office of Surface Mining's Technical Innovation and Professional Services (TIPS) Training (http://www.tips.osmre.gov/training/tips_html/links_nttp.asp):

Advanced Ground water Vistas Modeling for Mine Permitting and Reclamation - An intermediate ground water modeling course using Ground water Vistas software. This course will build on the introductory Ground water Vistas course and discuss integrating Ground water Vistas and ArcGIS, including the delineation of surface water catchments using ArcGIS 'Spatial Analyst'. Topics also include the creation of Ground water Vistas maps, properties and boundary conditions from GIS layers, and exporting grids and model results to ArcGIS with geological, hydrological and hydrogeological data.

Modeling and Analysis with GMS Ground water Modeling Systems - An intermediate course in ground water modeling using GMS - Ground water Modeling Systems software. The course assumes some familiarity with ground water modeling. A series of tutorials and lessons on the GMS interface to MODFLOW/MODPATH/ MT3DMS/RT3D will be presented including an explanation of how to use the Map Module to create numerical models directly from a high-level conceptual model constructed with GIS tools. Analytic element modeling with MODAEM may also be covered. Topics will include the graphical user interface, visualization tools, and presentation graphics.

Modeling and Analysis with Ground water Vistas - This hands-on course will review the underlying assumptions, theories, and practical utilization of numerical flow models and conceptually modeling ground water flow and introduce the use of the Ground water Vistas software. Students will work examples applying this software to coal mining and reclamation related analysis.

Testing and Analysis of Aquifer Characteristics with AQTESOLV -This hands-on course will review the underlying assumptions and theories of aquifer characterization and the practical utilization of analytical ground-water models. The course will provide an introduction to the use of AQTESOLV, including analysis of confined, unconfined, leaky, and fractured aquifers. Students will work examples applying this software to coal mining and reclamation-related analysis including investigating pump tests, slug tests and drawdown analysis.

SEDCAD Applications and Extensions for Mine Permitting and Reclamation - This proposed hands-on intermediate level course will build on the basic assumptions, theories, and practical utilization of the surface flow models and sedimentation characteristics in SEDCAD, and RUSLE. Students will be introduced to the AutoCAD Extension, and will work examples applying these software packages to coal mining and reclamation related situations.

SEDCAD for Mine Permitting and Reclamation - This course presents the assumptions, theories, and practical utilization of the surface flow models in SEDCAD for coal mine permitting and reclamation. An Introduction to the Revised Universal Soil Loss Equation will also be covered. Students will work examples applying this software to mining related and other situations.

AMDTreat - The program offers users a method to predict and model water treatment costs for mine drainage problems. It also allows for the determination of capital cost associated with treatment of polluted mine drainage. AMDTreat provides many different treatment options both for passive and active treatment systems. Over 500 variables are available to the user to customize the costing routines for site-specific conditions.

Mining and Reclamation Introduction to Geochemical Analysis using the Geochemist's Workbench - This hands-on course developed by Rockware for the Office of Surface Mining introduces participants to fundamentals of aqueous geochemistry using The Geochemist's Workbench software to address mining and reclamation analyses. The course introduces the Geochemist's Workbench software and provides hands- on exercises enabling participants to run speciation models, create Eh-pH diagrams, Piper diagrams, and Stiff plots. The GWB Essentials software and the GWB professional software will be introduced and discussed.

Statistics Workshop: Interpretation of Water Quality Date using StatGraphics and AquaChem – This is a hands-on class where participants learn to develop graphics and statistical analyses for technical reports from water quality data using AquaChem and Statgraphics. Students work with their own data sets in workshop type environment.

Water Quality Analysis using AquaChem - This hands-on introductory course covers the basic aspects of water chemistry, water sampling and methods of water quality data evaluation related to coal mining and reclamation using the AQUACHEM software package.

5. Modeling

Geologic

Geologic modeling is the applied science of creating computerized representations of portions of the Earth's crust, especially oil and gas fields and ground water aquifers. This type of modeling is a relatively recent subdiscipline of geology which integrates structural geology, sedimentology, stratigraphy, paleoclimatology, and diagenesis. A geologic formation is generally represented using a 3-dimensional array of relatively small subdivisions, or cells. The creation of geologic models is computationally intense, so this discipline has only existed since the development of high-speed digital processors.

Geologic Modeling is usually divided into four steps (Article on Wikipedia.org - the free online encyclopedia.):

(1) Structural Framework - Incorporating the spatial positions of the major boundaries of the formations, including the effects of faulting, folding, and erosion. The major stratigraphic divisions are further subdivided into layers of cells with differing geometries with relation to the bounding surfaces (parallel to top, parallel to base, proportional). Maximum cell dimensions are dictated by the minimum sizes of the features to be resolved (everyday example: On a digital map of a city, the location of a city park might be adequately resolved by one big green pixel, but to define the locations of the basketball court, the baseball field, and the pool, much smaller pixels need to be used).

(2) Rock Type - Each cell in the model is assigned a rock type. In a coastal clastic environment, these might be beach sand, high water energy marine upper shoreface sand, intermediate water energy marine lower shoreface sand, and deeper low energy marine silt and shale. The distribution of these rock types within the model is controlled by several methods, including map boundary polygons, rock type probability maps, or statistically emplaced based on sufficiently closely spaced well data.

(3) Reservoir Quality - Reservoir quality parameters almost always include porosity and permeability, but may include measures of clay content, cementation factors, and other factors that affect the storage and deliverability of fluids contained in the pores of those rocks. Geostatistical techniques are most often used to populate the cells with porosity and permeability values that are appropriate for the rock type of each cell.

(4) Fluid Saturation - Most rock is completely saturated with ground water. Sometimes, under the right conditions, some of the pore space in the rock is occupied by other liquids or gases. In the energy industry, oil and natural gas are the fluids most commonly being modeled. The preferred methods for calculating hydrocarbon saturations in a geologic model incorporate an estimate of pore throat size, the densities of the fluids, and the height of the cell above the water contact, since these factors exert the strongest influence on capillary action, which ultimately controls fluid saturations.

Surface Water

Integrated surface-water and ground-water modeling is rapidly becoming an integral part of the management of our global water resources. It attempts to simulate the entire land phase of the hydrologic cycle, including:

- Precipitation
- Evapotranspiration
- Overland flow
- Channel flow and Structures
- Unsaturated sub-surface flow
- Saturated ground water flow

Integrated surface-water and ground-water modeling can be used for the analysis, planning and management of a wide range of water resources and environmental problems related to both surface water and ground water, including:

- Surface water impact from ground water withdrawal
- Conjunctive use of ground water and surface water
- Wetland management and restoration
- Aquifer vulnerability mapping with dynamic recharge and surface water boundaries
- Floodplain studies and Flood Forecasting
- Impact studies for changes in land use and climate
- Non Point Source Water Quality (e.g., TMDL) studies

Surface water modeling links:
For sources of surface water modeling:
http://www.mindspring.com/~rbwinston/surf.htm

- www.tsatools.com "TSA TOOLS is a series of Microsoft Excel / VBA based applications intended to offer water resources and civil design professionals flexibility and efficiency in their computational analysis and design."
- The USGS Surface-water quality and flow Modeling Interest Group
- Object Watershed Link Simulation
- Soil and Water Assessment Tool (SWAT) is a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds. www.brc.tamus.edu/swat/index.html
- TR - 55, Urban Hydrology for Small Watersheds, program and documentation.
- Hydrologic Unit Modeling for the United States (HUMUS)
- AUS-IFD Version 1.2 is a MS Windows based program which calculates the design average rainfall intensities and temporal patterns for any location in Australia, using the procedures described in Australian Rainfall and Runoff, 1987.
- Computer-Aided Hydrology & Hydraulics.
- INTERNET SOFTWARE GUIDE FOR ENGINEERS.
- Resource Management Systems Group. Windows version of Catchment Management Support System (CMSS) and other tools.
- Engenious Systems. Inc WaterWorksHMS.
- David G. Tarboton's web page has the codes for the following papers.

    - "A New Method for the Determination of Flow Directions and Contributing Areas in Grid Digital Elevation Models",
    - "Utah Energy Balance Snow Accumulation and Melt Model (UEB)"
    - "A Spatially Distributed Energy Balance Snowmelt Model"
- Hidrosoft.
- Aquarian Software, Inc.
- Science Technology Associates.
- TOPOG is a physically based distributed parameter hydrological model written by researchers and scientists at CSIRO Land and Water, a party in the CRC for Catchment Hydrology.
- Science Technology Associates hydrograph analysis, hydro CD, culvert analysis.
- PCSWMM'96, "a fully windows and web compatible shell for USEPA stormwater management model and related programs".
- Utah Energy Balance Snow Accumulation and Melt Model (UEB).
- Decision Support Systems For Urban Stormwater Management Modelling.
- Check INWSMADA.ZIP: Hydgen for Windows v1.0 "Generates hydrographs in Windows 3.x. It allows you to create pollutographs, rainfall files, watershed files, and flow files. Output can be plotted, printed, or copied to clipboard." I don't know why it is mixed in with "WINDOWS FINANCE PROGRAMS".
- Flow Pro 2.0 by ProSoft Apps: a gradually varied water surface profile program for pipes, culverts, channels, and sluiceways with a wide variety of shapes and sizes. Fully functional demo available for download.
  They also have hydraulic design equations online along with the theory behind them.
- Hydrologic Engineering Center Computer Software, HEC-1, HEC-2, HEC-6.
- Environmental/Hydrologic/Hydraulic/Water Resources computer models mirrored in the Civil & Environmental Engineering Department, ODU.
- Prosoft Apps has Flow Pro 1.0a, a graphical water surface profile program.
- AquaDyn.
- Sewer and Stormwater Network Analysis and Design
- "AquaDyn is a powerful and easy to use hydrodynamic simulation package essential for water resources engineering studies, risk assessment, and impact studies."
- Geo-STORM for ARC/INFO from Innovative System Developers, Inc. demo available.
- Jeremy Benn Associates HEC-RAS, FlowMaster™, CulvertMaster™.
- Complete list of HOMS components from World Meteorological Organization Hydrology and Water Resources Programme.
- TideTracker; Handheld Tide and Current Computer.
- Tide Calculator.
- WWW Tide and Current Predictor.
    - WWW Tide and Current Predictor (Florida).
- Scripps Institution of Oceanography Pier Tide Predictor.
- *NRCS ENGINEERING SOFTWARE TR-20, TR-48, TR-55, TR-61. TR-64.
- Geosoft Ltd produces "Hydroscope - River networks and drainage basin analysis from Digital Elevation Models".

- BOSS International -USA Site has a variety of groundwater and surface water modeling programs. See also:
    - BOSS International - EUROPE Site
    - BOSS International - ASIA Site
- Hydrologic Modeling Resources Links to a wide variety of resources - many with outdated URL's.
- University of Central Florida Civil and Environmental Software A collection of programs for DOS that perform a variety of typical hydroligal analyses.
- A new book: Advances in Modeling the Management of Stormwater Impacts
- USGS Water Resources Applications Software. Too many programs to list.
- Software At The Hydraulics Laboratory at U. S. Army Corps of Engineers, Waterways Experiment Station TABS, CH3D SAM, SMS, GMS, WMS
- Water Resources Publications, LLC Book Publisher; many of the titles include software.
- Water Resources Models at WETnet.
- BAE 473/573 - Introduction to Surface Water Quality Modeling.
- Hydrology Models in GRASS.
- Hydrology and Hydraulics Software from Dodson & Associates.
- MIKE SHE An Integrated Hydrological Modelling System from the Danish Hydraulic Institute.
- Geo-STORM by Innovative System Developers, Inc. simulates watershed and river basin hydrologic and hydraulic processes using information maintained within your ARC/INFO database.
- The River System Simulator (RSS) is a computer-based simulation system for multi-purpose planning and operation of river systems, with special emphasis on hydropower and its environmental effects.
- WATFLOOD is an integrated set of computer programs to forecast flood flows for watershed having response times ranging from one hour to several weeks.
- The Geotechnical & Geo-environmental Software Directory details several hundred programs, software publishers and suppliers in the fields of Geotechnical Engineering, Engineering Geology, Hydrogeology, Geo-environmental Engineering, Data Analysis and Data Visualisation. Also lists other WWW pages with related software. Compiled by Tim Spink.
- ESIE Free Directory of Vendors at CAE Consultants This page gives phone numbers for a large number of vendors. Try looking under "Environmental Engineering".
- Biosystems Analysis Group Oregon State University POND Aquaculture Decision Support Software and Virtual Systems Simulator.
- ITS Resources PC and Mac transportation related software available for purchase.
- TOPMODEL rainfall-runoff modelling.
- IRRISOFT Database on IRRIGATION and HYDROLOGY SOFTWARE.
- Water Erosion Prediction Project. from the National Soil Erosion Research Laboratory.
- ENGINEERING SOFTWARE CENTER.
- Engineering Computer Graphics Laboratory. GMS, WMS, FastTABS, FastSeep, SMS, Cquel

- Water Resources Consulting Services - Hydrology Software TR-55, SWMM, Hec-1Time, Flow-duration template for Quattro Pro, Hydraulics utility programs.
- SWMM. Excerpts from the quarterly newsletter "SWMM News & Notes".
- The electronic catalog at this site lists several surface water models under "Highway Engineering/Hydraulics".
- ECGL SMS (Surface-water Modeling System).
- Register of ecological models. A significant number of surface and groundwater models are included along with a large number of strictly ecological models.
- WETnet Water Resources Models
- EPA Software. at Environmental Protection Agency WWW Server.
- Sea Air Land Modeling Operational Network
- Hydrocomp Home Page
- Software at Environmental HydroSystems, Inc.
- HEC - Software Products at Hydrologic Engineering Center - HEC
- Institute of Hydrology - Software Development
- Cullimore and Ring Technologies, Inc.
- Spatially Distributed Hydrologic modeling
- Water Resource Systems Research Unit SHETRAN a physically based distributed hydrological modeling system. TRACE123 an integrated suite of software designed for a wide range of subsurface pollution problems. MTB (Modified Turning Bands) rainfall modeling system.
- SSIIM for Windows "SSIIM is an abbreviation for Sediment Simulation In Intakes with Multiblock option. The program is designed to be used in teaching and research for hydraulic/river/sedimentation engineering. It solves the Navier-Stokes equations using the control volume method with the SIMPLE algorithm and the k-epsilon turbulence model. It also solves the convection-diffusion equation for sediment transport, using van Rijn's formula for the bed boundary. Also, a water quality module is included."
- David G. Tarboton
- The RiverTools Home Page
- Haestad Methods, Inc
- Computation Fluid Dynamics Codes List at James Todd Ratcliff's homepage.

Ground Water

Ground-water flow models are used to calculate the rate and direction of movement of ground water through aquifers and confining units in the subsurface. These calculations are referred to as simulations. The simulation of ground-water flow requires a thorough understanding of the hydrogeologic characteristics of the site. The hydrogeologic investigation should include a complete characterization of the following:

- Subsurface extent and thickness of aquifers and confining units (hydrogeologic framework),
- Hydrologic boundaries (also referred to as boundary conditions) which control the rate and direction of movement of ground water,
- Hydraulic properties of the aquifers and confining units,
- A description of the horizontal and vertical distribution of hydraulic head throughout the modeled area for both beginning (initial conditions), equilibrium

(steady-state conditions) and transitional conditions when hydraulic head may vary with time (transient conditions), and

- Distribution and magnitude of ground-water recharge, pumping or injection of ground water, leakage to or from surface-water bodies, etc. (sources or sinks, also referred to as stresses). These stresses may be constant (unvarying with time) or may change with time (transient).

The outputs from the model simulations are the hydraulic heads and ground-water flow rates which are in equilibrium with the hydrogeologic conditions (hydrogeologic framework, hydrologic boundaries, initial and transient conditions, hydraulic properties, and sources or sinks) defined for the modeled area.

Through the process of model calibration and verification (discussed in later sections of this document), the values of the different hydrogeologic conditions are varied to reduce any disparity between the model simulations and field data, and to improve the accuracy of the model. The model can also be used to simulate possible future changes to hydraulic head or ground water flow rates as a result of future changes in stresses on the aquifer system.

Fate and Transport Models

Fate and transport models simulate the movement and chemical alteration of contaminants as they move with ground water through the subsurface. These models require the development of a calibrated ground-water flow model or, at a minimum, an accurate determination of the velocity and direction of ground-water flow that has been based on field data. Fate and transport models are used to simulate the following processes:

- Movement of contaminants by advection and diffusion,
- Spread and dilution of contaminants by dispersion,
- Removal or release of contaminants by sorption, or desorption, of contaminants onto, or from, subsurface sediment or rock, or
- Chemical alteration of the contaminant by chemical reactions which may be controlled by biological processes or physical chemical reactions.

In addition to a thorough hydrogeological investigation, the simulation of fate and transport processes requires a complete characterization of the following:

- Horizontal and vertical distribution of average linear ground-water velocity (direction and magnitude) determined by a calibrated ground-water flow model or through accurate determination of direction and rate of ground-water flow from field data,
- Boundary conditions for the solute,
- Initial distribution of solute (initial conditions),
- Location, history and mass loading rate of chemical sources or sinks,
- Effective porosity,
- Soil bulk density,
- Fraction of organic carbon in soils,
- Octanol-water partition coefficient for chemical of concern,

- Density of fluid,
- Viscosity of fluid,
- Longitudinal and transverse dispersivity,
- Diffusion coefficient,
- Chemical decay rate or degradation constant,
- Equations describing chemical transformation processes, if applicable
- Initial distribution of electron acceptors, if applicable.

The outputs from the model simulations are the contaminant concentrations, which are in equilibrium with the ground-water flow system, and the geochemical conditions (described above) defined for the modeled area.

As with ground-water flow models, fate and transport models should be calibrated and verified by adjusting values of the different hydrogeologic or geochemical conditions to reduce any disparity between the model simulations and field data. This process may result in a re-evaluation of the model used for simulating ground-water flow if the adjustment of values of geochemical data does not result in an acceptable model simulation. Predictive simulations may be made with a fate and transport model to predict the expected concentrations of contaminants in ground water as a result of implementation of a remedial action. Monitoring of hydraulic heads and ground-water chemistry will be required to support predictive simulations.

Types of Models

The equations that describe the ground-water flow and fate and transport processes may be solved using different types of models. Some models may be exact solutions to equations that describe very simple flow or transport conditions (analytical model) and others may be approximations of equations that describe very complex conditions (numerical models). Each model may also simulate one or more of the processes that govern ground-water flow or contaminant migration rather than all of the flow and transport processes. As an example, particle-tracking models such as MODPATH simulate the advective transport of contaminants but do not account for other fate and transport processes. In selecting a model for use at a site, it is necessary to determine whether the model equations account for the key processes occurring at the site. Each model, whether it is a simple analytical model or a complex numerical model, may have applicability and usefulness in hydrogeological and remedial investigations.

<u>Analytical Models</u>

Analytical models are an exact solution of a specific, greatly simplified, ground water flow or transport equation. The equation is a simplification of more complex three-dimensional ground water flow or solute transport equations. Prior to the development and widespread use of computers, there was a need to simplify the three-dimensional equations because it was not possible to easily solve these equations. Specifically, these simplifications resulted in reducing the ground water flow to one dimension and the solute transport equation to one or two dimensions. This resulted in changes to the model equations that include one-dimensional uniform ground water flow, simple uniform aquifer geometry, homogeneous and isotropic aquifers, uniform hydraulic and chemical reaction properties, and simple flow or chemical reaction boundaries. Analytical models are typically steady-state and one-dimensional, although selected ground water flow models are two dimensional (e.g. analytical element models), and some contaminant transport models assume one-dimensional ground water flow conditions and one-, two- or three-dimensional transport conditions. Well hydraulics models, such as the Theis or Neumann methods, are examples of analytical one-dimensional ground-water flow models.

Because of the simplifications inherent with analytical models, it is not possible to account for field conditions that change with time or space. This includes variations in ground water flow rate or direction, variations in hydraulic or chemical reaction properties, changing hydraulic stresses, or complex hydrogeologic or chemical boundary conditions.

Numerical Models

Numerical models are capable of solving the more complex equations that describe ground-water flow and solute transport. These equations generally describe multi-dimensional, ground-water flow, solute transport and chemical reactions although there are one-dimensional numerical models. Numerical models use approximations (e.g. finite differences, or finite elements) to solve the differential equations describing ground-water flow or solute transport. The approximations require that the model domain and time be discretized.

The accuracy of numerical models depends upon the accuracy of the model input data, the size of the space and time discretization (the greater the size of the discretization steps, the greater the possible error), and the numerical method used to solve the model equations.

In addition to complex three-dimensional, ground-water flow and solute transport problems, numerical models may be used to simulate very simple flow and transport conditions that may just as easily be simulated using an analytical model. However, numerical models are generally used to simulate problems which cannot be accurately described using analytical models (Michigan Department of Environmental Quality). http://www.michigan.gov/deq/0,1607,7-135-3313_21698---,00.html

For sources of ground-water modeling:
http://www.mindspring.com/~rbwinston/big.htm

- Engineering Software Center
- USGS Ground-Water Software
- U.S. Salinity Laboratory
- Waterways Experiment Station (US Army Corps of Engineers)
- USGS Water Resources Applications Software via the USGS Water Resources page. Nearly all the USGS groundwater programs are available for downloading. Most are in source code form but some have been compiled for a variety of platforms.
- Ground-Water and Vadose Zone Models/Manuals at Center for Subsurface Modeling Support at Kerr Lab includes 13 different programs that are available for downloading including the public domain version of MT3D and BIOPLUME II.
- Models at Databases and Software at Environmental Protection Agency WWW Server.
- International Groundwater Modeling Center serves as a repository for nearly every model that exists. They also provide a variety of other services.

- The Scientific Software Group You can download a demo of Visual MODFLOW among other things. They have an extensive printed catalog as well as web pages on each of their products. You can download individual pages of their catalog in pdf format for more information. They list their programs both alphabetically and by function which makes it a good place to look for more information.
- Complete list of HOMS components from the World Meteorological Organization Hydrology and Water Resources Programme. There is information about a lot of different hydrology programs from many international (mostly governmental) sources.
- RockWare Inc. Earth Science Software has an extensive, well-organized, online catalog.
- The Geotechnical & Geo-environmental Software Directory details several hundred programs, software publishers and suppliers in the fields of Geotechnical Engineering, Engineering Geology, Hydrogeology, Geo-environmental Engineering, Data Analysis and Data Visualisation. Also lists other WWW pages with related software. Compiled by Tim Spink.
- The Hydrogeologist's Home Page has lots of information about all aspects of hydrology.
- ASCE Seepage/Groundwater Modeling Software is a set of links to many sites with information about groundwater modeling. Anyone can add a link to this site by filling out a form including a one paragraph description of their site.
- Hydrology Web

Groundwater Modeling Links

The United States Environmental Protection Agency’s Center for Subsurface Modeling Support (CSMoS) provides public domain ground-water and vadose zone modeling software and services to public agencies and private companies throughout the nation. CSMoS is located in Ada, Oklahoma at the National Risk Management Research Laboratory (NRMRL), the U.S. EPA's Center for Ground-Water Research. The primary aims of CSMoS are to provide direct technical support to EPA and State decision makers in subsurface model applications and to manage and support the ground-water models and databases resulting from the research at NRMRL. This research encompasses the transport and fate of contaminants in the subsurface, the development of methodologies for protection and restoration of ground-water quality, and the evaluation of subsurface remedial technologies. As a result, a major focus of CSMoS entails coordinating the use of models for risk assessment, site characterization, remedial activities, wellhead protection, and Geographic Information Systems (GIS) application. In these ways, CSMoS performs an active role in protecting, restoring, and preserving our nation's ground-water resources.

CSMoS integrates numerous individuals and organizations with expertise in all aspects of the environmental field in its effort to apply models to better understand and resolve ground water problems. CSMoS is supported by the scientists and engineers of the NRMRL whose specialties include hydrogeology, chemistry, soil science, biology, environmental engineering, and computer programming. CSMoS provides assistance in the following modeling areas:

- Conceptualization

- Model Development
- Model Application
- Model Distribution
- Model Training and Education

CSMoS is an integral part of the NRMRL's Technology Support Center. CSMoS distributes and services all models and databases developed by the NRMRL and provides general support on model application to ground-water and vadose zone problems. Technical assistance activities include developing educational documents, providing training courses, and distributing update notices and other pertinent information for all software developed at NRMRL as well as software developed under laboratory grants and contracts.

APPENDIX I

Bull Mountains Mine No.1

Cumulative Hydrologic Impact Assessment

Amendment AM3

TABLE OF CONTENTS

Acronyms used within this document.	
Acronym	**Definition**
ALS	Aquatic Life Standards (DEQ-7)
AM3	Amendment 3 to the Bull Mountains Mine No. 1 Permit
ARM	Administrative Rules of Montana
BMCM	Bull Mountains Coal Mining
BMPII	BMP Investments, Inc.
BMPs	Best Management Practices
BTCA	Best Technology Currently Available
CHIA	Cumulative Hydrologic Impact Assessment
CIA	Cumulative Hydrologic Impact Area
CPW	Coal Processing Waste
DEQ	Department of Environmental Quality
DEQ-7	Circular DEQ-7, Montana Numeric Water Quality Standards
DEQ-12A	Circular DEQ-12A, Montana Base Numeric Nutrient Standards
DNRC	Department of Natural Resources and Conservation
EC	Electrical Conductivity
EPA	Environmental Protection Agency
GWIC	Groundwater Information Center
HHS	Human Health Standards (DEQ-7)
K	Hydraulic Conductivity
LL&E	Louisiana Land and Exploration Company
LOM	Life of Mine
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MPDES	Montana Pollutant Discharge Elimination System
MSHA	Mine Safety and Health Administration
MSUMRA	Montana Strip and Underground Mine Reclamation Act
MWQA	Montana Water Quality Act
NAD 83 St. Pl.	North American Datum 1983, Montana State Plane Coordinate System
NSDWR	National Secondary Drinking Water Regulations
OSMRE	Office of Surface Mining Reclamation and Enforcement

Acronyms, continued.	
Acronym	**Definition**
OSW	Office Supply Well No. 1
PHC	Probable Hydrologic Consequences
RCRA	Resource Conservation and Recovery Act
SAR	Sodium Adsorption Ratio
SC	Specific Conductance
SMCL	Secondary Maximum Contaminant Level
SMCRA	Surface Mining Reclamation and Control Act
SMP	Surface Mining Permit
SPE	Signal Peak Energy LLC
SWL	Static Water Level
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorus
TR3	Major Revision 3 to the Bull Mountains Mine No. 1 Permit
TSS	Total Suspended Solids
USGS	United States Geological Survey
WDA	Waste Disposal Area

Unit Abbreviations used within this document.	
Unit Abbreviation	**Definition**
ac-ft	Acre-feet
amsl	Feet above mean sea level
ft	Feet
ft/d	Feet per day
gpd	Gallons per day
gpm	Gallons per minute
in.	Inches
meq/L	Milliequivalents per liter
mg/L	Milligrams per liter
mL/L	Milliliters per liter
mL/L/hr	Milliliters per liter per hour
s.u.	Standard units
yr	Years
°C	Degrees Celsius
°F	Degrees Fahrenheit
µg/L	Micrograms per liter
µS/cm	MicroSiemens per centimeter

1.0 INTRODUCTION

The Montana Department of Environmental Quality (DEQ) is the regulatory authority for coal mining operations in the state of Montana. *See* Section 82-4-203(15), 205, MCA. The state implements the Montana Strip and Underground Mine Reclamation Act (MSUMRA) which is set forth in Section 82-4-201 through 254, Montana Code Annotated (MCA), and the administrative rules pursuant to MSUMRA, Administrative Rules of Montana (ARM) 17.24.301 through 17.24.1826. The Federal Office of Surface Mining Reclamation and Enforcement (OSMRE) implements the Surface Mining Reclamation and Control Act of 1977 (SMCRA), and has granted primacy to DEQ as the regulatory agency for coal mining in Montana. As such, DEQ is responsible for the review and decisions on all permit applications to conduct surface coal mining operations within the state with oversight from OSMRE.

This cumulative hydrologic impact assessment (CHIA) is prepared by DEQ as part of the written findings for Amendment 3 (AM3), submitted by Signal Peak Energy, LLC (SPE) for the Bull Mountains Mine No. 1 [Surface Mining Permit (SMP) C1993017]. It includes an analysis of anticipated hydrologic impacts associated with mining in and adjacent to the proposed permit area.

2.0 REGULATORY ENVIRONMENT

Under MSUMRA, DEQ must prepare this CHIA as part of the written findings the DEQ must issue when it approves a permit or an amended permit. *See* Section 82-4-231(8) (f); ARM 17.24.314(5); 17.24.405(1).

In pertinent part, MSUMRA conditions approval of an application for coal mine operating permit on demonstration by the applicant that "the assessment of the probable cumulative impact of all anticipated mining in the area on the hydrologic balance has been made by the department and the proposed operation of the mining operation has been designed to prevent material damage to the hydrologic balance outside the permit area." Section 82-4-227(3)(a), MCA; *see also* ARM 17.24.405(6)(c).

This requirement was adopted to make MSUMRA's requirements equivalent to an identical requirement in the SMCRA. *See* Chapter 550, Laws of 1979. Neither SMCRA nor the applicable federal rules provide a definition of "material damage" or "designed to prevent material damage."[1] However, MSUMRA was amended to define "material damage" in 2003. *See* 2003 Mont. Laws p. 651, 655 (Ch. 204, § 2) (adopting definition for "material damage"). MSUMRA defines "material damage" as follows:

> *"with respect to protection of the hydrologic balance, degradation or reduction by coal mining and reclamation operations of the quality or quantity of water outside of the permit area in a manner or to an extent that land uses or beneficial uses of water are adversely affected, water quality standards are violated, or water rights are impacted. Violation of a water quality standard, whether or not an existing water use is affected, is material damage."*

Section 82-4-203(32), MCA. MSUMRA also provides a definition of "hydrologic balance":

> *"the relationship between the quality and quantity of water inflow to, water outflow from, and water storage in a hydrologic unit, such as a drainage basin, aquifer, soil zone, lake, or reservoir, and encompasses the dynamic relationships among precipitation, runoff, evaporation, and changes in ground water and surface water storage."*

Section 82-4-203(24), MCA. MSUMRA does not define "prevent" or "designed to prevent." Accordingly, "designed to prevent" should be understood according to its plain meaning within its statutory context. "Prevent" means "to stop (something) from happening or existing." (Merriam-Webster on-line

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[1] On July 17, 2015, OSMRE proposed to adopt a definition of the term "material damage to the hydrologic balance outside the permit area." The proposed definition is:

> [A]ny adverse impact from surface coal mining and reclamation operations or from underground mining activities, including any adverse impacts from subsidence that may occur as a result of underground mining activities, on the quality or quantity of surface water or groundwater, or on the biological condition of a perennial or intermittent stream, that would—
> (a) Preclude any designated use under sections 101(a) or 303(c) of the Clean Water Act or any existing or reasonably foreseeable use of surface water or groundwater outside the permit area; or
> (b) Impact threatened or endangered species, or have an adverse effect on designated critical habitat, outside the permit area in violation of the Endangered Species Act of 1973, 16 U.S.C. 1531 et seq.

This rulemaking proceeding is pending as of the date of this CHIA. *See* Federal Register, Vol. 80, No. 143, July 27, 2015 (82 Fed. Reg. 44436 at 44473).

dictionary: http://www.merriam-webster.com/dictionary/prevent). Therefore, “designed to prevent material damage” means designed to stop material damage from occurring.

Each permit application must contain a detailed description of the “measures to be taken during and after mining activities to minimize disturbance to the hydrologic balance on and off the mine permit area, and prevent material damage to the hydrologic balance outside the permit area” ARM 17.24.314(1). This CHIA considers measures and cumulative impacts for the proposed AM3 expansion of the Bull Mountains Mine No. 1. Although this CHIA considers cumulative impacts of other existing, previous, and anticipated mining, impacts caused by existing or previous mining that are not intensified or augmented by the expanded operations proposed for AM3 do not constitute grounds for denial of the AM3 application. Material damage determinations for existing and previous mining, if required, were made at the time that mining was approved, and this CHIA does not invalidate or supersede those determinations. Similarly, separate material damage determinations for future anticipated mining, if required, will be made in the CHIA(s) prepared for those permit applications at the time they are submitted by the applicant and determined to be acceptable by DEQ.

2.1 Material Damage Criteria

Following the general principles explained above, material damage criteria are established for the evaluation of both groundwater and surface water quality and quantity, and are used to determine whether water quality or quantity outside the permit area will be impacted to the extent that land uses or beneficial uses of water are adversely affected, water quality standards outside the permit area will be violated, or water rights outside the permit area will be impacted by the proposed operations of the AM3 expansion to the Bull Mountains Mine No. 1.

Material damage criteria include applicable numeric and narrative water quality standards, and criteria established to protect beneficial uses of water and water rights. Baseline water quantity and quality is compared against changes or anticipated changes in quantity and quality associated with mine activity to determine if beneficial uses have been adversely affected, water quality standards violated, or water rights affected outside the permit boundary.

The Montana Water Quality Act (MWQA), codified at Section 75-5-101 through Section 75-5-410, MCA, is the primary basis for water quality protection in the state of Montana. Rules promulgated under the authority of MWQA establish surface water and groundwater standards (ARM 17.30, Subchapters 6, 7, and 10) to protect the designated beneficial uses of state waters. Numeric standards published in Circular DEQ-7, Montana Numeric Water Quality Standards (MDEQ, 2012), were developed using guidance from the Environmental Protection Agency (EPA).

Montana's surface water and groundwater rules also contain narrative standards (ARM 17.30.620 through 17.30.670, and 17.30.1001 through 17.30.1045, respectively). The narrative standards are designed to address water quality for which sufficient information does not yet exist to develop parameter-specific numeric standards. These narrative standards are established to protect beneficial uses from adverse effects, supplementing the existing numeric standards.

The degradation or reduction of a surface water or groundwater supply outside the permit area as a result of the proposed mining such that a beneficial use is impaired is considered material damage. As required pursuant to ARM 17.24.314(1), the AM3 permit application contained a detailed description, including maps and data, of the measures SPE would take during and after the proposed mining activities to "minimize disturbance of the hydrologic balance on and off the mine plan area and to prevent material damage to the hydrologic balance outside the permit area."

2.1.1 Surface Water Material Damage Criteria

Material damage to surface water[2] occurs when, because of the proposed mining operations, any of the following criteria are met:

- Surface water quality standards outside of the permit area are violated;
- Surface water quality or quantity is degraded or reduced to the extent that land uses or beneficial uses of water outside of the permit area are adversely affected; or
- A surface water right outside the permit area is adversely impacted.

The following water quality standards are applicable to most surface waters:

1. Numeric water quality standards established in Circulars DEQ-7 and DEQ-12A (where applicable);
2. Specific water quality standards established to protect and maintain the beneficial uses (where applicable) for a waterbody's specific classification;

Numeric surface water standards for parameters of concern applicable to surface waters are shown in **Table 2-1**. The parameter list includes selected parameters known to be potentially associated with coal mining impacts monitored by Montana coal mines. Pursuant to ARM 17.30.637(4), these numeric water quality standards apply to perennial/intermittent streams but not to ephemeral streams. However, in a recent opinion issued by Judge Kathy Seeley of the First Judicial District Court, Lewis and Clark County, the Court indicated that surface waters that are classified as C-3 waters under Montana's water use classification system, may not be treated as ephemeral streams[3] for purposes of determining the applicable water quality standards, without complying with the procedures set forth in ARM 17.30.615(2) for reclassifying a specific water body in Montana.

Although Judge Seeley's opinion is not final and may be appealed to the Montana Supreme Court, for purposes of making its material damage determination with respect to the proposed mining operations in AM3, DEQ has applied the water quality standards applicable to non-ephemeral C-3 waters to all surface water bodies located inside and outside the permit area that are classified as C-3 waters, regardless of whether the surface waters meet the definition of ephemeral stream. DEQ has taken this conservative approach to ensure that its analysis is not subject to challenge for failure to apply the correct water quality standards to ephemeral drainageways that may be impacted due to the proposed mining operations in AM3.

Surface waters in the Bull Mountains are classified as C-3 surface waters [ARM 17.30.611(1)(c)]. Beneficial uses of surface waters are established according to stream water use classification. Beneficial uses of C-3 waters are set forth in ARM 17.30.629:

[2] "Surface waters" means any waters on the earth's surface including, but not limited to, streams, lakes, ponds, and reservoirs; and irrigation and drainage systems discharging directly into a stream, lake, pond, reservoir, or other surface water. Water bodies used solely for treating, transporting, or impounding pollutants shall not be considered surface water. [ARM 17.30.602(31)]

[3] "Ephemeral stream" means a stream or part of a stream which flows only in direct response to precipitation in the immediate watershed or in response to the melting of a cover of snow and ice and whose channel bottom is always above the local water table. ARM 17.30.602(10).

> *"Waters classified C-3 are to be maintained suitable for bathing, swimming, and recreation, and growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl, and furbearers. The quality of these waters is naturally marginal for drinking, culinary, and food processing purposes, agriculture, and industrial water supply."*

While beneficial uses have been established for C-3 waters, natural water quality and quantity in the Bull Mountains may change annually and seasonally in response to changes in geochemical and climatic conditions. 'Naturally marginal' C-3 waters may become unsuitable under a variety of conditions, both in the short and long term, making support of C-3 beneficial uses naturally dependent.

Numeric standards applicable to C-3 waters include the water quality standards in Circular DEQ-7.The criteria presented in DEQ-7 include numeric standards for the protection of human health (Human Health Standards), and aquatic life (Acute and Chronic Aquatic Life Standards). In addition to the numeric water quality standards established Circular DEQ-7, Circular DEQ-12A establishes numeric nutrient (nitrogen and phosphorus) standards for the protection of recreational (bathing, swimming and recreation) and aquatic life uses for wadeable streams. The standards established in DEQ-12A apply only to wadeable intermittent and perennial streams, and not to spring pools, ponds, or other water resources where a flowing channel is not present. With the exception of short reaches below a few springs that may support flow for some portions of the year, Circular DEQ-12A standards do not typically apply to springs in the Bull Mountains as they do not produce a wadeable flow.

Criteria for evaluation of support of human drinking water uses include the DEQ-7 human health standards in **Table 2-1**, and guidelines for drinking water in **Table 2-2**, as well as the availability of water in sufficient quantity to support the use. The human health standards in DEQ-7 are enforceable limits which cannot be exceeded. A violation of a DEQ-7 water quality standard outside the mine permit area as a result of the proposed mining operations in AM3 would constitute material damage. The guidelines in **Table 2-2** are not enforceable standards, but are used by DEQ in evaluating the suitability of pre- and postmine water quality for human use. Values based on health effects, such as the World Health Organization (WHO) Guideline Values and Maximum Contaminant Level Goals (MCLGs) are more critical for supporting human use than those based on aesthetic properties, such as WHO Acceptability Aspects and National Secondary Drinking Water Regulations (NSDWRs). The criteria for support of human drinking water use are also considered protective of culinary and food processing uses because the most restrictive requirements for these uses would be for water which comes in contact with food to be consumed by humans.

Criteria for evaluation of surface water support of livestock drinking water use include the water quality guidelines established for livestock use are shown in **Table 2-3**, and the availability of water in sufficient quantity to support the use. The limits are not enforceable standards but are used by DEQ for guidance in evaluating suitability of pre and postmine water quality for livestock use. These guidelines are considered to be pertinent credible information for evaluation of compliance with the narrative standards in ARM 17.30.1006. However, an exceedance of these guidelines does not constitute a violation of a water quality standard for purposes of making a material damage determination outside the permitted area, unless such exceedance were to result in the degradation or reduction of water quality outside the permitted area such that the beneficial use of drinking water for livestock and wildlife is adversely affected. The guidelines in **Table 2-3** represent values established from a variety of scientific studies and include both "threshold" and "upper" limits to accommodate uncertainty in scientific studies of toxicity in animals, the variety of species of livestock, and variability in other sources of these parameters in the livestock's diets. Threshold limits represent the values which below there are expected to be no adverse effects. Upper limits represent the concentration above which harmful effects have been documented to occur. Between the two limits adverse effects may or may not occur, and may or may not be considered harmful, depending on the specific details unique to the situation. Even above the upper limit, harmful effects are not guaranteed or even necessarily likely to occur. The criteria for livestock drinking water use are considered protective of wildlife drinking water use because wildlife are typically more adapted to naturally variable water quality than domesticated animals.

The criteria for evaluation of surface water support for irrigation use include the guidelines in **Table 2-4**, and the availability of water in sufficient quantity to support the use. The limits are not enforceable standards but are used by DEQ for guidance in evaluating suitability of pre and postmine water quality for irrigation use. The guidelines in **Table 2-4** represent values established from a variety of scientific studies and are considered to be pertinent credible information for evaluation of compliance with the narrative standards in ARM 17.30.1006. However, an exceedance of these guidelines does not constitute a violation of a water quality standard for purposes of making a material damage determination outside the permitted area, unless such exceedance were to result in the degradation or reduction of water quality outside the permitted area such that the beneficial use of irrigation of some agricultural crops is adversely affected. The guidelines in **Table 2-4** include both "threshold" and "upper" limits to accommodate uncertainty in scientific studies of toxicity in plants, the variety of species of crops, and variability in soil physical properties and chemistry. Threshold limits represent the values which below there are expected to be no adverse effects. Upper limits represent the concentration above which harmful effects have been documented to occur. Between the two limits adverse effects may or may not occur, and may or may not be considered harmful, depending on the specific details unique to the situation. Even above the upper limit, harmful effects are not guaranteed or even necessarily likely to occur.

No specific criteria have been established for the evaluation of the suitability of water for industrial and commercial uses. The water quality requirements for industrial and commercial uses are variable and dependent on the specific use, and are typically less stringent than the criteria for the other uses listed above. Available water quantity is a significant consideration when evaluating the suitability of surface water for industrial and commercial uses, as these uses often require water in much greater quantities than other uses.

Data records demonstrate that drainages in the Bull Mountains are predominantly ephemeral, and in normal precipitation years, flow only in direct response to precipitation or snowmelt. However, even though ephemeral streams are not considered 'wadeable' streams, and ARM 17.30.637(4) provides that "*ephemeral streams are not subject to the specific water quality standards of ARM 17.30.620 through 17.30.629*," for purposes of this Assessment, DEQ has treated ephemeral streams as if they are subject to the numeric water quality standards established in Circular DEQ-7, the base numeric nutrient standards established in Circular DEQ-12A, and the specific water quality standards for waters classified as C-3 established in ARM 17.30.629. In addition, DEQ has applied the General Prohibitions contained in ARM 17.30.637 to all C-3 surface waters, including ephemeral streams, located inside and outside the AM3 permit area. The General Prohibitions contained in ARM 17.30.637 are as follows:

> *"State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:*

(a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines;
(b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter), or globules of grease or other floating materials;
(c) produce odors, colors, or other conditions as to which create a nuisance or render undesirable tastes to fish flesh or make fish inedible;
(d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant, or aquatic life; and
(e) create conditions which produce undesirable aquatic life."

Several springs and stock ponds within the permit area maintain water several months a year and are not considered ephemeral. According to the definition of 'surface waters', these waters are considered 'state waters' and subject to the applicable water quality standards of C-3 waters. Most springs in the Bull Mountains generally do not provide surface flow, nor do they maintain water quantity necessary to support most of the beneficial uses of C-3 waters. Stock ponds in the area are typically developed from these small seeps and springs (i.e. dug out or piped to a tank) for the specific purpose of providing livestock watering.

The most productive springs within the permit area (17415 Litsky Spring, 14325 Busse Water Spring, 17145 Bull Spring, 16655 Coldwater Spring, 17165 Turtle Pond, 53505) are built and maintained for the purpose of stock watering, and support livestock land use in the Bull Mountains. Some springs maintain water quality sufficient to support other C-3 uses; however spring flows are typically not reliable enough to provide sufficient water volumes to support most beneficial uses.

Impacts to surface water supply and water rights are evaluated with respect to regional and local impacts to surface water resources and natural variations in seasonal and yearly runoff. Mitigation for the loss of a beneficial use of surface water or a water right requires provision of a dependable, long-term replacement water resource of acceptable quality for the designated use and adequate quantity to support the existing and/or planned future use [ARM 17.24.314(1)(c) and 17.24.648].

Material damage criteria are therefore a combination of applicable narrative standards, numeric standards, and beneficial use criteria. Impacts to surface water rights are evaluated on a case-by-case basis, and include an analysis of climatic conditions and the natural availability of surface water.

2.1.2 Groundwater Material Damage Criteria

Groundwater material damage occurs when, because of the mining operations, any of the following criteria are met:

- Groundwater quality standards outside of the permit area are violated;
- Beneficial uses of groundwater outside of the permit area are affected to an extent that is harmful, detrimental, or injurious to a use; or
- A groundwater right outside the permit area is adversely impacted.

Protection of groundwater quality for beneficial uses is based on narrative standards set forth in ARM 17.30.1006 and numeric standards for individual parameters in Circular DEQ-7. The groundwater classes defined in ARM 17.30.1006 determine which standards apply. Beneficial uses listed by ARM 17.30.1006 for each groundwater class are shown in **Table 2-5**. DEQ-7 numeric groundwater standards are human health standards. Numeric standards for parameters monitored by the mines are listed in **Table 2-1**.

Groundwater in the Bull Mountains area exhibits a locally variable natural specific conductance that spans Class I, Class II, and Class III, with Class II and Class III most common. For all groundwater classes present in the Bull Mountains DEQ-7 numeric human health standards apply, and for parameters for which human health standards for groundwater are not listed in DEQ-7, there is to be no increase of a parameter to a level that renders the waters harmful, detrimental, or injurious to the beneficial uses listed for the class (ARM 17.30.1006).

Listed beneficial uses for groundwater fall into four main categories:

- Human drinking water (public and private water supplies, drinking, culinary/food processing);
- Animal drinking water (drinking water for livestock and wildlife);
- Irrigation (both natural subirrigation and water pumped from wells); or
- Commercial/industrial uses.

Criteria for evaluation of groundwater support of human drinking water uses include the DEQ-7 human health standards in **Table 2-1**, and guidelines for drinking water in **Table 2-2**, as well as the availability of water in sufficient quantity to support the use. The human health standards in DEQ-7 are enforceable limits which cannot be exceeded. The guidelines in **Table 2-2** are not enforceable standards, but are used by DEQ in evaluating the suitability of pre and postmine groundwater quality for human use. These guidelines are considered to be pertinent credible information for evaluation of compliance with the narrative standards in ARM.17.30.1006. Values based on health effects (WHO Guideline Values and MCLGs) are more critical for supporting human use than those based on aesthetic properties (WHO Acceptability Aspects and NSDWRs). The criteria for support of human drinking water use are also considered protective of culinary and food processing uses because the most restrictive requirements for these uses would be for water which comes in contact with food to be consumed by humans.

Criteria for evaluation of groundwater support of livestock drinking water use include the water quality guidelines established for livestock use are shown in **Table 2-3**, and the availability of water in sufficient quantity to support the use. The limits are not enforceable standards but are used by DEQ for guidance in evaluating suitability of pre and post-mine water quality for livestock use. These guidelines are considered to be pertinent credible information for evaluation of compliance with the narrative standards in ARM.17.30.1006. The guidelines in **Table 2-3** include both “threshold” and “upper” limits to accommodate uncertainty in scientific studies of toxicity in animals, the variety of species of livestock, and variability in other sources of these parameters in the livestock’s diets. Threshold limits represent the values which below there are expected to be no adverse effects. Upper limits represent the concentration above which harmful effects have been documented to occur. Between the two limits adverse effects may or may not occur, and may or may not be considered harmful, depending on the specific details unique to the situation. Even above the upper limit, harmful effects are not guaranteed or even necessarily likely to occur. The criteria for livestock drinking water use are considered protective of wildlife drinking water use because wildlife are typically more adapted to naturally variable water quality than domesticated animals.

The criteria for evaluation of groundwater support for irrigation use include the guidelines in **Table 2-4**, and the availability of water in sufficient quantity to support the use. The limits are not enforceable standards but are used by DEQ for guidance in evaluating suitability of pre and postmine water quality for irrigation use. These guidelines are considered to be pertinent credible information for evaluation of compliance with the narrative standards in ARM.17.30.1006. The guidelines in **Table 2-4** include both “threshold” and “upper” limits to accommodate uncertainty in scientific studies of toxicity in plants, the variety of species of crops, and variability in soil physical properties and chemistry. Threshold limits represent the values which below there are expected to be no adverse effects. Upper limits represent the concentration above which harmful effects have been documented to occur. Between the two limits adverse effects may or may not occur, and may or may not be considered harmful, depending on the specific details unique to the situation. Even above the upper limit, harmful effects are not guaranteed or even necessarily likely to occur.

No specific criteria have been established for the evaluation of the suitability of water for industrial and commercial uses. The water quality requirements for industrial and commercial uses are variable and dependent on the specific use, and are typically less stringent than the criteria for the other uses listed above. Available water quantity is a significant consideration when evaluating the suitability of groundwater for industrial and commercial uses, as these uses often require water in much greater quantities than other uses.

Water levels and water quality are monitored inside and outside the permit boundary to establish baseline conditions and measure subsequent changes during and after mining. Analytical results of water quality parameters most likely to be affected by mining are compared to standards and guidelines to determine suitability of the water for beneficial uses. Groundwater level decline outside the permit boundary must not impact a use to the extent that groundwater supply for the use is no longer adequate.

2.1.3 Nondegradation of Water Quality

Montana’s nondegradation policy is codified at Title 75, Chapter 5, Part 3, MCA, and implemented in the ARM Title 17, Chapter 30, Subchapter 7. All state waters are subject to Tier 1 nondegradation policy, which means that existing and anticipated uses and the water quality necessary to protect those uses must be maintained and protected. See ARM 17.30.705(2)(a). Authorization is required to degrade any high quality water per ARM 17.30.705(2)(b). An authorization to degrade follows a detailed process described in Section 75-5-301(5)(c), MCA and the supporting administrative rules. As stated in Section 75-5-303(3)(c), MCA, existing and anticipated uses must be protected even when an authorization to degrade is issued.

The material damage determination in the context of permit review is a design review function [see Section 82-4-227(3)(a), MCA] that is not intended to serve as a groundwater discharge permit or an authorization to degrade. The process for authorization to degrade is not appropriate during MSUMRA permit review absent objective evidence of a discrete, quantifiable, potential point-source discharge to be evaluated. See ARM 17.30.707 and 708. At such time as of a discrete, quantifiable, potential point-source discharge outside the permit area is indicated, the process for an authorization to degrade may be warranted. Accordingly the parameters of concern for potential point-source discharges to surface and groundwater are subject to narrative standards for salinity which permit changes to water quality that do not have a measurable effect on an existing or anticipated use or cause measurable changes in aquatic life or ecological integrity. See ARM 17.30.715(1)(h).

Section 75-5-317, MCA, establishes categories and classes of activities that cause nonsignificant changes in water quality, and are therefore exempt from the nondegradation provisions. These activities include, in pertinent part:

> *“(2)(a) existing activities that are nonpoint sources of pollution as of April 29, 1993;*
> *(2)(b) activities that are nonpoint sources of pollution initiated after April 29, 1993, when reasonable land, soil, and water conservation practices are applied and existing and anticipated beneficial uses will be fully protected;”*

The definition of point source is found in Section 75-5-103(29), MCA:

> *‘"Point source" means a discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, or vessel or other floating craft, from which pollutants are or may be discharged.”*

The term “nonpoint source" means “a diffuse source of pollutants resulting from the activities of man over a relatively large area, the effects of which normally must be addressed or controlled by a management or conservation practice.” ARM 17.30.702(18). New source discharges to groundwater from mineralized spoil recharge water are exempt from the nondegradation policy under Section 75-5-317(2)(b), MCA, “when reasonable land, soil, and water conservation practices are applied and existing and anticipated beneficial uses will be fully protected.” "Reasonable land, soil, and water conservation practices" in turn means:

> *“[M]ethods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include, but are not limited to, structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities. “*

ARM 17.30.602(23). Nonpoint source discharges by mineralized mine spoil or gob water qualify for nonsignificance status because the mine operation applies "reasonable land, soil, and water conservation practices” that include measures to protect present and reasonably anticipated beneficial uses of groundwater such as underground mine seals, mine design, contouring spoil backfill to approximate premine topography including drainage morphology and density, revegetation of disturbed soil, drainage control and impoundments which detain surface runoff or for sediment control and management of runoff water. See ARM 17.30.602(23).

The protection of existing uses of state waters is honored by MSUMRA’s protection of water rights and private wells from mining impacts [ARM 17.24.314(1)(b)]. MSUMRA and attending administrative rules also require implementation of reasonable land, soil and water conservation practices [e.g. ARM 17.24.314(1)(a); ARM 17.24.314(2)(a) and (b); ARM 17.24.701(1) and (3); and Section 82-4-231(1), MCA].

Point sources for surface waters at the Bull Mountains Mine No. 1 comply with the nondegradation rules through their MPDES permit. See ARM 17.30.629(2)(i). Protection from point source pollution is ensured by the MPDES discharge permit.

Although the mine void a nonpoint source of spoil or gob water subject to reasonable land, soil, and water conservation practices imposed by MSUMRA and rules adopted under it, the Department is analyzing the potential for changes in salinity from spoil or gob water migration under ARM 17.30.715(1)(g) and (2) because of previous Board of Environmental Review action. In its January 14, 2016, Findings of Fact, Conclusions of Law, and Order regarding the previous CHIA for AM3, the Board found that the CHIA was deficient because the Department did not determine whether changes in salinity would have a measurable effect on existing or anticipated uses and because the Department did not consider the discretionary factors in ARM 17.30,715(2), including specifically the length of time that degraded water will continue to migrate from the mine. These issues are addressed in **Sections 9.2.6.3**, **9.2.6.4**, **9.2.6.5**, **9.2.6.6**, **9.2.7**, **10.1.2**, and **10.1.3**.

2.2 CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT

The CHIA is informed by an assessment of the Probable Hydrologic Consequences[4] (PHC) of the proposed operation that is submitted by the operator with the permit application (Nicklin, 2016[1]).The PHC is prepared by the applicant [ARM 17.24.314(3)] and must be approved by the regulatory authority (DEQ). Prior to making a permitting decision, DEQ makes an assessment of the cumulative hydrologic impacts[5] (this CHIA) to the hydrologic balance as a result of the proposed mining operation, including all previous, existing, or anticipated mining that may cumulatively impact surface and groundwater systems. The CHIA must determine whether the proposed operation has been designed to minimize impacts to the hydrologic balance on and off the permit area and prevent material damage outside the permit area [ARM 17.24.314(5)].

CHIA development involves the analysis of critical aspects of the hydrologic system within a defined cumulative impact area (CIA) to predict the type and magnitude of impacts to the hydrologic system from previous, existing, and anticipated mining. The CHIA process includes the following: 1) develop criteria for evaluating impacts to the hydrologic system, 2) define the cumulative hydrologic impact area[6]3) describe the hydrologic system, the baseline values, and natural variability, 4) identify hydrologic resources likely to be affected, 5) estimate the impacts of mining on hydrologic resources, and 6) make a material damage determination and prepare a statement of findings.

[4] "Probable hydrologic consequences" means the projected results of proposed strip or underground mining operations that may reasonably be expected to alter, interrupt, or otherwise affect the hydrologic balance. The consequences may include, but are not limited to, effects on stream channel conditions and the aquatic habitat on the permit area and adjacent areas.

[5] "Cumulative hydrologic impacts" means the expected total qualitative and quantitative, direct and indirect effects of mining and reclamation operations on the hydrologic balance.

[6]"Cumulative hydrologic impact area" means the area, including, but not limited to, the permit and mine plan area within which impacts to the hydrologic balance resulting from the proposed operation may interact with the impacts of all previous, existing and anticipated mining on surface and ground water systems. "Anticipated mining" includes, at a minimum, the entire projected lives through bond release of all operations with pending applications and all operations required to meet diligent development requirements for leased federal coal for which there is actual mine-development information available. ARM 17.24.301(32).

3.0 PROPOSED PERMITTING ACTION

Bull Mountain Mine No. 1 (**Figure 3-1**) is approximately 15 miles southeast of Roundup, Montana in Musselshell and Yellowstone counties and is the only currently permitted coal mine in the Bull Mountains, and Montana's only active underground coal mine. Signal Peak Energy, LLC (SPE) submitted Permit Amendment Application No. 3 that would increase the mine permit area of Bull Mountain Mine No. 1 by adding 7,161 acres and expanding the mine from five longwall panels (approved under Amendment 2) to fourteen longwall panels (**Figure 3-2**). This area is included in 18 Sections within Township 6 North, Range 27 East.

The proposed plan includes room and pillar mining to develop nine additional panels for longwall mining. If approved, AM3 would extend the permit boundary toward the northeast and increase the permit area by 7,161 acres for a total area of 14,896 acres. Total acreage of the underground mine plan would be 10,569 acres. Approval of AM3 would increase the potential area of the ground surface (directly above the panels and within the angle of draw) to be affected by subsidence caused by mining.

Approximately 20 acres of additional surface disturbance is expected as a result of AM3. This amount of additional disturbance is necessary to construct temporary surface facilities that support underground mining. Temporary surface support facilities include boreholes, associated pads, power lines, and roads. No significant changes to the reclamation plan are proposed since AM3 only addresses expansion of the permit area to allow continuation of underground mining. Plans for the mitigation of impacts to springs, seeps and drainages are included in SMP C1993017. Site-specific plans for the repair or mitigation of impacts related to subsidence or other mining impacts will be developed as they are identified, in consultation with DEQ and affected landowners.

If approved, AM3 would add approximately 176 million tons of in-place coal reserves or 110 million tons of mineable coal. Of this, approximately 83 percent would be recoverable (91 million tons of coal).

3.1 BACKGROUND & MINING HISTORY

Coal fields in the area extend from the Bull Mountains to just north of Roundup and the Musselshell River. Mining in the greater region began in the early 1880's, and commercial mining was underway by about 1906. Coal was shipped to smelters and used as a source of fuel for the railroads (Slagle et al, 1986). All of the mines near the town of Roundup were abandoned by 1956. By the mid-1980's, the last few mines operating in the coal field were located south of Roundup in the Bull Mountains and included the PM Mine, the Divide mine, and the Storm King Mine (Slagle et al, 1986) (**Figure 3-3**). These mines mined the Mammoth coal seam underlying the Bull Mountains that is approximately 10 feet to 15 feet in thickness.

The largest mines were the Divide (or Carlson) mine and the adjacent Gildroy mine, each with about 70 to 80 acres of underground room and pillar mining. These mines are approximately 1.5 miles south of the Bull Mountains Mine No. 1 portals area and extracted Mammoth coal. Two mines, the PM Mine and Meridian Test Pit (**Figure 3-3**), are the predecessors of Bull Mountains Mine No. 1. The PM Mine included 51 acres of room and pillar mining. The Meridian test pit included 90 acres of strip mining that were reclaimed upon completion of mining. The PM Mine was operated as an underground coal mine in the 1930's that was converted to a surface mine in 1972 by the Maged Family. In 1989 Meridian Minerals Company (Meridian) opened the Meridian Test Pit surface mine to the southeast. P.M. Coal

Company then reopened the underground mine in 1991. The Meridian Test Pit surface mine and the underground mine combined were termed the Bull Mountains Mine. The remaining mines in the area were all much smaller underground operations that used room and pillar or other simple mining techniques and have been abandoned. The majority of mines are located where the Mammoth coal crops out at the surface, and it is the coal seam that was most likely mined.

3.2 Current Mining Operations

Bull Mountains Mine No. 1 is permitted under SMP C1993017. SMP C1993017 was originally issued to Meridian Minerals on October 15, 1993, transferred to Glacier Park Company on September 25, 1995, transferred to Mountain Inc., on November 20, 1995, and to BMP Investments, Inc. (BMPII) on July 2, 2002. BMPII was renamed Bull Mountain Coal Mining (BMCM), Inc. on December 13, 2006 and the permit was transferred to SPE on September 15, 2008. In addition to SMP C1993017, SPE also holds coal prospecting permits in both Musselshell (X2012338) and Yellowstone (X2013342) counties.

The surface facilities of Bull Mountains Mine No. 1 are located in PM Draw and consist of the mine offices, shop, parking areas, equipment storage areas, water management facilities, coal stockpile areas, coal processing and loading facilities, the railroad loop, and the portals to the underground mine.

Coal at Bull Mountains Mine No. 1 is recovered using continuous mining and longwall mining methods. Continuous mining includes cutting parallel entries approximately eight to 10 feet high by about 20 feet wide intersected by regularly spaced tunnels or crosscuts. Pillars or unmined areas between the entries and crosscuts are the primary supports of the mine. This method of mining is known as “room-and-pillar mining” and is used primarily for developing entries necessary for transportation, ventilation, utilities, and providing access to longwall panels.

Longwall mining requires a significant amount of up-front preparation, or “development” using continuous mining methods. In order to supply power, water, air, and safe transportation corridors to the longwall panels, a set of five to eight parallel entries must be established. These main entries, or “mains,” are designed to remain intact for the life of the mine, and allow access to the longwall panels via “gate roads”. Gate roads are driven roughly perpendicular to the mains, and consist of three parallel entries. Besides providing worker access to the longwall panels, gate roads are vital for the installation of longwall equipment, ventilation of the working area, and transportation. Once gate roads have been developed around a panel, the longwall equipment can be installed.

Longwall mining is a method that removes all coal from each longwall panel, effectively achieving 100 percent coal extraction, and causes surface subsidence. Longwall mining uses a series of hydraulic supports, or “shields”, set up along the longwall face that function as temporary supports to protect workers and equipment. A cutting machine, or “shearer”, moves back and forth along the coal face and line of shields, cutting the coal in a series of passes. After the shearer completes a pass the entire system (shields, shearer, and face conveyor) advances (perpendicular to the shearer) and unsupported overburden is allowed to collapse into the void formally occupied by coal.

At full production SPE is capable of mining longwall panels at a rate of 11,000,000 tons of raw coal per year. This is equivalent to the longwall face advancing approximately 55 feet per day. However, actual production rates are expected to be less. Panels must be mined in sequential order to achieve maximum coal recovery. Each gate road is designed to stay open for the first panel, but yield as the adjacent panel is mined-out, thus mining out of sequence would limit access to some panels and limit coal conservation.

After the coal is extracted by either continuous mining or longwall methods it is conveyed to the surface via the gate roads and mains and processed at the mine's surface facilities in preparation for shipment off-site by train. This processing consists of crushing and washing the coal to remove coal fines and non-combustible materials, such as sandstone and shale. These reject materials, known as coal processing waste (CPW), are disposed of in an on-site waste disposal area (WDA1) located adjacent to the mine surface facilities (**Figure 3-4**). In the WDA the CPW is spread and compacted to achieve optimal density and reduce infiltration of water. When the WDA is filled to its permitted capacity it will be capped, soiled, and planted with approved vegetation in accordance with permit requirements.

Coal prospecting consists of drilling boreholes to identify and sample potentially minable coal seams. Disturbance from prospecting activities is minimal and consists of access roads and drill pads. After the completion of drilling, all boreholes are sealed and all disturbances are reclaimed.

3.3 Anticipated Mining

No additional coal extraction is anticipated beyond that proposed in AM3, however, SPE has submitted an application for a permit revision to construct an additional waste disposal area (WDA2). This application has been determined to be a major revision by DEQ, and designated as Major Revision 3 (TR3). If TR3 is permitted, WDA2 would be located east of WDA1, as shown in **Figure 3-4**. The operations and closure of WDA2 would be similar to that of WDA1. Likewise, the natural and operational processes acting on WDA2 would be similar, resulting in similar impacts to the environment. At the time of preparation of this CHIA, the TR3 application has not been determined acceptable, precluding a detailed evaluation of all potential impacts from the construction, operation, and maintenance of proposed WDA2. However, it is not anticipated that the effects of mining activities proposed under AM3 would interact with the effects of the proposed actions in TR3.

4.0 REGIONAL OVERVIEW

The permit and proposed amendment area of Bull Mountains Mine No. 1 is located in the Bull Mountains in central Montana, within the Northwestern Great Plains Level IV ecoregion (**Figure 4-1**). The Bull Mountains lie within the drainage basins of the Yellowstone River and the Musselshell River. The lands to the north of the Bull Mountains drain to the Musselshell River while the lands to the south drain to the Yellowstone River. The majority of the proposed permit amendment area is located within the Rehder Creek and Fattig Creek drainages, which are tributaries of the Musselshell River.

Differential erosion of rocks of varying hardness and resistance is the main process active in forming the present landscape. The underlying rocks are composed of interbedded shales, claystones, siltstones, coals, and sandstones; however, the high mesas and ridges are capped by "clinker". Clinker is a term used to describe the baked sedimentary rocks resulting from burning of underlying coal beds. The shales and claystones tend to be easily eroded, while the sandstone and clinker are more resistant to erosion. Sheet and rill erosion are active geomorphic processes in the upper drainage basins, and mass wasting occurs locally along the steep-walled ridges. Ephemeral streams occur throughout the area; intermittent flow has been observed along limited portions of the streams supported by springs or seeps associated with groundwater base flow.

Vegetation in the Bull Mountains Mine No. 1 study area includes silver sagebrush-mixed grasslands, mixed grasslands, ponderosa pine-mixed grassland, burned ponderosa pine-mixed grassland, and relatively small areas of improved pasture and wetlands. In 1984 an intense fire burned much of the forest leaving many scattered charred logs and dead trees. Currently the burned area is dominated by grasses.

4.1 CLIMATE

The climate of south central Montana is classified as semiarid continental. Precipitation and temperature measurements have been collected at the mine and also at the nearby climate stations at Roundup, Montana (National Weather Service Cooperative Observer ID 247214) and Billings, Montana (National Weather Service Cooperative Observer ID 240807). Climate data are available from the Western Regional Climate Center (WRCC, 2016) with temperature and precipitation records for Roundup and Billings going back to 1914 and 1948, respectively.

Figure 4-2 shows average precipitation data from the past 30 years at Roundup and Billings, Montana. The average annual precipitation (1983-2012) at Roundup (elevation 3,230 ft) is 13.58 inches and Billings (elevation 3,570 ft) is 13.36 inches. The average peak precipitation month is June at Roundup (2.53 inches) and May at Billings (2.21 inches), while the average minimum monthly precipitation occurs in January at Roundup (0.37 inches) and December at Billings (0.46 inches).

A weather station has also been monitored at the Bull Mountains Mine office since2010. Comparison of the limited period of record at the mine to the Billings and Roundup climate stations indicates average precipitation is similar at the mine as in Roundup or Billings, although the specific timing and intensity of individual storms varies between all three climate stations.

4.2 TOPOGRAPHY

The topography in the mine area consists of gently sloping valleys bounded by moderately steep to very steep ridges capped by isolated sandstone and clinker mesas. Elevations range from approximately 3,700 to 4,700 feet above mean sea level. Surface slopes vary from zero to 15 percent in the vicinity of the proposed surface facilities and up to 50 percent or more in the higher elevations of the Bull Mountains.

4.3 GEOLOGY

Alluvial deposits (gravel, sand, and silt) are generally unconsolidated and typically occur in ephemeral drainages or areas of lower elevation in the stream and valley bottom areas. Alluvial deposits are generally less than 40 feet in thickness.

The Bull Mountain region and vicinity is underlain by a sequence of sedimentary rocks that comprise the Bull Mountain Basin. This sequence of rocks is comprised of an alternating sequence of sandstones, siltstones, shales, carbonates, clinker, and coal approximately 12,000 feet in thickness that range from early Paleozoic to Tertiary in age. The basin is underlain by Precambrian metamorphic basement rocks (Wheaton, 1992). The sedimentary sequence was deposited or formed in a single depositional center of the Powder River Basin but is now isolated or separated from the main basin due to post-depositional tectonics and erosion.

Tertiary age continental rocks of the Tongue River Member of the Fort Union Formation are the principal rock units disturbed by longwall mining at the Bull Mountains Mine No. 1. Rocks of the Tongue River Member consist of interbedded siltstones, sandstones, shales and coals and form the bedrock under the mine area where they extend to depths in the range of about 1,100 feet below the base of the Mammoth coal. **Figure 4-3** illustrates the general geologic relationships in the region. **Figure 4-4** shows a detailed lithologic column for the Bull Mountains prepared by Meridian in 1990. It represents about 1,250 feet of the uppermost portion of the Tongue River Member occurring at Bull Mountains. Rocks of the Tongue River Member are situated in a broad (approximately 10 miles) and relatively long (axial trace of approximately 15 miles) north-northwest plunging syncline (less than one degree) that includes the Mammoth coal. This area includes approximately 150 square miles.

A general description of the shallow stratigraphy of the Tongue River Member includes:

- Overburden rocks include interbedded siltstones, sandstones, shales, clinker, and coal above the Mammoth coal. These rocks thicken toward the north-northwest or along the plunge of the syncline and range from approximately 200 feet to over 800 feet in thickness. Clinker, a reddish-brown, commonly brecciated pyro-metamorphic rock formed by prehistoric coal fires, occurs throughout the study area and commonly caps ridges or areas of higher elevation.
- The Mammoth coal lies immediately below overburden rocks. This coal seam is the principal economic seam in the area and varies in thickness from eight to ten feet within the permit boundary.
- Underburden rocks are similar to rocks of the overburden and are divided into the upper underburden (immediately below the base of the Mammoth coal) and deeper underburden.

5.0 CUMULATIVE IMPACT AREA

A cumulative hydrologic impact area (CIA) is defined by ARM 17.24.301(32):

> *‘"Cumulative hydrologic impact area" means the area, including, but not limited to, the permit and mine plan area within which impacts to the hydrologic balance resulting from the proposed operation may interact with the impacts of all previous, existing and anticipated mining on surface and ground water systems’." Anticipated mining" includes, at a minimum, the entire projected lives through bond release of all operations with pending applications and all operations required to meet diligent development requirements for leased federal coal for which there is actual mine-development information available.’*

The size and location of a given CIA depends on the surface water and groundwater system characteristics, the hydrologic resources of concern, and the extent of the interaction between projected impacts from the proposed mining operation, with the impacts from all previous, existing and anticipated mining operations included in the assessment. Since the CIA cannot be accurately delineated until representative hydrologic parameters have been monitored at numerous sites over the total time period during which impacts from mining occur, DEQ estimates the size, shape and location of the CIA for surface and groundwater on a map, which becomes the working CIA. The surface water CIA and a groundwater CIA are delineated separately to assess impacts associated within these distinct hydrologic resource areas. DEQ’s assessment includes only those impacts from previous, existing, and anticipated mining operations located within the CIA that may interact with impacts from the proposed mining operation in AM3. The estimated size and location of the surface water CIA and groundwater CIA are described in more detail below.

5.1 SURFACE WATER CUMULATIVE IMPACT AREA

The surface water CIA includes all areas that may see a measurable change in water quantity or water quality due to mining activities at the Bull Mountains Mine No. 1. The surface water CIA is presented in **Figure 5-1**. The CIA extends beyond the proposed AM3 boundary and includes Rehder Creek to its confluence with Halfbreed Creek, and Fattig Creek to stream monitoring station 52996, both of which flow north to the Musselshell River. The CIA extends southward to include a number of named and unnamed ephemeral watercourses that flow south from the Bull Mountains to the Yellowstone River. CIA boundaries were established to allow evaluation of any potential impacts to surface waters that could reasonably be affected by the proposed operation or affect any previous, existing, and future mining operations. The CIA boundaries are established down gradient from potentially affected streams and springs, and include surface water monitoring stations to allow assessment of impacts to stream water quality and quantity. Likewise, the CIA extends southward to include springs and ephemeral stream channels that could potentially be affected by subsidence-related changes in hydrology as Dunn Mountain and the southern portions of the permit area are undermined. The surface water CIA boundary includes those areas where runoff from mining operations, or changes in water supply could be impacted by mining operations.

5.2 GROUNDWATER CUMULATIVE IMPACT AREA

The groundwater CIA boundary is based on the anticipated or potential extent of impacts to groundwater affected by mining based on the hydrology of the mine area. Potential impacts to groundwater include changes to water level or water quality.

The groundwater CIA is presented in **Figure 5-2**. This area is drawn to include mining-induced groundwater impacts from drawdown of the Mammoth coal and underburden aquifers, as well as impacts upon shallow aquifers (alluvium and shallow fractured bedrock) from operations (ponds, conveyors, storage areas including fueling and laydown areas) within the facilities area, and impacts from the WDAs. Water storage areas or ponds, pipelines, conveyors, fuel and other storage areas including the WDAs have the potential to affect the shallow groundwater system of Rehder Creek and its tributaries such as PM Draw. Also, any measureable mining-induced water quality impacts are expected to be contained within the CIA.

Results of the transient flow model (Nicklin, 2016[2]) indicate that drawdown in the upper underburden and Mammoth coal aquifers immediately after the cessation of mining would extend approximately three miles down gradient of the permit boundary to the northwest and generally extend to the outcrop of the Mammoth coal in the cross and up gradient directions (**Figure 5-2**).

The groundwater CIA includes a buffer area around the modeled upper underburden five-foot drawdown contour and is also extended around the facilities area. The modeled drawdown for the upper underburden is used to define the CIA instead of the drawdown for the Mammoth coal because drawdown in the upper underburden has a greater areal extent.

6.0 MONITORING PROGRAM

Surface water and groundwater monitoring programs are required to meet mine permit obligations pursuant to ARM 17.24.314, ARM 17.24.645 and 17.24.646. Monitoring results from the Bull Mountains Mine No. 1 are the basis for assessment of mining impacts on water resources. The monitoring plan has been designed to collect water quantity and quality information in order to address the questions: 1) To what extent are impacts to the hydrologic balance occurring on or off the permit area as a result of mining operations?; and 2) Is material damage occurring as a result of mining operations?

The monitoring plan identifies site locations, hydrogeologic units monitored, sampling frequency, and parameters. Quality assurance is an integral part of sampling and analytical requirements. As mining proceeds or the potential for additional impacts are recognized, the monitoring plan is revised to accommodate changes, including replacement of monitoring sites or development of new sites. The monitoring plan was last revised and updated in 2015. Monitoring is required to continue through the final phase of bond release.

In addition to monitoring requirements issued under SMP C1993017, the Bull Mountains Mine No. 1 also monitors MPDES-regulated discharges from the facilities and waste disposal areas, as directed under MPDES Permit No. MT0028983. The Bull Mountains Mine No. 1 has eight outfalls under the MPDES Permit, of which six discharge to PM Draw and two discharge to Rehder Creek.

6.1 SURFACE WATER

Surface water monitoring began in 1989 with the original permit applicant, Meridian. Baseline surface water quality and quantity data were collected by Meridian from 1989 through 1991 as required by ARM 17.24.304. Meridian continued to collect surface water data until 1996 when the mine shut down. Monitoring resumed in 2003 when BMPII assumed the surface mining permit from Meridian. Currently SPE operates the mine and collects surface water monitoring data associated with streams, springs, and ponds in accordance with ARM 17.24.314 (SMP C1993017, Vol. 3, Section 314).

Stream flow is typically ephemeral in nature, with local spring inputs forming wet areas or short reaches of stream flow before infiltration into the alluvium. Flow from most springs is dependent upon precipitation and recharge of shallow perched aquifers that feed area springs and seeps, and typically result in variable flow conditions throughout the year.

Stream monitoring consists of the collection of water quality parameters and flow measurements at 11 established surface water monitoring stations within and outside of the permit area. Streams are sampled for a variety of field parameters, analytical constituents, peak flows, and instantaneous flows (**Table 6-1**). The stream monitoring network is shown in **Figure 6-1**.

Spring (spring and seep) monitoring consists of collection of water quality parameters and flow measurements at 81 established monitoring stations on and off the permit area. Springs are sampled for a variety of field parameters, analytical constituents, peak flows, and instantaneous flows (**Table 6-2**). The spring monitoring network is shown in **Figure 6-1**.

Pond monitoring consists of collection of field parameters at 16 established stock pond monitoring stations. Measurements are scheduled monthly at 13 ponds and semi-annually at three ponds.

Parameters associated with pond sampling are field parameters only, as included in **Table 6-2**. The pond monitoring network is shown in **Figure 6-1**.

6.2 GROUNDWATER

Meridian installed the majority of the wells in the original monitoring network at Bull Mountains Mine No. 1 between 1989 through 1991. A number of wells installed by the Montana Bureau of Mines and Geology (MBMG) as early as 1981 were incorporated into the monitoring network that included 110 monitoring wells by 1995. With the exception of MBMG wells and a few wells that were transferred to landowners, the Meridian monitoring wells were abandoned and reclaimed after the Bull Mountains Mine No. 1 closed in 1998.

In 2002 and 2003, BMPII constructed a new monitoring network for the Bull Mountains Mine No. 1. The new monitoring wells were designed and completed to monitor the same stratigraphic interval in the same general location as the former monitoring wells. In some cases, new well construction differed from construction of the former well due to different drilling conditions and other limitations or purposes. BMCM reinstated the frequency and type of groundwater monitoring specified in the Meridian permit document including water level measurements, water chemistry field parameters, and groundwater quality sampling and laboratory analyses. While data from the original set of wells can generally be compared with data from the new wells, differences in well construction or monitoring methods and techniques create problems that sometimes prevent direct comparison of water level and water quality data between the old and new monitoring networks.

Since 2003 several new monitoring wells have been installed to expand the existing groundwater monitoring network. Several monitoring wells which were damaged and no longer useable for monitoring have also been replaced. Throughout this CHIA, monitoring locations are referred to using the "BMP" well designation for the latest BMP well at a given location. Currently, there are 105 groundwater wells which are monitored: 44 alluvial, 25 overburden, 15 Mammoth coal, and 21 underburden (**Figure 6-2**).The existing groundwater monitoring wells and schedule are shown in **Table 6-3**. As overburden collapses into the void where Mammoth coal has been removed, future groundwater monitoring wells will be installed in the gob to monitor the quality and quantity of water as the gob resaturates.

7.0 BASELINE HYDROLOGIC CONDITIONS

The goals in establishment of baseline hydrologic conditions are to characterize the local hydrology, understand the regional hydrologic balance, and identify any water resource or water use that could be affected by the mining operation. Baseline data consists of data and information collected prior to mining influences and represents physical conditions that are unaffected by mining. As such, the data and discussion presented in this section represent hydrologic conditions that are unaffected by mining influences in the Bull Mountains.

The hydrologic and geologic data required to evaluate baseline hydrologic conditions, probable hydrologic consequences, and cumulative hydrologic impacts of mining was collected by the original permit applicant, Meridian, from 1989 to 1991 and submitted with the initial permit application, and are discussed in detail in SMP C1993017, Sections 17.24.304(1)(e) and (f).

Baseline hydrologic and geologic data of the permit area and adjacent area of potential hydrologic impact were collected from a number of sources including literature review, hydrogeologic field reconnaissance, static water level measurements, aquifer tests, groundwater and surface water sampling and well and spring inventories. Monitoring data were collected by Meridian, the Louisiana Land and Exploration Company (LL&E), Yellowstone Coal Company, the PM Mine, Consolidation Coal Company, the United States Geological Survey (USGS), MBMG, and the Mine Safety and Health Administration (MSHA).

Baseline monitoring in the area was begun by LL&E as early as 1980. MBMG began monitoring the area in 1981 with the installation of eight monitoring wells. During baseline monitoring between 1989 and 1991 by Meridian and MBMG, a total of 3,509 flow and water level measurements were taken, 614 water quality samples were collected, 59 aquifer tests were performed, and continuous flow data from three surface water sites and one spring were collected. In addition, narrative descriptions of surface drainage and channel characteristics were included in baseline water quality and quantity assessments.

Although the mining permit was originally issued to Meridian in the fall of 1993, substantial mining and disturbance at the mine site did not occur until mining by SPE began in 2008. Much of the data collected by BMPII and SPE from 2003 to 2008 may be considered baseline data for the purposes of impact assessment, and in many cases data collected from 2008 to present may also be considered baseline data where it was collected outside the area of mining influence (i.e. Fattig Creek drainage). DEQ has evaluated all data collected for the Bull Mountains Mine and determined which data can be used as baseline data. In this evaluation DEQ attempted to use a conservative approach in defining baseline data, such that in many cases data is excluded from consideration as baseline even when mining influences are unlikely. As a result of this approach it is highly unlikely that the baseline dataset includes any data which has been influenced by mining at the Bull Mountains Mine. DEQ also excluded data from the baseline dataset which showed obvious errors due to sample collection, analysis, or data processing. All baseline data is included in **Appendix A**.

7.1 SURFACE WATER BASELINE

Initial surface water baseline conditions were derived from a network of surface water monitoring stations (springs/seeps, streams, and stock ponds) established during initial permit development and include data predominantly from 1989 through 1996. Data collection resumed in 2003 with the onset of mining activities and continues presently. Much of the data collected after 2003 is also considered baseline data as it was collected prior to the influence of mining for most surface water monitoring stations.

For baseline analysis, surface water samples are broken into three categories: streams, ponds, and springs. Stream and pond water quality samples were chosen as representing baseline conditions if the sample was taken before mining related disturbance commenced upstream of the sampling location. Mining related disturbance included surface disturbances, such as the mine facilities, WDA, and support facility construction activities, as well as longwall undermining, which causes surface subsidence which may affect surface water.

Spring samples were chosen as representing baseline if no mining related disturbance had occurred to the source unit for the spring within one mile of the spring. One mile was chosen as it represents a conservative distance from which mining disturbance would have little or no effect on hydrologic conditions affecting springs.

For this analysis surface activities were considered to disturb the alluvium, longwall mining was considered to disturb all geologic units from the upper underburden to overburden unit one (including alluvium), and continuous miner mining was considered to disturb geologic units from the upper underburden to overburden unit six (not including alluvium). The one mile source area for springs was determined based on straight-line distance and only where the source unit was present.

As is common in the arid west, stock ponds are developed near spring resources and take advantage of natural spring flows to provide water for livestock use throughout the Bull Mountains. Developed springs typically consist of in-stream dugout stock ponds located adjacent to or downstream from spring/seep locations, or stock tanks fed by spring water piped from a sump constructed to collect spring water.

Within the CIA, many springs, seeps, and spring-fed stock ponds have been identified and monitored. The majority of springs in the Bull Mountains produce only small rates of flow (less than one gallon per minute) and many become dry for extended periods of time. Most springs respond to seasonal recharge, and may flow at a higher rate following periods of above average precipitation. In many cases, these springs and stock ponds provide a sufficient source of water to support livestock grazing and wildlife, but do not yield quantities of water that would support irrigated agriculture or other such intensive consumptive uses. In some cases where spring flows result in a short reach of flowing water below issue points, aquatic life may be supported. Some springs may produce water of sufficient quality to meet drinking water guidelines; however in most cases spring flows are not reliable enough to support domestic use.

7.1.1 Regional Drainage System

The region is drained by tributaries of the Musselshell and Yellowstone Rivers north and south of the permit area, respectively. Tributaries within and in the vicinity of the permit area that drain north to the Musselshell River include Fattig Creek, Rehder Creek, East Parrot Creek and Halfbreed Creek. Tributaries that drain south to the Yellowstone River include Pompey’s Pillar Creek, Railroad Creek, and Razor Creek. There are no perennial streams within the surface water cumulative impact area. The nearest perennial stream is lower Halfbreed Creek which flows into the Musselshell River approximately 18 miles to the north. The middle portion of Halfbreed Creek, downstream from its confluence with Rehder

Creek, and Fattig Creek beginning approximately three miles downstream from the AM3 permit boundary have intermittent flow. Intermittent flow within the CIA is limited to short (typically less than a few hundred feet) reaches near springs. Tributary streams in the area are generally ephemeral and have deeply cut valleys that often flood after heavy rains.

7.1.2 Surface Water Quantity

Baseline water quantity data consists of measurements collected from 1989 through 2015, and includes flow and/or water level data for streams, springs/seeps, and stock ponds. Stream flows in the Bull Mountains are typically ephemeral, with short reaches supporting streamflow during exceptionally wet years or periods of prolonged or above average precipitation. Typically, streams flow only in response to seasonal snowmelt, precipitation events, or directly below spring inputs from local perched aquifers. The shallow alluvium or colluvium and bedrock outcrops in the study area are generally conducive to natural spring discharges. These springs are an expression of groundwater as geologic units crop out (**Figure 4-3**).

Landowner manipulation of spring inputs has a dominant effect on surface flow as indicated at the major springs located within the permit area including numbers 14325 (Busse Water), 17415 (Litsky), 16655 (Cold Water) and spring 53505. At these locations, embankments have been constructed across the drainages to form ponds which impound water for livestock. These ponds control downstream drainage and in some cases the ponds are large enough to eliminate downstream flow. Ponds are typically located directly below spring issuances or directly atop the spring input and are a reflection of spring water inputs from shallow groundwater movement.

7.1.2.1 Stream Quantity Baseline

Stream flows in the Bull Mountains are typically ephemeral, responding to seasonal snowmelt or precipitation events. In the absence of immediate precipitation events or spring snowmelt, stream water quantity is generally governed by spring inputs from shallow perched aquifers that respond to seasonal precipitation. In most years, streambeds are dry, except below spring issue points. A network of eleven stream monitoring stations is maintained on Rehder Creek, Fattig Creek, Railroad Creek and their tributaries.

Sustained stream flows were observed in 1991 when 19.1 inches of precipitation was recorded in Roundup, an amount over five inches above the 30-year (1986-2015) annual average of 13.96 inches. Sustained stream flows on Rehder Creek and Fattig Creek were again observed in 2011 and 2014 as a result of well-above average precipitation during the spring of 2011 and 2014. In each of these years, steady streamflow was observed at some monitoring locations throughout the spring and summer months as the recent precipitation-driven recharge moved through the system. After the recharge pulse had passed, streamflow ceased and the channels returned to predominantly dry conditions. Due to predominantly ephemeral conditions, streamflow data is extremely limited and precludes detailed analysis and establishment of typical numeric baseline streamflow conditions.

7.1.2.2 Pond Quantity Baseline

Ponds in the Bull Mountains consist of stock ponds constructed solely for the storage of water for livestock watering. The location of stock ponds is limited to where spring inputs provide water, or where in-stream impoundments capture and store runoff water from precipitation or snowmelt events. Where ponds are located down gradient from spring issue points, pond volumes are directly related to spring flows, and may dry up as seasonal spring flows diminish or cease. Pond reliant solely on water from runoff events are less reliable and may only hold water for short periods of time. Within the permit area, ponds 52227, Busse Water pond (associated with spring 14325), Cold Water Spring pond (associated with spring 16655) and 'Big Dam on Top' (associated with spring 17165) have been observed to maintain ponded conditions year-round. Many ponds monitored periodically during the early baseline period of 1989 through 1996 have been reported as dry for the majority of the time since 2003.

7.1.2.3 Spring Quantity baseline

Springs in the Bull Mountains typically occur where groundwater travels laterally along a low-permeability rock unit (typically shale or claystone) and discharges to the surface at the outcrop (**Figure 4-3**). Several separate lithologic units have been identified that support spring flows: alluvium, overburden, mammoth coal, and underburden units. Within the overburden, six distinct lithologic units have been identified that may maintain water to support spring flows or wet seeps at times. Most springs monitored exhibit a history of both dry and low-flow conditions, responding to local and regional precipitation trends. For instance, from 2003 to 2007, many springs in the Bull Mountains exhibited dry conditions, correlating to the below-average precipitation from the late 1990s through the mid-2000s (**Figure 4-2**). Beginning in about 2007, some spring flows have demonstrated an increasing trend in flow volumes, and in number of months in which flowing conditions are observed. In all 143 different springs and seeps have been monitored since baseline monitoring began in 1989. Of these 143 springs and seeps, approximately half (72) are located within the proposed AM3 permit boundary.

Most springs in the Bull Mountains do not produce water in reliable amounts and may go dry during normal or low-precipitation years. Of the 143 springs and seeps monitored for flow during baseline conditions from 1989 to 2015, 32 springs, however, demonstrated regular seasonal or annual flow conditions with median flow rates greater than 0.5 gpm (**Table 7-1** and **Figure 6-3**). Many of these springs provide a reliable source of water to support livestock, and in a few cases maintain flows sufficient to support aquatic life. Where springs are developed for livestock watering, development typically consists of the construction of impoundments, stock tanks, or other distribution and storage systems.

Where springs discharge flow volumes that generate surface flow downstream of the issue point, aquatic life may colonize and use the aquatic habitat. In 1996 water was sufficient to allow sampling of aquatic habitat at nine springs: 16365, 16625, 16655, 16755, 16855, 16955, 17415, 17515, and 17685 (**Figure 6-4**). During the early 2000s aquatic habitats were severely limited due to drought conditions. Of the nine spring stations sampled in 1995, only three maintained aquatic habitats in 2002, and in 2005 only a single station, 16365, maintained flow sufficient to support aquatic habitats. More recently, periodic spring flow has returned to some of the stations sampled originally in 1995 (16365, 16625, 16655, and 17685) while others have remained predominantly dry (16755, 16855, 16955, and 17515). While aquatic surveys have not been conducted since 2005, field observations by DEQ staff in 2016 have reported aquatic habitats below spring 16365 and spring 16355.

While the more reliable springs in the Bull Mountains provide support for livestock and in some cases, aquatic life, there is not a sufficient supply of water to support water-based recreation, or more consumptive uses such as irrigated agriculture, or large scale industrial use. And while it has not historically been a practiced use, it is possible that, where water quality is sufficient, some springs could support a small-scale private drinking water supply, however reliability as a year-round water source may limit typical domestic use.

7.1.3 Surface Water Quality

Baseline water quality data consists of measurements collected from 1989 through 2015. Water quality data consists of selected indicator parameters consisting of common ions, metals and nutrients analyzed from grab samples collected at stream, spring and stock pond sampling stations, as well as field measurements of pH, conductivity, and temperature. Baseline sampling includes those indicator parameters or measurements that can reasonably be affected by mining activities. For instance, some parameters such as E.coli, dissolved oxygen, or other carcinogenic or toxic parameters are not typically measured in surface waters because of the lack of mining sources that may affect concentrations of these parameters.

Applicable standards for surface waters in the Bull Mountains are given in **Section 2.1.1**. The general water quality prohibitions given in ARM 17.30.637 apply to all surface waters in the region. Within the Bull Mountains and the permit area of AM3, compliance with the general prohibitions of ARM 17.30.637 is hindered in some places by historical and ongoing livestock use that can create undesirable aquatic life (nuisance algae and/or impacted aquatic communities) or conditions that are harmful to aquatic life. Likewise, impacts from historic livestock use may also hinder compliance with the specific water quality standards of 17.24.629(2)(a-k), particularly those that may be influenced by livestock use or disturbance from livestock watering (i.e. E.coli, DO, pH, and sediment).

Surface waters in the Bull Mountains include springs/seeps, streams, and stock ponds. Surface waters in the region are classified as C-3 waters by the state. Streams in the Bull Mountains are predominantly ephemeral, and in normal precipitation years flow only in direct response to precipitation or snowmelt. The marginal nature of the water quality of C-3 waters in the Bull Mountains limits their ability to naturally support all beneficial uses established for C-3 waters. Likewise the ephemeral nature of stream flows in the Bull Mountains limits their ability to naturally support C-3 beneficial uses. Where springs discharge sufficient water to develop flow below issue points, some C-3 beneficial uses are supported. In some of these cases, livestock watering, wildlife and aquatic life may be supported. Limited water volumes, however, generally preclude the support of bathing, swimming and recreation, support of non-salmonid fishes, irrigated agriculture, and industrial uses.

Baseline water quality conditions have been affected by livestock use and grazing in the Bull Mountains, with most wet areas exhibiting impacts from livestock use. In most cases, water sources are heavily used by livestock, and water quality is compromised by habitat destruction, animal waste, and general trampling of stream channels, springs, and other water resources. Where springs support aquatic life, aquatic resources are limited by channel and habitat degradation, and likely by nutrient enrichment. There are very few, if any, water resources in the Bull Mountains that have not been impacted by livestock use.

7.1.3.1 Stream Quality Baseline

As stream flows in the Bull Mountains are typically ephemeral, water quality data typically reflects conditions dominated by precipitation and runoff, snowmelt, or by short-lived flows resulting from local recharge events. Such flashy conditions and periodic sampling frequencies result in high variability in sampling results, and it is not uncommon for sampling results for some parameters to span two or three orders of magnitude (**Table 7-2**).

A network of eleven stream monitoring stations is maintained on Rehder Creek, Fattig Creek, Railroad Creek and their tributaries. **Table 7-2** presents baseline stream water quality in the Bull Mountains. For purposes of baseline water quality characterization, only water quality lab samples were used to generate statistics given in **Table 7-2**. It must be noted that over 40% of the samples included in the baseline dataset (1989-2015) were collected during 2014, when some streams segments were flowing in response to above-average precipitation in the spring of 2014.

As with ephemeral flows, the limited stream flows and extremely variable stream water quality data set precludes detailed analysis and establishment of typical numeric baseline streamflow conditions. Ephemeral flows may be high in suspended solids when they occur in response to storm-driven events, resulting in detects of several metals (iron, lead, nickel, manganese, aluminum, and zinc) associated with suspended sediment. Snow-melt driven flows show the opposite condition with low suspended and dissolved solids results, resultant from clean snowmelt, sometimes over frozen ground. In some instances, snowmelt-driven conditions can result in low hardness values and have contributed to exceedances of DEQ-7 aquatic life criteria for some metals (metals criteria are lower under lower hardness values). The frequency and variability of flow conditions is reflected in the variability of water quality results.

In general metals concentrations are low, with iron and lead having the highest exceedance rate. Iron exceeded the DEQ-7 chronic aquatic life standard (ALS) 17 times in 103 samples with most exceedances occurring during runoff events where high iron concentrations correlated with high total suspended solids (TSS) concentration. Lead exceeded the DEQ-7 human health standard (HHS) eight times in 103 samples and exceeded the DEQ-7 chronic ALS two times in 103 samples. Lead HHS exceedances occurred predominantly under runoff conditions with high TSS, while chronic ALS lead exceedances occurred during low-hardness snowmelt runoff conditions. Exceedances of HHS and ALS for other metals were very infrequent with most occurring on June 23, 2009, related to a runoff event associated with very high (8,700 mg/L and 17,500 mg/L) TSS values. The only baseline DEQ-7 exceedances of arsenic, chromium, nickel, selenium, and zinc were reported on this date.

Nutrient (nitrogen and phosphorus) data consists primarily of nitrate-nitrate and orthophosphate measurements. There have been no exceedances of the DEQ-7 HHS for nitrate-nitrite in any of the 103 baseline water quality samples. More recently, total nitrogen (TN) and total phosphorus (TP) data has been collected to allow evaluation of newly promulgated nutrient standards established in Department Circular DEQ-12A in August 2014. TP has exceeded the criteria established in DEQ-12A in three of 58 samples collected since 2013. TN sampling began in 2015; of six baseline samples collected, none exceed the TN criteria established in DEQ-12A.

7.1.3.2 Pond Quality Baseline

Water quality data for ponds is limited and highly variable (**Table 7-3**). Water quality data represents a periodic condition for most ponds due to the fact that water quality samples are only collected when ponded water exists, and may represent a variety of conditions, from recent runoff to stagnant summer pools. TDS concentrations are typically above 1,000 mg/L (median TDS = 1,090 mg/L), and with the exception of iron, metals concentrations are very low. Iron exceeded the DEQ-7 chronic ALS in 26 of 88 samples (30 percent), and arsenic exceeded the DEQ-7 HHS in three of 75 samples. Other reported exceedances were of cadmium and lead, however these reported exceedances were collected in 1991 and are all reported at the same values (0.002 and 0.003 mg/L for cadmium, and 0.02 mg/L for lead), which were common reporting limits at the time of collection. It is likely that these historic baseline values were not detects but were analytical reporting limits incorrectly reported as sampling results. No exceedances of cadmium or lead are reported in over 70 samples collected from ponds since 1991.

Stock ponds in the area of the Bull Mountains are developed for livestock use, and water quality marginally supports livestock use. However some parameters, particularly magnesium and sodium, are naturally elevated above the livestock use criteria established in **Table 2-3.** Nonetheless, livestock utilize stock ponds for watering in the absence of better water quality alternatives. In most cases, livestock use has affected water quality in most ponds, with the highest nitrate-nitrite and ammonia concentrations reported for ponds that see consistent livestock use.

Stock ponds are not used for private or public drinking water supplies, and high TDS levels and low reliability of suitable water quantity preclude their reasonable development as such water sources. And, while water quality in ponds may meet agricultural requirements for crop use, available water volumes are not sufficient to support irrigation or other consumptive agricultural uses other than livestock watering.

7.1.3.3 Spring Quality Baseline

Springs in the Bull Mountains occur where groundwater travels laterally along a low-permeability rock unit (typically shale or claystone) and discharges to the surface at the outcrop (**Figure 4-3**).

Field parameters (pH, conductivity, temperature) are measured at all of the more than 140 springs sampled in the Bull Mountains. Water quality samples are collected regularly at 27 springs and are analyzed for a variety of common ions, metals and nutrients. **Table 7-4** presents baseline spring water quality in the Bull Mountains. For purposes of baseline water quality characterization, only water quality lab samples were used to generate statistics given in **Table 7-4**.

Several separate lithologic units have been identified that support spring flows: alluvium, overburden, mammoth coal, and underburden. Within the overburden, six distinct lithologic units (OB1, OB2, OB3, OB4, OB5, OB6) have been identified that contribute water to spring flows. In general, specific conductivity (SC) increases naturally (**Table 7-5** and **Figure 7-1**) from the uppermost overburden unit (OB1) to the lower units (OB6) as groundwater percolating through overburden units dissolves additional salts (**Figure 4-3**). Increases in specific conductivity are mainly due to increases in dissolved constituents: sulfate, magnesium, calcium, sodium.

Generally, springs sourced from the uppermost overburden units (OB1 and OB2) have much better water quality with low levels of sodium, sulfate, iron, magnesium, and most other dissolved constituents (**Figure 7-1**). Spring water sourced from deeper overburden units (OB3, OB4, and OB5) typically have more dissolved constituents than stratigraphically higher units, however there are some exceptions, such as springs 16365, 72155, and 16655 which are listed as being sourced from OB4 and OB5 units, yet produce higher quality water than most other deeper overburden springs, with lower levels of SC, sulfate and sodium.

Springs sourced from the Mammoth coal produce some of the poorest water quality of all springs with high SC, sulfate, sodium and other dissolved constituents. Some of the most productive springs in the Mammoth coal (53505 and 53485) produce some of the poorest water quality in the Bull Mountains with the 25th percentiles of field SC measurements 2,950 µS/cm and 2,300 µS/cm (meaning 75 percent of water quality field measurements are above these values.)

Only three springs (51255, 52855, and 71465) that receive measureable flow are sourced from underburden units. These underburden springs exhibit similar water quality conditions and variability as underburden wells.

Metals concentrations are generally low in spring samples, with most analytical results reported as non-detects. Exceedances of DEQ-7 HHS criteria for metals were rare. The only exceedances of DEQ-7 HHS for metals in spring samples were seen for arsenic, lead, zinc and selenium. Twenty-two exceedances of the DEQ-7 HHS for lead were reported, with 19 of those exceedances occurring prior to 1995. Of these 19 exceedances, all were reported with values of 0.02 mg/L or 0.03 mg/L. As these values were common reporting limits at the time, it is likely that these results were simply misidentified as result values rather than reporting values. There have been only three lead exceedances since 1995. In addition to HHS exceedances, baseline data also showed several DEQ-7 chronic ALS exceedances for parameters iron (65 chronic exceedances), selenium (32 chronic exceedances, 2 acute exceedances) and zinc (29 chronic and acute exceedances). Nutrient data collected from springs is typically collected from spring ponds or stockponds where nutrient criteria do not apply. In the few locations where springs generate surface flow in a channel for a short reach (17685, 16365, 16625, 16655), no exceedances of nutrient criteria were reported.

Springs in the Bull Mountains do not produce a water volume that would support water-based recreation, irrigated agriculture, or most consumptive industrial uses. Where springs have been developed into stock tanks or stock ponds, or where spring discharges result in flow or ponded water downstream of issue points, wildlife and livestock use is generally observed even though many of the livestock water quality guidelines given in **Table 2-3** are not met. For instance, water quality analytes calcium, magnesium, and sodium in spring baseline samples regularly exceed livestock guidelines. Livestock drinking water quality guideline exceedances of sulfate, alkalinity, and total dissolved solids are less common, but may periodically exceed criteria (<less than 1.5 percent exceedance rate with greater than 1,000 samples). And, while water quality from some springs may meet agricultural requirements for crop use, available water volumes are not sufficient to support irrigation or other consumptive agricultural uses other than livestock watering.

Drinking water use is not generally supported by springs in the Bull Mountains, mainly due to high total dissolved solids (TDS) concentrations. The only springs that consistently have water quality that meets TDS guidelines for drinking water given in **Table 2-2** are those springs sourced from stratigraphically higher OB1 and OB2 units. Other overburden units (OB3 through OB6) regularly exceed TDS guidelines for drinking water, with the exception of springs 14325 (Busse Water), 16365, 52355, 72155, and 16655 (Cold Water Spring). While water quality may be suitable for human consumption at the aforementioned springs, the reliability of spring flows at these locations would severely limit their use as a domestic water supply. The Federal Housing Administration (FHA) requires three to five gallons per minute for older wells and a rate of five gallons per minute for new wells to pass inspection (HUD, 2016).

7.2 Groundwater Baseline

Baseline water level and water quality were measured in the alluvium, overburden, Mammoth coal, and underburden during the baseline period 1989 through 1991. Monitoring continued during ownership by subsequent operators, but most of the monitoring wells used to determine baseline conditions were abandoned when the mine closed in 1998. A new network of 121 monitoring wells was completed in 2002 and 2003 by BMPII and continued to monitor baseline conditions in many locations as substantial mining disturbance had not yet occurred. The groundwater monitoring network was described in more detail in **Section 6.2**.

Groundwater samples were chosen as representing baseline if no mining related disturbance to the geologic unit in which the well was completed had occurred within one mile. For this analysis surface activities were considered to disturb the alluvium, longwall mining was considered to disturb all geologic units from the upper underburden to overburden unit one (including alluvium), and continuous miner mining was considered to disturb geologic units from the upper underburden to overburden unit six (not including alluvium). The one mile distance from wells was determined based on straight-line distance and only where the unit was present. One mile was chosen as it represents a conservative distance from which mining disturbance would have little or no effect on hydrologic conditions affecting groundwater. Based on monitoring data collected from wells near to mining disturbance, possible impacts have not been observed in alluvial wells except within 500 feet of active sediment ponds and where undermined by longwall mining. Observations in overburden wells show no mining related impacts until longwall mining is within 0.5 miles, or less, of a well. In the confined water bearing units of the Mammoth coal and upper underburden, drawdown has been observed to extend further distance from mining, thus water level trends in wells were analyzed to determine if any mining related drawdown could have occurred at wells further than one mile from mining. While drawdown does not typically affect water quality except in partially saturated units, as a conservative approach, water quality samples from any wells showing potential mining related drawdown were excluded from consideration as baseline.

DEQ compared water quality in the original Meridian monitoring wells to the replacement BMP wells to determine if these wells were sampling the same water. When water quality in the original and replacement wells were similar, these wells were treated as a single sampling location for baseline purposes. If there were significant differences in water quality between the original and replacement wells, each well was treated as a separate location for baseline purposes.

7.2.1 Groundwater Regime

Groundwater in the mine area occurs in the alluvium, overburden, Mammoth coal, and underburden. Groundwater flow is generally toward the north-northwest except in the often dry alluvium. Contiguous rock units including the sandstone above the Rock Mesa coal (OB5), the Mammoth coal, and the underburden are saturated across much of the study area. Groundwater flow in these contiguous rock units is generally toward the north-northwest. In the alluvium, where groundwater is present it tends to flow downstream. Upper overburden units tend to only contain perched groundwater which flows towards the outcrops of these units (**Figure 4-3**).

Aquifer tests were performed by MBMG and Meridian from 1982 through 1991. Aquifer tests results are summarized in **Table 7-7**. These results show a wide range of hydraulic conductivity between geologic units with geometric means between 28 and 0.013 ft/d. Geometric means are frequently used to describe hydrogeologic properties instead of arithmetic means because measurements of these properties do not typically display a symmetrical normal distribution, but more frequently have a skewed log-normal distribution. Because of this tendency, a geometric mean represents the true central tendency of a distribution of hydrogeologic properties more accurately than an arithmetic mean. Unconsolidated alluvium has a hydraulic conductivity that is orders of magnitude greater than that of the bedrock. Hydraulic conductivity is also highly variable within each geologic unit, with typical variability of three to four orders of magnitude. Storage coefficients were determined by 11 pumping tests in the bedrock. These results indicate a wide range of storage coefficients in the overburden and the Mammoth coal ranging from 1×10^{-3} to 6×10^{-6}. The underburden values were even wider in range, from 1×10^{-1} to 4×10^{-6}. In general, this indicates that groundwater typically occurs under confined conditions in the bedrock.

7.2.2 Alluvial Baseline

Alluvial sediments locally are up to 20 feet in saturated thickness but are generally dry in the permit area except following periods of significant precipitation. Alluvial baseline water quantity was determined by a network of 26 locations with relatively shallow monitoring wells completed in alluvium that occurs in the valley bottoms of the larger ephemeral stream channels. Alluvial material is not a major water supply in the region due to its limited saturation and areal distribution.

Water level measurements from baseline alluvial wells indicated that the alluvium is generally dry in the permit area and becomes partly saturated in Rehder Creek near the northern border of the permit boundary. Alluvial groundwater flow in Rehder Creek is toward the west-northwest (downstream). The alluvium of ephemeral tributaries from the permit area into Rehder Creek is generally dry and becomes partly saturated along short reaches due to spring discharge and during significant seasonal precipitation events. The alluvium in the Fattig Creek drainage lies to the northeast of the permit boundary and is typically partially saturated. Railroad Creek alluvium is dry except after major precipitation events.

Alluvial baseline water quality was determined by monitoring 26 wells (**Table 7-7**). Data from these wells indicate that alluvial groundwater in the permit area and vicinity is generally of a magnesium-sulfate or magnesium-bicarbonate composition. SC ranged between 759 μS/cm and 4,940 μS/cm with a median of 1,960 μS/cm, and sulfate concentrations ranged from 59 mg/L to 3,550 mg/L with a median of 671 mg/L. **Figure 7-2** shows box and whisker plots for SC in alluvial groundwater baseline data. These plots show that alluvial groundwater quality is variable, both at individual locations and between different locations. Groundwater quality in Rehder Creek alluvium, was generally better quality than in its tributaries (PM Draw, 15, 16, and 17 drainages). Fattig Creek alluvial groundwater had the highest typical SC values of all alluvial groundwater. Alluvial groundwater ranged between Class I and Class III water (**Table 2-5**). However, most alluvial groundwater quality falls into Class II.

Alluvial water quantity is generally not suitable for public water supplies, domestic use, or culinary and food processing purposes. Water quality of alluvial groundwater is marginally suitable for human consumption. The maximum concentrations of lead and nitrate-nitrite detected in alluvial groundwater exceeded the DEQ-7 HHS in **Table 2-1**, although the median concentration of lead is below the detection limit and the median concentration of nitrate-nitrite 0.72 mg/L. The median concentrations of TDS, hardness, and sulfate exceed aesthetic guidelines from the WHO and EPA (**Table 2-2**), as do the maximum concentrations of sodium, aluminum, iron, and manganese. If sufficient water quantity could be located in the alluvium to supply these uses, treatment would likely be desired to make the alluvial groundwater more palatable.

Water quantity of the alluvial groundwater could provide a limited, intermittent supply for livestock drinking water. Water quality of most alluvial groundwater is marginally suitable for livestock when compared to the guidelines in **Table 2-3**. The median value for magnesium exceeds the upper limits, along with the maximum values for TDS, alkalinity, bicarbonate, calcium, sodium, sulfate, and manganese. The minimum value for magnesium exceeds the threshold limit, as does the median value for sodium, and the maximum value for chloride.

Alluvial groundwater is only available for drinking water for wildlife at springs. The suitability of spring water for wildlife use is discussed in **Section 7.1.3.3**.

Water quantity in the alluvium is insufficient for the development of irrigation wells, and there is no evidence of subirrigation, thus irrigation use of the alluvial groundwater is not supported by the premine condition. The groundwater quality in the alluvium is generally suitable for irrigation of crops typically grown in the area. The maximum value of SC exceeded the threshold limits for alfalfa and grasses in **Table 2-4**. The maximum concentrations also exceed the threshold limits for fluoride, manganese, and nitrate.

Water quantity in the alluvium is also insufficient to support most industrial or commercial uses, however alluvial water quality would likely support these uses if sufficient quantity could be located.

7.2.3 Overburden Baseline

Overburden rocks are commonly over 200 feet in thickness and range to over 800 feet in thickness within the permit boundary. Shallow overburden groundwater is typically unconfined, perched, and often moves laterally along sedimentary layers before discharging as springs, seeps, or into alluvium (**Figure 4-3**). Water levels in the perched aquifers and spring flow issuing from them are strongly influenced by seasonal and periodic fluctuations in precipitation. Deeper overburden groundwater occurs in sandstones stratigraphically above the Rock Mesa coal (OB5) and the Mammoth coal (OB6) seams (**Figure 4-4**). These sandstones are up to 80 feet in thickness. Flow in these sandstones is generally toward the north-northwest, nearly coincident with the synclinal structural axis.

Overburden baseline groundwater quantity was determined by a network of 26 groundwater wells. Where saturated, overburden groundwater occurs under both confined and unconfined conditions depending upon the proximity to the outcrop. Baseline data indicate that overburden groundwater is associated with alternating perched aquifers and rock units of low permeability and unsaturated rocks that extend to approximately 100 feet in depth. However, deeper overburden rocks are saturated and in hydrologic connection with the underlying strata. Fourteen of the 26 baseline overburden monitoring wells were completed in sandstones within the lower overburden above the Rock Mesa and the Mammoth coal seams.

Twenty-nine wells were used to determine the baseline water quality of the overburden aquifer (**Table 7-8**). Water in the overburden wells is generally of sodium-bicarbonate or sodium-sulfate composition, and is highly variable in quality. Overburden baseline SC ranged from 438 μS/cm to 6,080 μS/cm with a median of 2,060 μS/cm, and sulfate concentrations ranged between 9 mg/L and 4,040 mg/L with a median of 542 mg/L. **Figure 7-3** shows box and whisker plots for SC in overburden groundwater baseline data. **Figure 7-3** shows that overburden groundwater quality is highly variable from well to well, and also variable at individual wells over time. Water sampled from overburden wells ranged from Class I through Class III groundwater, but most wells produce Class II water. The uppermost overburden units (OB1 and OB2) consistently produce the best quality groundwater. Only wells BMP-78 and BMP-63, completed in the uppermost portions of the overburden, had water classified as Class I groundwater.

Groundwater quantity in the overburden is rarely sufficient to support public water supplies or culinary and food processing uses, but could provide a marginal supply for domestic use in some areas. Water quality of the overburden groundwater is generally unsuitable for domestic use, except in a few local areas. Exceedances of DEQ-7 HHS (**Table 2-1**) were reported for arsenic, cadmium, lead, and nitrate-nitrite in at least one baseline sample, although the median values for all these parameters were near or below their detection limits. The median concentrations for TDS, hardness, and sulfate, and the maximum values reported for pH, sodium, aluminum, iron, and manganese are higher than aesthetic guidelines from the WHO and EPA (**Table 2-2**). In most locations, with the notable exceptions of BMP-63 and BMP-78, overburden groundwater would be unpalatable for human consumption and treatment would be necessary for domestic use.

Overburden groundwater quantity is sufficient in many locations to be used as a supply of livestock drinking water. Baseline water quality within the overburden monitoring wells is marginally suitable for livestock in some areas when compared to the guidelines in **Table 2-4**. The median concentration for magnesium and the maximum concentrations for TDS, alkalinity, bicarbonate, calcium, fluoride, sodium, sulfate, arsenic, and manganese exceed their upper limits. Additionally, the median concentrations for calcium and sodium, and the maximum concentration of nitrate-nitrite were higher than the threshold limits.

Overburden groundwater is only available for drinking water for wildlife at springs. The suitability of spring water for wildlife use is discussed in **Section 7.1.3.3**.

Water quantity in the overburden is insufficient for the development of irrigation wells in most locations, and few agricultural fields are underlain by overburden. The groundwater quality in the overburden is generally suitable for irrigation of crops typically grown in the area. The maximum value for SAR exceeded both of the upper limits in **Table 2-4**. The threshold limits are exceeded by median value of SC for alfalfa and the maximum values of SC for wheat and grasses. The maximum concentrations also exceed the threshold limits for fluoride, iron, manganese, selenium, and nitrate.

Water quantity in the overburden is typically insufficient to support most industrial or commercial uses, however overburden water quality would likely support these uses if sufficient quantity could be located.

7.2.4 Mammoth Coal Baseline

The west margin of the Mammoth coal crops out at the mine portal and the southern Mammoth coal crop occurs along the south face of Dunn Mountain. To the east the coal crops along the eastern branch of Fattig Creek. Near the western and southern margins, the coal is dry but becomes saturated and eventually becomes confined toward the east and north. Groundwater flow in this unit is toward the north-northwest (**Figure 7-4**), following the direction of synclinal plunge. Recharge reaches the Mammoth coal via exposed outcrops, subcrops, and from infiltration through the overburden.

The geometric mean hydraulic conductivity of the Mammoth coal is 0.16 ft/day (**Table 7-6**). Although the hydraulic conductivities for the Mammoth coal are relatively higher than the overburden, the average ten-foot thickness of the coal results in a low transmissivity which is typically inadequate to provide a reliable source of well water.

Mammoth coal baseline groundwater quantity was determined by a network of 14 groundwater wells. Water levels in most Mammoth coal wells showed little natural fluctuation and did not vary more than two feet over the period of baseline monitoring, except in one well near the Mammoth coal outcrop which showed larger fluctuations apparently in response to precipitation.

Baseline water quality of the Mammoth coal was determined from samples from 16 wells (**Table 7-9**). Generally, sodium and sulfate are the dominant ions in groundwater collected from most Mammoth coal monitoring wells. SC and sulfate baseline concentrations in the Mammoth coal tend to be greater than in the overburden. SC ranged from 1,400 μS/cm to 5,580 μS/cm with a median of 2,188 μS/cm. sulfate concentrations ranged from 251 mg/L to 4,200 mg/L, with a median of 719 mg/L. **Figure 7-5** shows box and whisker plots for SC in Mammoth coal groundwater baseline data. As shown in **Figure 7-4** SC is variable based on location, and can also vary greatly at some individual wells while other wells are fairly consistent. Mammoth coal baseline groundwater samples fall approximately evenly into Class II and Class III groundwater. Of the 16 locations where Mammoth coal monitoring wells have been installed, six produce only Class II water, six produce both Class II and Class III water, and four produce only Class III water.

Groundwater quantity in the Mammoth coal is generally inadequate to support public water supplies or culinary and food processing uses, but could provide marginal supply for domestic use in many locations. Groundwater quality in the Mammoth coal is frequently unsuitable for domestic use. The maximum concentration of lead exceeds the DEQ-7 HHS (**Table 2-1**) and the maximum value for cadmium was higher than WHO health based guideline values (**Table 2-2**). The minimum concentration for TDS and sulfate, the median concentrations for hardness and sodium, and the maximum values for pH, aluminum, iron, manganese, and ammonia exceeded aesthetic guidelines from the WHO and EPA (**Table 2-2**). In all baseline locations Mammoth coal groundwater would be unpalatable for human consumption and treatment would be necessary for domestic use.

The quantity of groundwater available in the Mammoth coal would support marginal livestock water supplies. Mammoth coal groundwater quality is marginally suitable for watering livestock. The median values for sodium, and the maximum values for TDS, alkalinity, bicarbonate, calcium, magnesium, sulfate, and manganese were higher than the upper limits in **Table 2-4**. Additionally, the minimum value for sodium, median value for magnesium, and the maximum value for vanadium were higher than the threshold limits.

Mammoth coal groundwater is only available for drinking water for wildlife at springs. The suitability of spring water for wildlife use is discussed in **Section 7.1.3.3**.

Water quantity in the Mammoth coal is insufficient for the development of irrigation wells. The groundwater quality in the Mammoth coal is generally suitable for irrigation of crops typically grown in the area. The maximum value for SAR exceeded both of the upper limits in **Table 2-4**, and the median value exceeded the threshold limits for waters with a SC of 1,000 μS/cm. The threshold limit is exceeded by median value of SC for alfalfa and the maximum values of SC for grasses. The maximum concentrations also exceed the upper limit for iron, and the threshold limits for fluoride, manganese, selenium, and nitrate.

Water quantity in the Mammoth coal is insufficient to support most industrial or commercial uses, however Mammoth coal water quality would likely support these uses if sufficient quantity could be located.

7.2.5 Underburden Baseline

In the context of the mine permit, the term underburden refers to rocks below the base of the Mammoth coal. Generally, the underburden can be divided into two distinct hydrostratigraphic units: 1) the upper underburden immediately below the base of the Mammoth coal that is hydraulically connected to the Mammoth coal, and 2) the deeper underburden sandstones hydraulically isolated from the upper underburden that typically occur hundreds of feet below the base of the Mammoth coal.

The upper underburden has very low conductivities with a geometric mean of 0.013 ft/day and does not supply substantive amounts of groundwater to wells. The deeper underburden is characterized by a 50-foot thick massive fluvial sandstone at a depth of approximately 350 feet below the Mammoth coal. A pump test of the office well completed in this deeper sandstone indicated a hydraulic conductivity of 3.8 ft/d, which is two to three orders of magnitude higher than the conductivities of the upper underburden and the Mammoth coal (**Table 7-6**).

Upper underburden baseline quantity was determined from a network of 19 wells. Groundwater in the upper underburden generally occurs under confined conditions and flows north-northwest like groundwater in the overlying units. Water quantity of the deeper underburden was determined from four monitoring wells and the numerous water supply wells completed in this unit. Deeper underburden groundwater occurs under confined conditions and generally flows in a northward direction.

Baseline water quality of the upper underburden was determined by 23 monitoring wells (**Table 7-10**). The baseline water quality of the upper underburden is similar to that of the Mammoth coal. Sulfate was the dominant anion and sodium tended to be the dominant cation. Respective SC and sulfate concentrations of the upper underburden ranged from 1,450 μS/cm to 4,810 μS/cm and 216 mg/L to 3,120 mg/L. Median SC and sulfate concentrations were2,200 μS/cm and 727 mg/L, respectively. **Figure 7-6** shows box and whisker plots for SC in upper underburden groundwater baseline data. The majority of the upper underburden wells (labeled UUB in **Figure 7-6**) are completed within approximately 50 feet of the base of the Mammoth coal, while BMP-55, BMP-84, and BMP-117 (labeled UB in **Figure 7-6**) are 50 to 150 feet below the Mammoth coal. Upper underburden groundwater falls into Class II and Class III, with slightly more than half of the wells typically producing Class II groundwater.

Water quantity in the upper underburden is insufficient to support public water supplies or culinary and food processing uses in most locations, but is generally suitable for domestic water supplies. Upper underburden groundwater quality is usually unsuitable for domestic use. The maximum concentrations of arsenic, cadmium, and lead exceeded the DEQ-7 HHS (**Table 2-1**). The minimum value for TDS, the median values for hardness, sodium, and sulfate, and the maximum values for pH, aluminum, iron, and manganese exceeded aesthetic guidelines from the WHO and EPA (**Table 2-2**). In most locations upper underburden groundwater would be unpalatable for human consumption and treatment would be necessary for domestic use.

Water quantity in the upper underburden is suitable for livestock drinking water supplies in most locations. Upper underburden water quality is marginally suitable for livestock use. The median value for sodium, and the maximum values for alkalinity, bicarbonate, calcium, fluoride, magnesium, sodium, sulfate, arsenic, and manganese were higher than the upper limits in **Table 2-4**. The minimum values for sodium, and the maximum value for chloride were higher than the threshold limits.

Water quantity in the upper underburden is insufficient for the development of irrigation wells. The groundwater quality in the upper underburden is generally suitable for irrigation of crops typically grown in the area. The maximum value for SAR exceeded both of the upper limits in **Table 2-4**, and the median value exceeded the threshold limits for waters with a SC of 1,000 μS/cm. The threshold limit is exceeded by median value of SC for alfalfa and the maximum values of SC for grasses. The maximum concentrations also exceed the threshold limits for fluoride, iron, manganese, and nitrate.

Water quantity in the upper underburden is insufficient to support most industrial or commercial uses, however upper underburden water quality would likely support these uses if sufficient quantity could be located.

Baseline water quality of the deeper underburden was determined from a network of five wells (**Table 7-11**). Deeper underburden groundwater tends to be of sodium-sulfate type and have better overall quality than the overlying units. SC ranges from 1,410 μS/cm to 2,390 μS/cm with a median of 1,800 μS/cm, and Sulfate from 481 mg/L to 751 mg/L with a median of 617 mg/L. **Figure 7-6** shows box and whisker plots for SC in deeper underburden groundwater baseline data, which demonstrate that water quality in the deeper underburden is more consistent than that of any other hydrostratigraphic unit. All deeper underburden wells produced Class II groundwater.

Water quantity in the deeper underburden is sufficient for public water supplies, domestic use, and culinary and food processing uses. Water quality in the deeper underburden is marginally suitable for human drinking water. The median concentration for arsenic exceeded the DEQ-7 HHS (**Table 2-1**) at three of the six baseline sites. The minimum values for TDS, sodium, and sulfate, the median value for hardness, and the maximum values for iron and manganese exceeded aesthetic guidelines from the WHO and EPA (**Table 2-2**). In most locations treatment would likely be desired to make the deeper underburden groundwater more palatable. Where arsenic concentrations exceed the DEQ-7 HHS treatment would be necessary before the deeper underburden groundwater could be safely consumed by humans. Commercially available reverse osmosis filtration systems would likely provide sufficient treatment for the low levels of arsenic present in the deeper underburden.

Water quantity in the deeper underburden is suitable for livestock drinking water supplies. Deeper underburden water quality is marginally suitable for livestock use. The median value for sodium, and the maximum values for fluoride and arsenic were higher than the upper limits in **Table 2-4**. The minimum values for sodium, and the maximum value for magnesium were higher than the threshold limits.

Water quantity in the deeper underburden is sufficient for the development of irrigation wells. The groundwater quality in the deeper underburden is generally suitable for irrigation of crops typically grown in the area. The maximum value for SAR exceeded the upper limit, and the median value exceeded the threshold limits for waters with a SC of 1,000 μS/cm (**Table 2-4**). The maximum SC exceeds the threshold limit for alfalfa.

Groundwater quantity and quality in the deeper underburden is sufficient to support many industrial and commercial uses.

Upper underburden and deeper underburden groundwater is only available for drinking water for wildlife at springs. The suitability of spring water for wildlife use is discussed in **Section 7.1.3.3**.

8.0 WATER RESOURCE USES

Historic and current surface and groundwater uses in and adjacent to the mine area include public water supply, private water supply, livestock, wildlife, irrigation, and industrial uses. Water quality criteria have been developed to allow evaluation of the suitability of water quality and quantity to support beneficial uses and are given in **Section 2.0**. Discussion of supported uses is given in Section 7.0 and Section 9.0.

Wells located within and immediately adjacent to the CIA were identified from the Montana Bureau of Mines and Geology, Groundwater Information Center (GWIC). Registered surface water and groundwater rights were identified from records at the Montana Department of Natural Resources and Conservation (DNRC). Groundwater users (wells and groundwater rights) are shown in **Table 8-1** and **Figure 8-1**, and surface water users (surface water rights) are shown in **Table 8-2** and **Figure 8-2.**

As shown in **Table 8-1**, most wells and springs in the CIA are used for stockwater. Wells are primarily completed in the underburden, while springs are primarily sourced from the overburden. **Figure 8-1** and **Table 8-1** show that SPE owns many of the wells and the rights to springs in the CIA. Other major holders of wells and groundwater rights include the Charter Ranch, Ellen Pfister, and the Sallie Busch Wheeler Trust.

As shown in **Table 8-2**, surface water rights in the Bull Mountains are dominated by a few users. SPE owns nearly all of the surface water rights within the AM3 permit boundary (**Figure 8-2**). Ellen Pfister is the other major owner of surface water rights, and holds the remaining rights within the AM3 permit boundary and several other surface water rights in the southern portion of the CIA.

The mine operator must replace water rights or water supply interrupted by strip or underground mining (ARM 17.24.648). Supply of water for domestic, agricultural, industrial or other use of surface or groundwater is protected from diminution, contamination or interruption resulting from coal mining.

8.1 PUBLIC WATER SUPPLY

The only current public water supply in the CIA is the water supply for the Bull Mountains Mine No. 1, and is permitted as water system MT0004676 by DEQ's Public Water Supply and Subdivisions Bureau. Office Supply Well No. 1, which supplies water to the mine office facilities, produces from the deep (355 to 405 feet) and relatively thick (50 feet) underburden sandstones. Water from the Office Supply Well is used by the mine for toilets, showers, and sinks, but the mine supplies bottled water for employee drinking water.

Due to water quantity requirements for the permitting of public water supplies, any future public water supplies in the Bull Mountains would likely also be supplied by wells completed in the deeper underburden. As discussed in **Section 7.2.5**, due to arsenic concentrations above DEQ-7 HHS in half of the deeper underburden well sampled, treatment of deeper underburden water may be necessary in some locations before human use.

8.2 PRIVATE WATER SUPPLY/DRINKING

Private water supplies and drinking water use are generally classified as domestic use in the GWIC and DNRC databases, and the term domestic is used to describe these uses throughout this CHIA. Domestic use is indicated in GWIC or DNRC records for 33 wells within the groundwater CIA (**Table 8-1** and **Figure 8-1**). Domestic or private wells in the area generally produce water under confined conditions from relatively deep underburden sandstones that are hydrologically separated from the upper underburden aquifer and Mammoth coal, although a few domestic wells are completed in the upper underburden. Two domestic wells are completed across multiple units from the overburden to the upper underburden, including the Mammoth coal. As discussed in **Section 7.2.5**, sampling results indicate the presence of arsenic at concentrations over DEQ-7 HHS in half of the deeper underburden wells monitored by SPE. It is likely that many of the domestic wells completed in the deeper underburden also contain natural levels of arsenic over the DEQ-7 HHS, although DEQ is unaware of any sample results from these domestic wells.

8.3 Culinary and Food Processing

There are no known culinary or food processing uses in the CIA. Any culinary or food processing use would likely be required to be permitted as a public water supply.

8.4 Industrial and Commercial

Three industrial supply wells, located within the facilities area of the mine (**Figure 3-4**), are currently used for mining operations. These industrial supply wells are completed in carbonate rocks of the Madison Group, at depths greater than 8,700 feet. These wells produce hot (approximately 165^{o}F) and highly mineralized water that is isolated from the shallower groundwater of the Fort Union Formation by thousands of feet of confining rock units. The water contains concentrations of fluoride and radionuclides in excess of drinking water standards for groundwater that make the deep Madison well water unsuitable as potable water. The mine also captures and stores storm water runoff in on-site ponds for industrial use.

Industrial water from the Madison wells and storm water is stored in lined Madison Pond No. 1 and a 500,000 gallon concrete tank near the waste disposal area. Water from these storage facilities is used by the mine for coal processing in the preparation plant and plate press, and to control road dust and underground dust generated during mining. Wastewater generated from the preparation plant and underground dust control is filtered and re-used in a closed-loop system.

In the past the mine also used water from deeper underburden wells for industrial purposes, however since the installation of the Madison wells this use has been discontinued. Madison well water is used sparingly, and most of the water stored in the Madison pond and storage tank is stormwater and water pumped from underground mine workings.

Due to the water quantity requirements for industrial or commercial uses, any future industrial or commercial uses in the Bull Mountains would likely also supplied by wells completed in the deeper underburden or Madison Group.

8.5 Livestock

Livestock watering is the dominant water use in the CIA, and surface water, springs, and groundwater wells in the CIA area are used for livestock watering. Water quality in surface water, springs, and shallow wells is variable and may change seasonally with the availability and use of the water source. Deeper wells provide a more consistent and reliable water source.

Sixty wells that lie within the groundwater CIA are identified for stockwater use in the GWIC and DNRC databases (**Table 8-1** and **Figure 8-1**). The completion depths listed for stockwater wells indicate that groundwater resources used for supply include alluvium, overburden, Mammoth coal, and upper and deeper underburden groundwater. There are also 46 groundwater rights listed for stockwater use at springs in the groundwater CIA. These springs are primarily sourced from overburden aquifers with a few sourced by the Mammoth coal or underburden.

Livestock are listed as the use at 30 of the surface water rights within the surface water CIA in the DNRC database. Livestock use of surface water is typically directly from the source or at a stock pond. Nearly half of the surface water rights in the surface water CIA are owned by SPE.

8.6 IRRIGATION

Irrigation use is listed in the GWIC and DNRC databases for four surface water rights and one well in the CIA. An additional four wells list lawn and garden as one of their uses. Three of the surface water rights and the only well which list irrigation as its use are owned by SPE. Wells listing lawn and garden as a use are completed in the underburden.

8.7 AQUATIC AND WILDLIFE HABITAT AND WILDLIFE DRINKING WATER

Aquatic plants, macroinvertebrates, and vertebrates are associated with springs and stock ponds in the permit area. Fish have not been found in any of the stock ponds or stream reaches, and no threatened or endangered aquatic species or habitat has been identified in the area. Aquatic species are associated predominantly with stock ponds and some springs, and rely on spring-water inputs for the maintenance of habitats. Aquatic habitats are limited by impacts from livestock use of springs and stock ponds. Terrestrial and avian wildlife also use springs and stock ponds as drinking water sources.

9.0 HYDROLOGIC IMPACT & MATERIAL DAMAGE ASSESSMENT

As required by ARM 17.24.314(5), DEQ must provide an assessment of the cumulative hydrologic impacts of the proposed operation and all previous, existing, and anticipated mining upon surface and groundwater systems in the cumulative impact area. The assessment must be sufficient to determine if the proposed operation of the AM3 mining operation has been designed to prevent material damage to the hydrologic balance outside the permit area. In other words, the analysis must be sufficient for DEQ to determine whether the proposed AM3 mining operation will cause degradation or reduction of the quality or quantity of water outside the permit area in a manner or to an extent that land uses or beneficial uses of water outside the permit area are adversely affected, water quality standards outside the permit area are violated, or water rights outside the permit area are impacted (MCA Section 82-4-203(32)). This process takes into account the measures to be taken during and after mining to minimize impacts to the hydrologic balance, and evaluates hydrologic monitoring data with respect to these measures to determine whether impacts to the hydrologic balance have been minimized and material damage prevented. In making this determination, DEQ applies the material damage criteria outlined in **Section 2.1**.

9.1 MINIMIZATION OF IMPACTS AND PREVENTION OF MATERIAL DAMAGE

MSUMRA requires permit holders to employ measures to minimize disturbance to the hydrologic balance on and off the mine plan area and to prevent material damage to the hydrologic balance outside the permit area. Material damage is defined in **Section 2.1**. Pursuant to ARM 17.24.314(1), the proposed measures must minimize disturbance to the hydrologic balance sufficiently to sustain the approved postmining land use and the performance standards of ARM 17.24 subchapters 5 through 12, and must provide protection of:

> *"(a) the quality of surface and groundwater systems, within both the proposed mine plan and adjacent areas, from the adverse effects of the proposed strip or underground mine operations;*
> *(b) the rights of present users of surface and ground water; and*
> *(c) the quantity of surface and ground water within both the proposed mine plan area and adjacent areas from adverse effects of the proposed mining activities, or to provide alternative sources of water in accordance with ARM 17.24.304(1)(e) and (f) and ARM 17.24.648, where the protection of quantity cannot be ensured."*

Among these measures are requirements and performance standards given for a variety of processes and activities. These include requirements and standards for drainage control, pond design and maintenance, sediment control, road design and maintenance, reclamation, permitted discharges to surface water, and protection of undisturbed drainages.

Specific provisions for protection of and minimization of impacts to groundwater include requirement for prevention or control of harmful mine drainage into groundwater (ARM 17.24.643), restoration of the approximate recharge capacity (ARM 17.24.644), selective placement of acid and toxic forming materials in mine backfill to prevent leaching (ARM 17.24.501, 17.24.643), and permanent sealing of drilled holes (ARM 17.24.632).

In addition, adherence to Best Technology Currently Available (BTCA) and Best Management Practices (BMPs) in the design and implementation of facilities, equipment, devices, systems, methods, and techniques is required for the minimization of hydrologic disturbance. These requirements and performance standards established in ARM 17.24 subchapter 5 through subchapter 12 are incorporated into mine operation and reclamation plans.

9.2 MINING IMPACTS

Impacts to the hydrologic system are expected as a result of mining. Groundwater and surface water may experience both short term and long term impacts that include: diminishment of spring flow due to subsidence, drawdown of groundwater levels or declines in pressure head, and changes in groundwater quality. Impacts are not limited to the permit area. There are anticipated impacts outside the permit area; however they are not expected to result in material damage. Impacts to surface and groundwater are discussed in detail below.

9.2.1 Historic, Prelaw Mining

Past coal mining in the area include the PM Mine and some historic, small-scale operations along the Mammoth coal outcrop that utilized room and pillar methods, which resulted in some limited residual subsidence (USDI, 2011). Existing residual impacts from historic coal mining in the area near the Bull Mountains Mine No.1 are unknown, as water quality data for these historic mining areas is unavailable.

Water quality data from underground coal mines to the north of the CIA (near Roundup, Montana), however, is available. Water quality data reported by Reiten and Wheaton (1988) indicate that the average groundwater concentrations of TDS and sulfate at underground coal mines in the Roundup area, sampled between 1910 and 1986, were 1,324 mg/L and 659 mg/L, respectively. Later, Wheaton (1992) again reported concentrations of TDS and sulfate in the groundwater of coal mined areas near Roundup collected between 1986 and 1991. Average TDS and sulfate concentrations were 2,647 mg/L and 1,445 mg/L, respectively.

These data do not represent water quality at the Bull Mountains Mine No. 1, but are presented to illustrate that residual water quality from abandoned mines in the area north of the Bull Mountains have the potential to influence water quality where historic workings are in close proximity to existing monitoring wells. At this time no residual impacts from historic mining near the Bull Mountains Mine No. 1 have been identified to indicate that historic workings in the CIA have influenced water quality.

9.2.2 Alluvial Valley Floors

As defined in Section 82-4-203(3)(a) and (b), MCA:

> *"'Alluvial valley floor' means the unconsolidated stream-laid deposits holding streams where water availability is sufficient for subirrigation or flood irrigation agricultural activities. The term does not include upland areas that are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion and deposits by unconcentrated runoff or slope wash, together with talus, other mass movement accumulation, and windblown deposits"*

The presence of an alluvial valley floor is determined by the presence of geologic, hydrologic, and biologic properties necessary to support agriculture. Alluvial deposits are found in both the Rehder and Fattig Creek valleys, however the alluvial deposits are generally dry and do not provide a source of subirrigation. Historic and current farming also does not depend on surface irrigation. Therefore, no alluvial valley floor has been identified in the area.

9.2.3 Surface Facilities and Waste Disposal Area Impacts

The facilities and WDA of the Bull Mountains Mine No. 1 are located in the northwest portion of the permit area (**Figure 3-4**). The main facilities area lies within PM Draw and includes coal processing, storage and loading facilities, unpaved roads, the rail loop, equipment fueling and storage areas, shops, the mine portal, and the mine offices. Additional peripheral infrastructure and facilities such as unpaved roads, crib pads, boreholes, power lines, and other improvements are located throughout the permit area and serve to support mine operations.

WDA1 is located in an unnamed ephemeral tributary to Rehder Creek immediately to the east of the facilities area. The WDA1 area includes the waste fill, plate press facility, equipment fueling and storage area, water storage tank, and a small office. A conveyor and slurry and water pipelines run from the main facilities area to WDA1. Major Revision 3 (TR3) proposes to construct a second WDA (WDA2) in another unnamed tributary of Rehder Creek immediately to the east of WDA1. The WDA2 area would consist of only the waste fill and the WDA support facilities would remain in WDA1. The conveyor would be extended across WDA1 to WDA2.

Within the disturbed area, Bull Mountains Mine No. 1 uses a network of ditches and detention ponds to convey and treat mine water and stormwater runoff. Mine water and stormwater from disturbed areas are detained within ponds, allowing suspended solids to settle out before discharge to ephemeral drainages, Rehder Creek and PM Draw, in accordance with MPDES Permit MT0028983. Solids retained in the ponds are removed to maintain sediment volume in the pond below 60 percent of the as-built storage volume. Sediments removed from settling ponds are disposed of in the WDA along with coal processing wastes (CPW) and mine development wastes. CPW are comprised of shales, sandstones, mudstones, and unrecovered coal fines that are removed from mined coal to make it marketable. CPW makes up more than 90 percent of the material disposed of in the WDA. Mine development wastes consist of shales, sandstones, mudstones, and poor quality coal that are removed to access economic-quality, or to maintain safety and access to underground workings. Mine development wastes are hauled directly to the WDA from underground without further processing. Mine development wastes makes up less than 10 percent of the materials in the WDA. Both coal processing waste and underground mine wastes use water from the deep underburden Madison wells (see **Section 8.4**) for cleaning and processing.

Each MPDES-permitted outfall at the facility is associated with a sediment pond designed to contain the runoff from a 10-year, 24-hour rainfall event. **Table 9-1** provides a description of the discharge point for each outfall. Influent flow to sediment ponds consists mainly of stormwater runoff from the disturbed zones within the facilities area. Sediment ponds are discharged periodically by pumping to retain pond storage capacity once the required retention time has been met, so that the discharge will comply with applicable MPDES requirements. Precipitation events in excess of the design capacity of a pond may cause discharges from ponds as flows overtop low lying spillways. Outfalls 001 and 008 are the primary outfalls controlling release of mine-produced water to Rehder Creek and PM Draw.

In addition to stormwater runoff, Outfall 006 is associated with a sediment pond (Pond F) that also receives groundwater discharged from underground mine workings (**Figure 3-4**). Water in this pond is either used for dust control or pumped into a second, lined storage pond for re-use underground. Ponds at outfalls 001, 002, 004, 005, and 008 may occasionally receive underground mine discharge water if water must be pumped from Pond F to other sediment ponds.

9.2.3.1 Impacts to Surface Water: Surface Facilities and WDA

Effects to the quantity and quality of surface water from mining operations at the facilities and WDA areas (**Figure 3-4**) are expected to be temporary, and limited to within the permit boundary. Flow through disturbed areas is ephemeral, occurring only in response to precipitation, and is managed through sedimentation ponds and regulated under DEQ's MPDES permitting section.

Due to the low precipitation in the area, pond discharges are infrequent. Discharges in 2011, 2013, and 2014 were the first since 1991. Extended wet spring conditions were widespread across much of Montana in the spring and early summer of 2011, 2013, and 2014 and wet-weather discharges were reported at the Bull Mountain Mine No. 1 in each circumstance.

During discharges which occurred in 2011 (**Table 9-2**), total recoverable iron, pH, total suspended solids (TSS), and oil and grease were within allowable limits. Settleable solids and pH effluent limitations were exceeded during a July 2011 discharge at Outfall 008, however violations were not issued due to widespread flooding throughout the region, and a 'state of emergency' issued by Montana Governor Schweitzer, in response to the extreme hydrologic conditions.

Discharges at several outfalls (001, 002, 006, 008, and 010) occurred in 2013 (**Table 9-3**). Several of these discharges were the result of a precipitation event in excess of the 10-year, 24-hour event flow, and effluent limitations for iron and TSS are therefore not applicable pursuant to ARM 17.24.633(5). SPE did receive a violation, however, due to settleable solids results being in excess of permit effluent limitations at Outfall 008, which controls discharge from the WDA. DEQ conducted a follow-up assessment in response to this discharge by sampling channel sediments at three locations downstream from Outfall 008. At each location, sediments were sampled for a variety of constituents including arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Toxicity characteristic leaching procedure (TCLP) analyses were conducted, and results compared against EPA solid waste criteria established under the Resource Conservation and Recovery Act (RCRA). Results showed non-detects for all TCLP parameters in all samples at levels well below criteria established by RCRA, indicating that's settleable solids released during these events posed no toxic threat to the environment.

The MPDES discharge samples taken on August 23, 2014 at outfalls 008 and SW-007 were the result of an unplanned discharge and caused by a precipitation event in excess of the 100-year 24-hour storm (**Table 9-4**). Over 3.6 inches of rain fell on 8/23/2014, overwhelming the capacity of the WDA pond to retain and treat runoff. It was noted that samples collected below the WDA pond at MPDES Outfall 008 were black with a high amounts of solid material. Settleable solids were measured at 215 mL/L/hr. Accordingly, the sample was elevated in comparison with past samples in organic nitrogen, phosphorus, and several metals (iron, lead, nickel, copper and zinc). SPE received a violation for pH exceeding effluent limitations at outfalls 002 and 010, and for total settleable solids exceeding effluent limitations at outfall 008.

Due to the use of deep Madison well water for coal processing, there is a potential for Madison well water constituents to accumulate in coal processing waste deposited in the WDA. Samples from deep Madison well water in 2006 and 2009 exceeded the HHS for both fluoride and radionuclides (Radium 226 + Radium 228). In April, 2014, the DEQ requested that SPE conduct water quality sampling to assess the potential for radium and fluoride concentrations reported in deep Madison aquifer wells to impact local water resources:

- Water samples from the Madison wells, Madison Pond, Pond F, and underground mine water were collected to assess the concentrations of radium and fluoride in water used for coal waste processing.
- Processed coal waste deposited in the WDA was sampled to assess radium concentrations in WDA material.
- Water samples from WDA Pond 1, and down gradient wells BMP-52 and BMP-33 were collected to assess whether radium and fluoride derived from Madison well sources listed above were present in surface or groundwater water that comes into contact with processed coal waste.

As displayed in **Table 9-5**, water quality results verify that groundwater from all three Madison wells contains radium and fluoride in concentrations that naturally exceeds the HHS. Underground mine water, Pond F water, and Madison Pond water all contained significantly lower concentrations of radium and fluoride due to dilution of recycled Madison water with naturally occurring groundwater. Excepting a radium result of 7.785 pCi/L from Madison Pond on 5/13/14, all radium and fluoride samples taken from these sources were below human health standards.

Water quality results from WDA Pond 1 and down gradient monitoring wells BMP-52 and BMP-33 (**Figure 3-4**) exhibited low levels of radium and fluoride (**Table 9-5**), with no exceedances of human health standards, verifying that runoff from coal waste deposited in the WDA has not accumulated radium or fluoride in concentrations that would cause impacts to downstream surface or groundwater resources.

During the life of the mining operation, ditches and culverts are employed to handle surface runoff within and around the mine facilities area. All ditches and culverts are routinely inspected to ensure that accelerated erosion is not occurring at the outfalls. No long term or permanent water quality impacts are anticipated due to the emplacement of these structures. Ponds are used to retain stormwater runoff from events equivalent to or less than the 10-year, 24-hour precipitation event. Ponds are anticipated to alter the duration, volume, timing, and frequency of stormwater runoff through PM Draw downstream of the mine area. This attenuation of runoff has limited potential to affect downstream surface water quantity since no surface water rights are held on PM Draw or Rehder Creek downstream of the facilities area (**Figure 8-2**); therefore, diminution or withholding of streamflows from ephemeral flow events is not expected to significantly impact downstream surface water users. The nearest downstream water rights are located on intermittent/perennial reaches of Halfbreed Creek, which is located over three miles distance downstream of the WDA.

Outside the main facilities area, land disturbance from peripheral support facilities has the potential for hydrologic impacts, and may include geomorphic alteration of channels, increases in sediment loading to drainages, and alteration of stream hydrographs. Surface water impacts to ephemeral streams resulting from surface disturbance are assessed through adherence to established and approved design criteria for the installation and maintenance of roads, culverts, and other surface structures, and through the proper placement and usage of BMPs designed to minimize surface impacts to watercourses. Surface water control and treatment plans have been designed to protect the hydrologic balance within the permit area and adjacent areas in accordance with ARM 17.24.314(2)(a) and (b) and 17.24.631 through 17.24.652. A detailed discussion of practices employed to comply with these requirements is provided in SMP C1993017, Vol. 3, Section 314, 3.0 Surface Water and Groundwater Control and Treatment Plan.

Adherence to the surface water control plan is evaluated through monthly inspections by DEQ staff. Where impacts or the potential for impacts is observed, DEQ conducts an assessment of the issue and directs the operator to comply with permit conditions as stated in the approved control and treatment plan. There is no evidence that surface disturbance has impacted surface water resources off the permit area.

9.2.3.2 Impacts to Groundwater: Surface Facilities and WDA

The alluvial groundwater with the greatest potential to be affected by operational impacts from the surface facilities is in PM Draw since this drainage goes through the principal area of operations. **Figure 9-1** presents hydrographs of static water level (SWL) and selected water quality data for alluvial monitoring wells in PM Draw. BMP-122 is down gradient from the mine facilities and BMP-40 and BMP-27 are up gradient. These wells show that the alluvium has generally been unsaturated except after the significant precipitation in 1991 and 2011. Well BMP-122 was a replacement for BMP-26 and was drilled to a slightly deeper depth. BMP-122 has shown a small amount of saturation since it was installed in May 2014.

Groundwater quality data in the PM Draw alluvium is limited by the infrequent presence of water. As is typical for marginally saturated alluvium, water quality is highly variable from location to location, and is likely dependent on the local lithology of the alluvial materials. The only numerical standard exceeded in PM Draw alluvial groundwater was nitrate-nitrite at BMP-27 in 2011. Because BMP-27 is located up gradient from the mine disturbance, this exceedance is not related to mining activities. This well is located near a stock tank used for cattle watering, and cattle are the most likely source for the elevated nitrate-nitrite observed in this sample. Water chemistry at the down gradient location, BMP-122, falls within the typical ranges observed for baseline alluvial groundwater quality. No deleterious trends have been observed, thus the suitability of PM Draw alluvial groundwater for its listed beneficial uses has not changed, and no material damage is indicated. Because no major changes to the mine facilities are proposed as part of AM3, no material damage is anticipated to occur and AM3 is designed to prevent material to PM Draw alluvial groundwater.

Groundwater extraction from the Madison aquifer for industrial use at the mine facilities is expected to be less than 600 acre-feet per year and will not have a significant drawdown effect on the aquifer. Due to the cost associated with pumping from this deep aquifer, SPE has been attempting to limit use of the Madison wells by capturing and reusing storm water and water pumped from the mine workings. nearest Madison well off site is approximately 20 miles from the mine and calculations indicate that the radius of influence of the Madison Group wells in use at the mine is limited to several miles (DNRC, 2012), thus no water quantity impacts are anticipated from pumping at the Madison wells and no material damage is expected.

WDA1, where coal waste is currently disposed, is in the drainage of an unnamed tributary just south of Rehder Creek (WDA1 tributary). There is potential for impacts to the Rehder Creek alluvial aquifer and shallow bedrock due to precipitation runoff and infiltration from WDA1. However, these impacts are limited by compaction to engineering standards of materials placed in WDA1 and detention of storm water runoff in sediment ponds. **Figure 9-2** presents hydrographs and selected water quality data for alluvial monitoring wells BMP-33 and BMP-104, and overburden monitoring well BMP-52, which are located near the northern permit boundary and down gradient from WDA1. Well BMP-104 is located in the thin alluvium of the WDA1 tributary, and is typically dry. Alluvial well BMP-33, completed in the Rehder Creek alluvium at the mouth of the WDA1 tributary, and overburden well BMP-52 have contained water throughout the period of record. Water levels in both wells show a response to the high precipitation event of 2011 indicating that the shallow overburden is in direct hydraulic connection to the alluvium at this location.

Recent water quality data for wells BMP-33 and BMP-52 have shown increases in conductivity, TDS, and sulfate. Similar increases also occurred in up gradient Rehder Creek alluvial well BMP-1 (**Figure 9-11b**); down gradient Rehder Creek alluvial wells BMP-16, BMP-87, and BMP-53 (**Figure 9-12**); and Fattig Creek alluvial well BMP-77 (**Figure 9-16a**), making it unlikely that WDA1 is the source of these concentration increases. The abnormally high water levels in the shallow groundwater due to the significant precipitation in 2011 may be responsible for mobilizing additional ions and producing the observed increases in water quality parameters. It is possible that storage of storm water and water from Madison Pond 1 for dust control in WDA Pond 1 adjacent to these wells is contributing to this effect. SPE, in consultation with DEQ, will develop a plan to evaluate the parameter increases near WDA Pond 1, and DEQ will require appropriate mitigation if mining related activities are contributing to the water quality parameter increases. SPE has already discontinued use of WDA Pond 1 for storage of Madison Pond 1 water for dust control. These increases in water quality parameters do not indicate the potential for material damage because the changes are within the range of natural increases observed during the same timeframe. Thus the suitability of the shallow groundwater for its listed beneficial uses has not changed relative to the natural condition.

After the WDA1 fill has reached its final elevation and is graded, it will be covered with a minimum of 4 feet of the best available non-toxic and non-combustible material, including subsoil and topsoil as described in the Reclamation Plan. No subdrainage systems will be installed. Toxic, acid-forming, and other deleterious materials, if encountered, will be handled and covered in accordance with ARM 17.24.505(2). WDA1 will be revegetated in accordance with the Reclamation Plan. The compaction of the fill material, the location of the fill above the typical saturated zone, and the cover and vegetation of the fill will limit any movement of water through the fill and therefor limit any potential for water quality impacts after closure of the fill. Water quantity may be slightly affected due to the reduction in infiltration, however these changes are expected to be insignificant to the hydrologic balance because WDA1 is not located in a significant recharge area and the natural geologic strata also had low permeability. The above described measures are sufficient to minimize disturbance to the hydrologic balance on and off the permit area, and to prevent material damage to the hydrologic balance outside the permit area. Thus no material damage is anticipated from WDA1 after its closure.

No major changes to the design, operations, or closure of WDA1 were proposed as part of AM3, thus AM3 is designed to minimize impacts to shallow groundwater near WDA1, and is not expected to cause material damage to the hydrologic balance outside the permit area.

Major Revision 3 (TR3) proposes to construct an additional WDA (WDA2) in the drainage of an unnamed tributary to Rehder Creek located just east of WDA1. WDA2 is proposed to be designed, operated, and closed similarly to WDA1 (see **Section 3.3**), thus the impacts from WDA2 are expected to be similar to WDA1. The location of WDA2 further inside the permit boundary also limits the possibility of any unlikely impacts from WDA2 extending outside the permit boundary and resulting in material damage. The TR3 application for WDA2 is still under review and may be modified prior to a permitting decision by DEQ. Although the cumulative impacts from all anticipated mining including WDA2 are considered in this CHIA, DEQ will conduct a separate cumulative hydrologic impact analysis for the TR3 permit application, which constitutes a major revision to the permit, prior to making the TR3 permit decision.

9.2.4 Impacts Due to Subsidence

Subsidence impacts include those hydrologic impacts introduced as a result of surface subsidence cracks or deformation of overlying strata as the coal is mined. Each longwall panel at the Bull Mountains Mine No. 1 consists of a large block of coal, approximately 1,250 feet in width by 15,000 feet to 23,300 feet in length. Surface depressions or subsidence troughs are expected to form as the overburden is undermined and coal is extracted. Overburden rocks are allowed to flex downward, fracture (creating a fractured zone) and collapse or cave into the void (forming a caved zone) causing immediate and progressive surface subsidence as the longwall system advances along the length of the panel. Generally, the amount of surface subsidence is less than the thickness of the coal seam and has been predicted to be about 70 percent of the extraction height in the Bull Mountains (Agapito, 1990).

The Mammoth coal ranges in thickness from eight feet to 12 feet in the permit area, so approximately seven to eight feet of surface subsidence is expected. This was confirmed in August 2011 when Panel 2 undermined the communication tower on Dunn Mountain and seven feet of subsidence was recorded. No damage to the towers was recorded; tension on the guy-wires was constantly adjusted as Panel 2 approached and undermined the tower. Linear surface fractures, minor rockslides, and small sink-like depressions (approximately five feet in depth) have occurred in some areas of higher overburden. This amount of subsidence including surface fracturing was anticipated as discussed in the protection/mitigation plan that was submitted and approved prior to initiation of longwall mining.

9.2.4.1 Topography Impacts

Continued mining as proposed under AM3 would create surface subsidence features similar to those experienced to date. Where subsidence features occur within established ephemeral watercourses, the profiles of these drainages may be modified by small ridges held up over barriers, pillars, mains, and gate roads, and by depressions over the longwall panels. Minor damage to roads and fences is anticipated, and minor cracks have been observed in the fall of 2013 along some roads above Panel 3. Additional subsidence features are observed where brittle rock units have fractured, leaving subsidence cracks on the land surface, particularly in areas of high cover.

Subsidence associated with the northern end of longwall Panel 4 in March 2014 resulted in a change in topography which would have impounded the flow of the 17-drainage. In response to this subsidence, and with concurrence of DEQ, SPE reconstructed the 17-drainage channel downstream from the end of longwall Panel 4 to restore the natural drainage connectivity and ensure passage of stream flows to maintain the hydrologic balance.

State regulations require mine operators to promptly repair damage to private property, and landowners must be provided with a mining schedule at least six months before their property is undermined. The schedule must contain enough information to enable landowners to move cattle to safe areas, and to avoid hazardous areas while mining is taking place.

9.2.4.2 Water Quantity Impacts

The main hydrologic issue regarding subsidence at the Bull Mountains Mine No. 1 is the potential for loss or diminution of the quantity of groundwater and surface water, and impacts to wells, springs, ponds, and stream reaches as a result of subsidence-related fracturing of overburden shales and sandstones. The potential exists for the alteration of surface and shallow groundwater flow paths as a result of subsidence-related fracturing.

Near vertical subsidence fractures are expected to be controlled or buffered by thick and relatively soft shales. Subsidence fractures in areas of shallow overburden cover may cause diversion of the shallow groundwater, and some increased lateral drainage from higher overburden units to lower springs also may occur as a result of flow along subsidence fractures. Settling and compression after mining are expected to heal or close most subsidence fractures soon after subsidence, thereby returning the shallow groundwater flow directions, including flow to springs, to approximately the premining orientation. Some spring impacts are expected as not all preexisting hydrologic flow-paths may be reestablished to premine conditions. If flow to the springs is impacted, the permittee is required pursuant to ARM 17.24.314(1)(c) to replace the water resource following methods discussed in SMP C1993017, Vol. 3, Section 314, Appendix 314-3 Spring Impacts Detection and Mitigation.

Discharge from the main mine portal at the facilities area is possible, but unlikely, after reclamation, and would be controlled initially by seals and a piping system as the rubble zone saturates and water levels rise. However, even without a piping system, the temporary effectiveness of the portal seals would probably not allow water levels to raise much beyond the elevation of the portal. Chemical and physical deterioration of the portal seals is expected to limit the operational life of the seals to a relatively short period. See page through the fractured shallow bedrock around the portal seals and deterioration of the seals should prevent filling of the mine pool much above the elevation of the portal. Any water flowing through the portal opening would be discharged into PM Draw at an approved MPDES discharge location, and be subject to MPDES regulatory requirements.

To date, only the first five panels of the proposed total of 14 longwall panels have been mined under the current permit (**Figure 9-3**). A network of springs and surface water stations are monitored regularly to evaluate the potential for impacts or material damage during or post mining. As longwall mining approaches monitored springs, the frequency of flow monitoring increases from monthly or quarterly to weekly so that any discernible impacts may be evaluated and mitigated in a timely manner and in accordance with the approved mitigation plan. Thus far, nine springs above Panels 2, 3, and 4 have been undermined. Undermined springs include: 17415, 17115, 17145, 17165, 17185, 17315, 17515, 17255, and 17275.

Litsky Spring (Station No. 17415) was undermined in late-March/early-April of 2012, and was the first known spring to be affected by mining operations (**Figure 9-3**). Adjacent monitoring wells BMP-60 and BMP-90 (**Figure 9-4**) recorded the drop in overburden water levels as the area under Litsky Spring was mined, followed by recharge of monitoring wells as subsidence fractures healed and water levels rebounded. The drop in water level in well BMP-60 was more pronounced as it was located over the middle of Panel 2, while BMP-90 is located closer to an underground gate road which limits the short-term subsidence observed at this well location. Presently, the water level in well BMP-60 is about seven to ten feet below historically low levels, while BMP-90 remains about three feet above historically low levels. The drop in water level in BMP-60 reflects a near-equivalent amount of subsidence. Recent recharge from abnormally high precipitation in 2011 and 2013 limits comparison of existing well levels to historical (2003 to present). As subsurface strata continues to deform and heal, it is anticipated that water levels will be reestablished at a stratigraphic level equivalent to pre-undermining. Continued monitoring of water levels will inform understanding of short and long-term response of underlying strata and consequent flow paths to undermining and subsequent recovery. Recent site visits and monitoring data confirm that the pond at Litsky Spring maintains water for livestock and wildlife use during wet periods and periodically goes dry during extended periods of low precipitation. In accordance with permit obligations defined in Appendix 314-3, Spring Impact Detection and Mitigation, SPE is required to provide replacement water for livestock and wildlife use to ensure that land uses are not adversely impacted. Presently, Litsky Spring does provide water supply to support livestock and wildlife land uses.

More recent undermining of springs occurred in 2013 and 2014 when several springs (17115, 17145, 17165, 17185, 17315, 17515, 17255, and 17275) were undermined as the longwall miner advanced through Panel 3 and Panel 4 (**Figure 9-3**). Springs 17115, 17255, 17315, and 17515 are typically dry, precluding any evaluation of impacts from undermining.

Spring 17145 (Bull Spring) is located above a gate road between Panels 3 and 4 (**Figure 9-3**) and was undermined to the west in February 2013, and to the east in April 2014. Prior to undermining, Bull Spring maintained low flows with median baseline flow conditions of one gpm, and with spring and summer flows commonly approaching three to four gpm. In May of 2014, Bull Spring exhibited an increase in flows through early July of 2014, after which spring flows tapered and ceased. Since November of 2014, Bull Spring has exhibited dry conditions, the first dry conditions reported since December of 2006. Undermining in the area has resulted in many discernable fractures in the uplands immediately adjacent to Bull Spring. This physical evidence, in conjunction with unexpected diminution of flows from Bull Spring suggests that Bull Spring may have been impacted by undermining. In accordance with permit obligations defined in Appendix 314-3, Spring Impact Detection and Mitigation, SPE initiated interim mitigation procedures to address the potential flow depletions. Continued monitoring of Bull Spring, and execution of the Interim Mitigation Plan proposed by SPE will inform whether permanent mitigation procedures will be necessary.

Spring 17165 is located down gradient from Bull Spring (**Figure 9-3**) and supplies spring water to an adjacent stock pond, 'Big Dam On Top'. Because spring 17165 is typically below the water level of the pond, spring flows are not able to be measured. The water level of 'Big Dam On Top', however, has lowered concomitant with the loss of flows at up gradient Bull Spring. While monitoring data does not conclusively confirm that 'Big Dam On Top' has been impacted by undermining, its proximity to Bull Spring suggests that undermining may be influencing the change in water levels at this location. Continued monitoring will inform whether mitigation measures will be necessary.

Spring 17185 is located approximately 1,500 feet down gradient of spring 17165 (**Figure 9-3**). Adjacent lands were undermined in May of 2013 and again in June of 2014. Prior to undermining, spring 17185 maintained low flows with median baseline flow conditions of two gpm, and with spring and summer flows commonly three to greater than 20 gpm. Beginning in July of 2015, spring 17185 exhibited its first dry conditions since February of 2007. Given its proximity to Bull Spring it is possible that undermining may be influencing the diminution of spring flows at this location. Continued monitoring of spring 17185 will inform whether mitigation procedures will be necessary.

Spring 17275 is located over the middle of Panel 4 (**Figure 9-3**), and was undermined in July of 2014. Prior to undermining, spring 17275 maintained low flows with a median baseline flow of 1.25, and seasonal spring flows commonly up to six gpm. Data collected after undermining shows spring flows similar to those measured prior to undermining. Presently, there is no evidence to suggest that spring flows at 17275 have been impacted by mining activity.

To date, all springs impacted by undermining have been within the permit area. For those springs impacted, mitigation is required. Mitigation of impacts from subsidence generally involves replacement of water supplies lost or diverted by subsidence-related processes with the purpose of maintaining premine land uses. Mitigation plans in the permit include restoring springs, stream reaches, and ponds by opportunistic development of springs where they appear, guzzler emplacements, horizontal wells, vertical wells, pipeline systems, deepening or rehabilitating existing wells, reclamation of stream reaches and function, water treatment where appropriate or necessary, and restoring premine land uses (MDSL, 1993). Detailed monitoring and mitigation plans are provided in SMP C1993017, Vol. 2, Section 313, Appendix 313-2 Spring/Seep Mitigation Plan.

Likewise, the rights of present and future groundwater and surface water owners or users will be protected in accordance with ARM 17.24.314(1)(b) and 17.24.648. ARM 17.24.648 states that "the permittee will replace the water supply of any owner of interest in real property who obtains all or part of his supply of water for domestic, agricultural, industrial or other legitimate use from a surface or underground source if such supply has been affected by contamination, diminution, or interruption proximately resulting from strip or underground mining operation by the permittee". To protect uses replacement water must be of a quality and quantity sufficient to satisfy premining consumption requirements.

As mining continues, undermining is expected to impact springs that are located over or adjacent to planned panels. As spring response to undermining is governed by a variety of factors, spring flow response to undermining is varied and may be different for each spring. Continued monitoring of wells and springs will allow additional evaluation of potential impacts as longwall mining advances and additional springs are undermined. Because spring response to undermining is limited to those springs located over or adjacent to longwall panels, it is not anticipated that springs outside the permit area will be affected by undermining.

9.2.4.3 Water Quality Impacts

Of the nine springs proximally undermined, only spring 17275 exhibits changes in water quality concurrent with undermining. Spring 17275 was undermined in July of 2014. Specific conductivity field measurements of spring waters increased from 1,280 μS/cm on July 9, 2014, to a maximum of 2,935 μS/cm on May 5, 2015, after undermining. Since the peak SC of 2,935, SC has gradually dropped to 2,600 μS/cm and appears to be trending downward. Laboratory analysis of grab samples collected verifies the increases in dissolved constituents. Total dissolved solids increased from 806 mg/L on April 7, 2014, to 1,620 mg/L on April 3, 2015, with increases in constituent concentrations calcium, magnesium, sodium, and sulfate responsible for over 75 percent of the dissolved solids increases. No increases were seen in metals concentrations. The probable mechanism for the increases in dissolved constituents is the dissolution of newly exposed mineral surfaces as a result of subsurface fracturing and cracking, allowing water to percolate through newly exposed surfaces.

To date, all springs impacted have been within the permit area, and the only changes in water quality that can be attributed to mining activity (subsidence) have been observed at spring 17275. Because any water quality effects to springs are expected to be limited to those springs that are located directly above or adjacent to mined panels, it is not anticipated that spring water quality will be affected outside the permit area.

9.2.5 Impacts to Surface Water

Potential impacts to surface waters are confined to those impacts resulting from land subsidence, facilities area and WDA disturbance, peripheral infrastructure and facilities (permit lands not including the main facilities and WDA).

Surface streamflow in the area is ephemeral and driven by storm events and extended periods of wet weather that act to recharge perched aquifers. Perched aquifers, in turn, supply spring flow and dry up during extended periods of below normal precipitation. Spring-flow may be impacted through subsidence processes related to undermining of the overburden aquifers, potentially interrupting, and/or altering subsurface flow-paths. Springs and seeps are monitored regularly in order to assess impacts from mining. Where flows from springs and seeps are impacted, water quantity, water quality, and water rights have the potential to be impacted. Impacts to water rights are assessed and evaluated with respect to regional and local impacts to spring systems that feed surface water resources.

As underground mining thus far has progressed through Panel 4 and part of Panel 5, potential impacts to surface waters have been confined to springs located over or proximal to undermined areas. As described in **Section 9.2.4.2**, impacts due to subsidence include diminution of spring flows at spring 17145, and increases in SC at spring 17275. SPE has begun to implement remedial mitigation measures at spring 17145, and continues to monitor water quality and quantity to assess whether recently identified impacts are temporary in nature, or will require more permanent solutions. Impacts identified thus far have been within the permit boundary and are anticipated. Mitigation measures have been implemented as prescribed in the operating permit in response to these anticipated changes.

To date, impacts from subsidence events have been limited to springs over mined areas. There have been no subsidence impacts to surface waters observed or recorded outside of the permit area, thus no material damage has occurred. As the current mining activity is proposed throughout the AM3 permit area, impacts similar to those observed to date are expected to occur as mining continues and no future material damage is anticipated. As impacts occur, mitigation procedures as described in Section 314-3 will be employed to remediate affected resources and to minimize disturbance to the hydrologic balance on and off the mine plan area.

Surface water runoff in the facilities area and WDA is controlled through a series of ponds and diversion structures and regulated through DEQ's MPDES program. Discharges to surface waters are very infrequent with the first discharges in 20 years occurring during extreme wet periods in 2011, 2013, and 2014. **Section 9.2.3** describes expected and observed hydrologic impacts and water management operations in the facilities and WDA.

Water management controls on peripheral infrastructure and facilities (permit lands not including the main facilities and WDAs) include structures to control runoff from mine roads, pads, and other land surface disturbances, and are managed through the implementation of BMPs. BMPs include a variety of design considerations (culvert sizing, berming, placement of structures, etc.) and are described in detail in SMP C1993017, Vol. 3, Section 314, 3.0, Surface Water and Groundwater Control and Treatment Plan. Evaluation of impacts relating to surface water runoff and management are therefore evaluated with respect to adherence to approved design plans and permit conditions in controlling and managing surface runoff. **Section 9.2.3** describes potential impacts and hydrologic controls implemented to minimize hydrologic impacts of peripheral facilities and infrastructure.

To date, there have been no impacts to surface waters located outside the permit area from the facilities, WDA, or peripheral infrastructure. All disturbances have been within the permit boundary, and no impacts have been observed outside of the permit boundary. Thus no material damage outside the permit area has occurred. Design plans for the control of pollution are sufficient to prevent off-permit impacts. Through implementation of these design plans, SPE has taken appropriate measures to minimize disturbance of the hydrologic balance on and off the mine plan area and to prevent material damage outside the permit area.

9.2.5.1 Exceedances of Water Quality Standards

Evaluation of impacts to surface waters as a consequence of mining is assessed through water quality monitoring, field observations, and monthly compliance inspections. Underground longwall mining does not create pollution sources that would typically alter nutrient or metals concentrations at the surface or create discharges of toxic materials that would result in violations of the C-3 standards of ARM 17.30.629(2) or the general prohibitions of ARM 17.30.637 (see **Section 2.1.1**). The potential for impacts to surface waters is therefore limited by type of pollutant sources that could affect surface waters as a consequence of mining.

Surface water quality samples that have an analyte that exceeds the HHS, the acute and/or chronic ALS established in Circular DEQ-7, or the nutrient standards established in Circular DEQ-12A are discussed below. Data used in the evaluation of the exceedances discussed below include data collected *after* the baseline data period addressed in **Section 7.0**. For a discussion of exceedances observed during baseline monitoring, see **Section 7.1**.

Exceedances of Circular DEQ-7 metals criteria in stream water quality samples include:

- Two chronic ALS exceedances of dissolved aluminum in February and March of 2014 at stream monitoring station 11756;
- Two chronic ALS exceedances of cadmium in February and March of 2014 at stations 11256 and 11756;
- A single chronic ALS exceedance of copper in March 2014 at station 11256;
- Ten chronic ALS exceedances of iron in February and March of 2014 at five different stream monitoring stations (11256, 11756, 12456, 15116, and 17516); and
- Six chronic ALS exceedances of lead in February and March of 2014 at stations 11256, 11756, 12456, and 15116.

There were no exceedances of the nutrient criteria established in Circular DEQ-12A at any stream monitoring stations, nor were there any exceedances of HHS established in Circular DEQ-7.

Exceedances of Circular DEQ-7 metals criteria in spring water quality samples include:

- Two chronic ALS exceedances of selenium in February and March of 2014 at spring monitoring stations 17315 and 17415; and
- A single chronic and acute ALS exceedance of zinc in July of 2011 at spring monitoring station 17415.

There were no exceedances of the nutrient criteria established in Circular DEQ-12A at any spring monitoring stations, nor were there any exceedances of HHS established in Circular DEQ-7.

Nearly all chronic ALS exceedances occurred during periods of snowmelt and runoff in February and March of 2014 and area associated with higher total suspended solids concentrations and low hardness conditions when metals criteria are much lower (aquatic life standards are dependent on hardness and are lower at lower hardness values). The chronic ALS exceedances observed fall within expected baseline ranges, and similar exceedances of iron, lead, copper, and cadmium were reported during the same runoff events (February and March, 2014) at other stream monitoring stations (53796, 12186, 52996) that have no potential to be effected by mining thus far. Additionally, Circular DEQ-7 allows a chronic ALS exceedance rate of once in three years, on average. So, while exceedances of some metals were identified at stream sampling stations outside the permit boundary, these exceedances fall within expected ranges and frequencies of baseline data, and do not constitute violations of water quality standards. Likewise, there have been no violations of the narrative general prohibitions of ARM 17.30.637 or the C-3 beneficial use criteria of ARM 17.30.629 as a result of mining in any water quality data collected, nor have water quality standards violations been observed or reported through field observations or monthly compliance inspections.

9.2.6 Groundwater

Groundwater monitoring data, maps, graphs, and the groundwater flow model included in the PHC were the primary tools used to assess groundwater impacts to the hydrologic balance within the CIA. Groundwater levels and quality data reported in annual hydrology reports submitted to DEQ each year by SPE were also used in this analysis. This data was used to evaluate water quantity and water quality in the potentially affected hydrostratigraphic units in the groundwater CIA.

As described in **Section 9.2.4** above, the longwall method of underground coal mining completely removes the target coal seam within each longwall panel and allows the overlying strata to collapse into the mine void as mining progresses. The collapsed material is known as gob. Fracturing and deformation resulting from subsidence extends through the overburden, becoming progressively less intense further upwards from the coal seam. As the Mammoth coal and lower overburden are saturated throughout much of the area there are impacts to groundwater and associated parts of the hydrologic system. Potential hydrologic changes include:

- Declines in groundwater water level or pressure head in mined hydrostratigraphic units;
- Potential water level declines or changes in pressure head in stratigraphically adjacent hydrostratigraphic units;
- Changes in groundwater flow direction and gradient near the mine due to water level declines or changes in hydrologic head;
- Loss of flow or diminished flow in springs ;
- Creation of localized recharge due to ponding in sediment control structures;
- Water quality declines in alluvial groundwater due to seeping of impounded sediment pond water into alluvium;
- Creation of gob with hydrologic properties different than the strata it replaced;
- Higher dissolved solids concentrations in gob due to dissolution of salts from fragmented and fractured overburden minerals; and
- Potential decline in water quality in adjacent hydrostratigraphic units due to movement of gob water.

The two main impact categories are changes in water level (or head) and water quality. The evaluation of impacts to water levels is based on analysis of observed changes in monitoring well water levels as mining approaches and exits from an area. Observations include the amount of decline in water level (or head) and the amount of time it takes for recovery. Variation in annual precipitation affects water levels, especially in shallow aquifers, and thus climatic effects must be considered in the analysis of water level response.

Current monitoring indicates mining has affected groundwater quantity by producing an area of drawdown around the dewatered mine workings. This area of drawdown is expected to increase and expand as mining progresses and then recover after mining is completed. Potential impacts to identified groundwater users in the groundwater CIA are shown in **Table 8-1**. Impacts to groundwater quantity are discussed in more detail in the following sections.

Potential changes in water quality attributable to mining are assessed by examining water quality at individual monitoring sites in the following sections. Water quality impacts are assessed by evaluating changes in analytical concentrations through time based on proximity to mining and other potential influences such as climate. TDS, as an indicator of the degree of water mineralization, is the primary indicator of a change in water quality. Changes in TDS largely reflect the change in sulfate concentration, and to a lesser degree, calcium, magnesium, and sodium. Although specific conductance (SC) is often used as an assessment of water quality, TDS is a better laboratory measurement of total mass in the sample. Both TDS and SC are used as indicators of water quality in the following sections. In addition to TDS and SC, all groundwater quality parameters monitored at the mine were evaluated during preparation of the CHIA, and any significant trends or insight derived from the analysis of additional parameters is included in the subsequent sections.

9.2.6.1 Groundwater Model

The AM3 application includes transient groundwater flow models to evaluate the potential effects of mining on groundwater in the area surrounding the mine. The main groundwater model simulates flow in all aquifers of concern but is focused on the Mammoth coal and upper underburden, as these aquifers are expected to experience the greatest effects from mining (Nicklin, 2016[2]). **Figure 9-6** shows the main model domain and layering. A separate model was also created which focuses on the deeper underburden (Nicklin, 2014). The groundwater models are calibrated by comparing model results to measured water levels from monitoring wells and adjusting model parameters to achieve the best simulation of groundwater conditions.

After calibration the model was run forward in time to predict water levels until the end of mining. In this predictive simulation, the mine tunnels are added to the model according to the proposed mine plan and schedule as drains which simulate the dewatering associated with mine development. As mining progresses the material properties of the Mammoth coal and overburden layers are also modified to simulate the collapse of material into the void left behind by longwall mining, and the subsidence and fracturing that occurs above the mined out areas. The results of this simulation are shown in **Figure 9-7**, which displays the predicted drawdown in the Mammoth coal and upper underburden at the end of mining. In the Mammoth coal, the area of the mine workings is completely dewatered, and an area of drawdown extends primarily to the north of the mine. A drawdown cone of depression is formed in the upper underburden, centered on the northern part of the mine workings and extending throughout the life of mine area and to the north. Drawdown to the south, east, and west in both the Mammoth coal and the upper underburden is limited by the outcrops of the aquifers in those directions. The implications of this drawdown are discussed in more detail in subsequent sections.

In order to predict the groundwater system response following the end of mining, another transient modeling simulation was utilized. All transient model simulations must represent a finite time period, with a beginning and end. In this case a fifty-year time period after the end of mining was used. This fifty year time period was chosen based on the professional judgement of the modeler, with the concurrence of DEQ's hydrogeologists.

The fifty-year time period provides sufficient information to quantify the nature and magnitude of changes to the groundwater system, and provides a basis for additional analyses outside of the groundwater model. The fifty-year time period encompasses the period of water level recovery after mining, such that by the end of the fifty-year period groundwater flow approximates a steady state condition. Particle-tracking analyses based on the fifty-year postmine model demonstrate the approximate rate of groundwater movement, which is expected to remain relatively constant after the fifty-year time period. Because of this quasi-steady state, the directions and rates of groundwater movement after this period are effectively demonstrated by end of the fifty-year time period and no additional insight would be gained by continued simulations.

The predictive capability of the model decreases over time, due to increasing uncertainty as the prediction progresses further into the future, and away from the known calibration time period. This increasing uncertainty is an unavoidable part of any model. Use of a numerical model beyond its reasonable predictive capability also implies a level of certainty in the predictions which is not justified and could be considered deceptive. Continuing the model simulation beyond fifty years provided no valid scientific insight beyond what could be derived from other methods of analysis.

Additional methods of analysis will provide the basis for projections of changes in water quantity and quality beyond the 50-year postmine model time period. These additional analyses, which can be based on the results of the model or on other data and observations, vary from theoretical conceptualizations to analytical calculations. These analyses are conducted by professionals with knowledge of groundwater flow and transport and are carried out to the level of complexity deemed appropriate to achieve an acceptable level of certainty within the constraints of the scientific process. No scientific analysis is capable of achieving 100 percent certainty and the level of certainty achievable decreases as the natural variably of the system being analyzed increases. The results of these additional analyses are discussed in the following sections of this document.

After the conclusion of mining, the gate roads are designed to and expected to cave. However, the exact timing of the gate roads caving is unknown, and therefore, two scenarios were tested using the postmine groundwater model. In the first scenario the hydraulic properties of the gob were assigned to all of the mined out area, to simulate complete caving of the gate roads. In the second scenario a much higher hydraulic conductivity was assigned to the cells representing the gate roads to simulate the gate roads remaining intact. It is probable that the first scenario (gate roads caving) most closely represents the actual post mine condition. Observations of the gate roads by mine personnel after the longwall has passed have demonstrated that the second scenario (gate roads remain intact) is not occurring. Any more resilient portions of the gate roads which cave more slowly, or experience only partial caving, are likely to be widely separated and not form the hydraulic connections necessary to create the mine pool simulated by the second scenario. Additionally, as mining progresses, concrete seals are constructed around each longwall panel which serve to further sever any possible hydraulic connections which could create widespread mine pooling.

If the gate roads completely cave, groundwater levels in the northern part of the mine area and north of the permit area will return to near premine levels. If the gate roads remain intact, a mine pool will form in the northern part of the mine workings resulting in postmine water levels higher than premine near the north permit boundary. In the postmining simulation representing the most likely scenario, water level recovery proceeds such that flow out of the mine workings towards the north begins approximately eight years after mining, near the western end of the mine. Flow out of the entire northern edge of the mine workings is not predicted to occur until approximately 20 years postmining.

By 50 years after the conclusion of mining (**Figure 9-8**) water levels are near a steady state condition and approximate the premine water levels outside the permit boundary and in the north part of the mine. Some residual drawdown will persist in the southern part of the mine area indefinitely due to the change in hydraulic properties from coal to gob (**Figure 9-9**).

A particle tracking model was used evaluate the rate of movement of groundwater in the Mammoth coal in the vicinity of the mine workings after mining. The particle tracking simulation was conducted for the Mammoth coal because this unit is most directly affected by mining, and has a higher permeability than the upper underburden. This model calculates the path a “particle” of water will take and the velocity of that water particle based on the groundwater flow model output. The particle tracking simulation results for the worst-case, unlikely scenario of the gate roads remaining intact show the first water particle reaching the permit boundary 31 years after mining. It must be noted again that this scenario has already been confirmed to be unlikely by observations of gate road collapse at the mine. For the likely scenario, the first particle of water reaches the permit boundary 138 years after mining. Based on the results of the modeling, the earliest that any water which had come into contact with mine gob is expected to reach the permit boundary is over 100 years after the end of mining. It must be made clear that the particle tracking model does not predict solute transport rates or concentrations, which are affected by factors other than the movement of groundwater. These other factors, such as dispersion, sorption, and dilution generally serve to slow solute transport rates and reduce solute concentrations. The groundwater water quality implications of the movement of gob water down gradient into the Mammoth coal are discussed in **Section 9.2.6.6**.

9.2.6.2 Alluvium

Forty-five alluvial monitoring wells monitor the alluvial aquifer system in the Bull Mountain area (**Figure 9-10**). Historic monitoring data indicates that the alluvium within and near the permit boundary is often dry. Generally, alluvial water levels have increased over time (since 2003) and are responsive to seasonal precipitation events, especially during the events in May of 2011.

Rehder Creek drains much of the proposed permit area. **Figure 9-11** shows upper Rehder Creek alluvial water levels in well BMP-17, BMP-19, BMP-46, and BMP-1, indicating that all wells responded to increased precipitation in 2007, 2011, 2013, and 2014. Also notable is how the degree and duration of saturation increases moving downstream. At upstream well BMP-17 (**Figure 9-11a**) alluvial water is present only after major precipitation events, moving downstream at wells BMP-19 and BMP-46 (**Figure 9-11a**) a small amount of water is usually present except during long dry periods, further downstream at well BMP-1 (**Figure 9-11b**) alluvial groundwater is always present. **Figure 9-12** shows lower Rehder Creek alluvial water levels in wells BMP-16, BMP-87, and BMP-53. Lower Rehder Creek alluvial well BMP-33 is shown in **Figure 9-2**. These wells show that the alluvium in lower Rehder Creek is nearly always saturated. Water levels in all of these wells responded to higher precipitation years, particularly 2011.

Water quality in upper and lower Rehder Creek alluvium (**Figure 9-11** and **Figure 9-12**) was fairly consistent prior to 2011, with concentrations of dissolved constituents increasing slightly from upstream to downstream. Following the high precipitation year of 2011, concentrations increased by 30 to 40 percent in most wells. These increases are most likely a result of higher alluvial water levels mobilizing additional ions from typically unsaturated alluvium. Since 2011 water quality trends in Rehder Creek alluvial wells have shown variable trends. In the most upstream wells concentrations have decreased, partway downstream they have remained steady, and further downstream they have increased. It appears that the soluble ions mobilized during the unusual hydrologic conditions in 2011 are being flushed downstream in the alluvium over time.

Tributaries of Rehder Creek known as the 16 and 17 drainages drain the majority of the area mined to date. These drainages join to form the 15 drainage near the end of longwall Panel 4, and the 15 drainage joins Rehder Creek a short distance upstream from WDA1. Water levels and quality in alluvial wells in these drainages are shown in **Figure 9-13**, **Figure 9-14**, and **Figure 9-15**. These hydrographs show that alluvial saturation generally increases in frequency and depth moving downstream. None of the wells show continuous saturation, but rather each well responds to major precipitation events and wet and dry periods. Alluvial well BMP-62 (**Figure 9-14**) shows an example of alluvial groundwater influenced by inflow from the shallow overburden aquifer. Alluvial groundwater is present in this well most of the time, with seasonal variations in water level due to snowmelt and increased spring precipitation evident. Water quality at BMP-62 is also much better than at other alluvial wells. Alluvial water quality samples from most wells in the 15, 16, and 17 drainages are limited by the limited water quantity in the alluvium of these drainages. The 17 drainage is the only drainage which has been undermined by the longwall to date, and the 15 drainage lies down gradient from that mining. The 16 drainage has not been disturbed by longwall mining, and thus still represents the natural condition. Alluvial monitoring wells BMP-32 (**Figure 9-14**) in the 16 drainage and BMP-45 (**Figure 9-13b**) in the 17 drainage show that alluvial water quantity and quality are similar in both drainages, indicating that undermining has not affected alluvial water quality or quantity in the 17 drainage. Both of these wells show increased concentrations as a result of the 2011 high precipitation and water levels.

Portions of the proposed permit area are also drained by Fattig Creek and Railroad Creek, and alluvial wells from these drainages are shown in **Figure 9-16** and **Figure 9-17**. Both the Fattig Creek and Railroad Creek drainages have not been disturbed by any mining activities and all data from these drainages represent natural conditions. Wells BMP-77 and BMP-93 (**Figure 9-16a**) are completed in the Fattig Creek alluvium and show similar water level trends with response to precipitation events as seen in the Rehder Creek alluvium. Alluvial groundwater quality in these wells also show a response to the significant precipitation event of 2011, with increases in SC, TDS, and sulfate. Wells BMP-125, BMP-126, and BMP-127 (**Figure 9-16b**) are new wells installed to gather additional water quantity and quality data in the upper portions of the Fattig Creek drainage prior to any mining disturbance. The data history for these wells is limited, but show greater water quantity in the eastern fork of Fattig Creek (BMP-125 and BMP-127) than in the western fork (BMP-126). Water quality parameter concentrations in the eastern fork of Fattig Creek are slightly higher than in the western fork. Well BMP-80 (**Figure 9-17**) is located in the Railroad Creek drainage, and shows the presence of alluvial groundwater in response to spring runoff and major precipitation events. Water quality in the Railroad Creek alluvium is highly variable.

Because the alluvial aquifer within the area to be mined is typically a perched aquifer supplied by recent precipitation or snow melt, additional mining is not expected to affect water levels in the alluvial aquifer unless significant fracturing from subsidence under the alluvium intercepted the perched alluvial water and allowed it to migrate into the bedrock. Even if this occurred, it would have no overall adverse impact on the hydrologic balance as the area of alluvium which will be undermined is minimal and rarely saturated. Alluvial water redirected into the bedrock by fracturing would likely re-emerge into the alluvium within a short distance downstream. These unlikely impacts would not constitute material damage because any adverse effects would be contained well within the permit boundary.

The alluvial hydrographs discussed above indicate that there is no evidence that mining and associated dewatering of the Mammoth coal have affected water levels of the alluvial aquifer system within or outside the permit boundary. Conversely, most alluvial monitoring wells show increases in water levels over time, even at BMP-1 where the alluvium appears to have some hydraulic connection with bedrock units which have experienced drawdown from mining. North of the permit boundary where the alluvium is saturated, the much greater permeability and storage capacity of the alluvial material compared to bedrock units makes any additional movement of water from the alluvium into the bedrock due to drawdown in the bedrock insignificant to water quantity in the alluvium.

Water quality of the alluvial groundwater has generally declined recently, however, based on the alluvial water quality graphs discussed above this appears to be due to significant precipitation in 2011 and the resultant higher alluvial water levels. When water levels rise in the alluvium, groundwater comes into contact with alluvial material which is not typically saturated and can dissolve available soluble ions from that alluvium. Since 2011 some wells have shown improvements in water quality, while others have remained at the higher concentrations. There is no evidence that alluvial water quality has been impacted by mining and the few exceedances of water quality standards observed in alluvial monitoring wells are not attributable to mining (**Section 9.2.6.7**). Therefore, no material damage outside the permit area has occurred. After mining, no groundwater which has measurably altered water quality due to flow through the mine gob is expected to discharge to alluvial groundwater. Based on the lack of any impacts to alluvial water quality from longwall undermining in the 17 drainage, the additional mining proposed in AM3 is not expected to have any effects on alluvial water quality in other drainages inside or outside the permit boundary, thus AM3 is designed to minimize disturbance to the hydrologic balance prevent material damage to alluvial groundwater.

9.2.6.3 Overburden

Overburden water levels are monitored by 28 monitoring wells located within the permit boundary and vicinity (**Figure 9-18**). Generally, water levels in overburden wells have increased over time.

The water levels and quality in wells BMP-63 and BMP-78 are shown in **Figure 9-19**. These wells are located in the highlands in the south portion of the AM3 area and are completed in perched groundwater in the uppermost overburden units. Both wells show water level responses to the increased precipitation in 2011. As discussed in **Section 7.2.3** the uppermost overburden units have the best water quality in the area, and both wells show steady trends of water quality over time.

Figure 9-20 shows that the water-level response of shallow overburden well BMP-2 is similar to that of nearby Rehder Creek alluvial well BMP-1 (**Figure 9-11b**), and BMP-50 is similar to adjacent alluvial well BMP-49 (**Figure 9-15**), indicating that both the shallow overburden and alluvium rapidly respond to seasonal precipitation events. Respective well logs show alluvium directly overlying overburden bedrock in these drainages indicating a likely hydraulic connection. Overburden well BMP-29 is not located near alluvial deposits, but this shallow overburden well also responds to precipitation, indicating that sandstones in the overburden allow rapid recharge of these shallow water bearing strata.

By contrast, deeper wells show stable to slowly increasing water levels in the deeper overburden aquifer in the area remote from mining (**Figure 9-21**). Both BMP-4 (north of the AM3 area) and BMP-118 (south of the AM3 area) show gradual increasing trends in water level, while well BMP-13 (east of the AM3 area) has steady water levels. The graphs for BMP-4 and BMP-13 in **Figure 9-21** also demonstrate that although the replacement wells installed in 2003 targeted the same depths of completion as the previous wells, not all replacement wells encountered the same groundwater conditions. Water levels in the well 02-2 were approximately 50 feet lower than in BMP-4. This amount of difference cannot be explained by changes in water level over time, and indicate that BMP-4 is completed in a different water bearing unit than 02-2 was. At BMP-13, although water levels are similar to the previous well, 09-2, the water chemistry is different also indicating a different hydrostratigraphic unit for the two wells. These types of differences in water quantity and quality in wells located in almost the same location are another example of the extreme spatial variability which is typical to the water bearing units in the Bull Mountains.

Currently, there is little evidence that longwall mining has had a significant impact upon overburden water levels except in and immediately adjacent to areas affected by subsidence. Water levels in monitoring wells BMP-60 and BMP-90 in the vicinity of longwall panel 2 have shown declines of approximately ten feet, respectively (**Figure 9-22a** and **Figure 9-4**). Inspection of the detailed hydrographs based on continuous recorder data in **Figure 9-4** for the two wells indicates that water levels in these relatively shallow overburden wells (BMP-60, TD=50 feet; BMP-90, TD=30 feet) were slowly declining after the precipitation of 2011 and then declined abruptly between February 2012 and April 2012 when BMP-60 went dry. **Figure 9-4** indicates that after this period water levels in both wells began to recover and subsequently have shown variations due to precipitation similar to before mining.

The abrupt decline of water levels suggests that the relatively shallow overburden and perched groundwater system in the vicinity of these wells was partially drained via subsidence fractures that healed over the period between February and April 2012 leading to the water level rebound due to precipitation recharge as seen in **Figure 9-4**. Well log data indicates that relatively impermeable gray shale occurs below the respective screened intervals. These rocks may have become fractured, allowing perched groundwater to drain into the mine workings, and then healed due to compression and settling. This data may illustrate that the various perched aquifers within the upper overburden may have become temporarily dewatered by subsidence fractures in the vicinity of BMP-60 and BMP-90 due to mining. Monitoring data will continue to be collected to evaluate the affect upon local overburden dewatered due to subsidence fractures.

Wells BMP-34 and BMP-58 (**Figure 9-22b**) are located over longwall Panel 3, and showed water level declines due to the mining of longwall Panel 2, approximately 900 feet away, from April to June 2012. Well BMP-34 showed further declines from September to October 2013 as longwall Panel 3 mining approached, and both wells were damaged by undermining in October 2013 and abandoned in 2014. BMP-10 (**Figure 9-22a**) and BMP-43 (**Figure 9-22b**) were located over longwall Panel 4 and were undermined in July 2014 and March 2015, respectively. Neither of these wells showed any water level response to longwall mining as it approached.

Figure 9-23 shows water levels and quality in overburden wells located near mining. Well BMP-107 is located over the barrier pillar for longwall Panel 1 and completely surrounded by room and pillar mining. Longwall Panel 1 stopped approximately 1,100 feet southeast of this well in April 2011. No impacts to water levels in this well from mining are evident. Wells BMP-57 and BMP-7 are located over longwall Panel 6. Gate roads were constructed west of these wells in the first quarter of 2014 and east of these wells in the summer of 2015. The nearest longwall mining to date is longwall Panel 4, approximately 2,500 feet to the southwest. Well BMP-57 is a shallower well and shows responses to seasonal precipitation, but no influences from mining. Well BMP-7 is deeper and shows overall steady water levels. The cause of the anomalous water levels measured in the past three years is unknown, but they do not correlate to the approaches of any mining activity, and water levels have returned to typical values between the anomalous measurements. A measurement error is most likely responsible for these anomalous water level readings.

Based on the responses of wells in the overburden near to an within the active mining area, temporary overburden dewatering may occur over all longwall mining areas as subsidence occurs, but these effects are expected to be limited in spatial and temporal extent. None of the overburden dewatering is expected to extend outside of the permit boundary. Because overburden groundwater in the Bull Mountains is sourced from local precipitation, the time necessary for recovery of water levels in overburden units which are drained by subsidence related fracturing will depend on local climate trends. While water levels in the overburden wells after undermining may be lower, as demonstrated by well BMP-60, the water bearing strata is also lower due to subsidence, resulting in no significant change in the saturated thickness. No permanent effects on overburden water quantity are expected as a result of mining.

Comparison of current and baseline water quality concentrations of TDS, sulfate, bicarbonate, and specific conductance in overburden wells BMP-60 and BMP-90 (**Figure 9-22a**), which have been undermined by the longwall, show no significant increases, indicating that undermining has not impacted water quality of the overburden aquifer. Although all other overburden wells which have been undermined have been damaged by subsidence and abandoned, these wells and overburden wells near mining have (**Figure 9-22** and **Figure 9-23**) also shown no impacts to water quality due to mining. The water quality of some shallower overburden wells (BMP-43, **Figure 9-22b**; BMP-90, **Figure 9-22a**; and BMP-57, **Figure 9-23**) show a decline in water quality during the rise of water levels associated with the 2011 high precipitation event, although this effect is generally muted compared to that seen in alluvial wells. Deeper overburden water quality at wells distant from mining (**Figure 9-21**) has remained generally consistent over time.

Elevated arsenic concentrations were reported in 2006 from monitoring well BMP-10. In 2006 BMP-10 was located just outside the eastern permit boundary and up gradient from mining until the approval of Amendment 2 in October 2012. Since that time BMP-10 has been located inside the permit boundary and over longwall Panel 4. The initial arsenic concentration (0.051 mg/L) recorded in 2006 was approximately five times the DEQ-7 HHS of 0.01 mg/L. Arsenic concentrations in this well have rapidly declined (**Figure 9-24**) and are currently near or below laboratory detection limits. A similar pattern of declining concentrations was recorded in this well for iron, which was associated with a less pronounced decline of specific conductance, TDS, sulfate, and bicarbonate (**Figure 9-22a**). Total suspended solids (TSS) concentrations have also shown a similar decreasing trend, indicating that the elevated concentration of these metals may be due to excess sediment remaining in the well after it was installed. As this excess sediment was removed by repeated pre-sampling well purging and TSS decreased, the concentrations of metals associated with sediment would also be expected to decrease similar to the observed trend for arsenic and iron. The source of the elevated arsenic concentrations in the overburden at BMP-10 is unknown but its location up gradient indicates that it is not related to mining. Accordingly, the proposed mining will not cause a violation of the water quality standard for arsenic outside the permit area and therefore no material damage will result from elevated concentrations of arsenic.

The few exceedances of numeric water quality standards for other water quality parameters in overburden wells are also not attributable to mining (**Section 9.2.6.7**). The fracturing associated with subsidence in the overburden does not significantly alter the availability of soluble ions in those units. Any changes in water quality are likely to be localized over the longwall panels. Because overburden groundwater does not flow through the mine workings, or come into contact with the highly fragmented mine gob, mining is not expected to affect overburden groundwater quality or cause exceedances of DEQ-7 standards outside the permit area. There will be no measurable effects on existing or anticipated uses, and no changes in water quality which will be harmful detrimental or injurious to the listed uses for Class II and Class III groundwater, therefore no material damage is expected as a result of AM3.

9.2.6.4 Mammoth Coal

Seventeen groundwater monitoring wells monitor water levels of the Mammoth coal inside and outside of the permit boundary (**Figure 9-25**). Water level data associated with a number of wells, especially those within the permit boundary, indicate that longwall mining and the development of gate roads has lowered water levels and created a cone-of-depression in the Mammoth coal that radiates outward from Panels 3 and 4 as mining continues. **Figure 9-26** indicates that drawdown or the radius of influence is greater east of mining where confined conditions exist within the coal; unconfined conditions prevail west and south of mining where the radius of influence is limited.

Hydrographs show that the respective water levels in BMP-37 and BMP-11 (**Figure 9-27**), and BMP-8 (**Figure 9-28**) have shown drawdown from approximately 24 feet to 47 feet near mining. BMP-37 and BMP-11 have both been abandoned and mined through. Room and pillar mining has surrounded well BMP-8 and the nearest completed longwall mining (Panel 4) is approximately one half mile west of this well. BMP-70 (**Figure 9-27**) has also been mined through but showed no discernable drawdown.

Water levels in the Mammoth coal north of the permit boundary in wells BMP-132 (formerly BMP-3) and BMP-5 generally declined slightly from 2003 through 2010, which is possibly attributable to mining related drawdown (**Figure 9-28** and **Figure 9-29**). Water levels in both of these wells increased following the high precipitation of 2011, with BMP-132 water levels rising 15 feet due to an apparent hydraulic connection of the Mammoth coal and alluvium near this location. After 2011 water levels in BMP-3 declined to approximately four feet below 2010 levels by early 2014 when BMP-3 failed resulting in abnormally high water levels. Water levels in the replacement well, BMP-132, are at approximately the same level as observed in BMP-3 in 2010. BMP-5 water levels have declined approximately two feet below 2010 levels. The high precipitation of 2011 may have acted to temporarily interrupt mining related drawdown at BMP-3 and BMP-5, but does not appear to have altered the long term trend of drawdown north of the mine as predicted by the groundwater flow model.

Mammoth coal drawdown is not observed two to three miles east of mining toward BMP-123 (**Figure 9-28**). Drawdown rapidly decreases west of the mine as water levels in BMP-30 have shown a general increasing trend since 2003 and well BMP-86 shows variable water levels typical of shallow wells influenced by precipitation (**Figure 9-29**). To the southeast at wells BMP-119, BMP-82, and BMP-21 (**Figure 9-30**), and to the east at wells BMP-14 and BMP-92 (**Figure 9-31**), water levels have remained stable or increased slightly. The water level record at BMP-74 (**Figure 9-31**) is sporadic, but generally shows stable water levels with a possible small response to the 2011 precipitation. Mammoth coal wells BMP-25 and BMP-115 are typically dry.

The water level observations in Mammoth coal monitoring wells are generally consistent with the expected pattern of decreasing drawdown radiating outward in all directions from the dewatered mine area. Current Mammoth drawdown illustrated in **Figure 9-26** (calculated drawdown 2004-2015) lies within the predicted drawdown of the groundwater flow model described in the PHC. Hydrologic impacts of longwall mining activity upon the Mammoth coal are limited by the extent of the coal to the south and west. The amount and extent of drawdown in the Mammoth coal is expected to increase as mining progresses, particularly to the north of the active mine area. The maximum predicted drawdown occurs at the end of mining, and the potential impacts to water users in the CIA are shown in **Table 8-1** and **Table 8-2**. These changes in water quantity due to mining will have no measurable effect on existing or anticipated uses of groundwater outside the permit boundary. Following the completion of mining, water levels will begin to recover, and are expected to reach a postmine equilibrium in less than 50 years as described in **Section 9.2.6.1**. Water quantity outside of the permit boundary after water level recovery is complete will be unchanged from the premining condition.

There is no evidence that mining has affected the water quality of the Mammoth coal aquifer. Comparison of SC, TDS, sulfate, and bicarbonate concentrations in Mammoth coal wells over time indicate that there are no persistent trends associated with mining. **Figure 9-27**, **Figure 9-28**, **Figure 9-29**, **Figure 9-30**, and **Figure 9-31** indicate that water quality data have generally been consistent over time regardless of changes in water level. Water quality of BMP-37, BMP-11, and BMP-8 are generally unchanged through time despite being in the immediate vicinity of active longwall mining, and experiencing mining related water level declines. Few exceedances of DEQ-7 standards were observed in the Mammoth coal wells and none are attributable to mining (**Section 9.2.6.7**). Based on current monitoring data there is no evidence that material damage to Mammoth coal groundwater quality outside the permit boundary is occurring.

Because mine dewatering produces groundwater flow towards the mine working during mining, no water quality affects are expected during mining. After mining is completed the Mammoth coal in the mine area will be replaced by the mine gob. Potential impacts from mine gob water migrating into the Mammoth coal are discussed in **Section 9.2.6.6**.

9.2.6.5 Underburden

The underburden aquifer in the area is monitored by 22 monitoring wells within and nearby the permit area (**Figure 9-32**). The drawdown map (**Figure 9-33**) of the upper underburden aquifer within the permit area shows water level declines similar to and development of a cone-of-depression nearly coincident with the drawdown observed in the overlying Mammoth coal aquifer. This indicates water levels in the upper underburden aquifer have also been affected by mining and that a hydraulic connection exists in some areas between the Mammoth coal and upper underburden aquifers where the potentiometric heads are similar.

Comparing the hydrographs for upper underburden wells BMP-12 (**Figure 9-34**) and BMP-9 (**Figure 9-35**) to the hydrographs for co-located Mammoth coal wells BMP-11 (**Figure 9-27**) and BMP-8 (**Figure 9-28**), respectively, shows that while drawdown has occurred at both locations in both hydrostratigraphic units at similar times, the magnitude and details of timing of drawdown can vary. This is likely due to the variable geology of the underburden, where the water bearing units tend to be discontinuous and separated by lower permeability rocks. Although no underburden well is co-located with Mammoth coal well BMP-37 (**Figure 9-27**), underburden well BMP-44 (**Figure 9-34**), located approximately one mile north shows a similar water level response to mining. Well BMP-71 (**Figure 9-34**) only showed drawdown immediately before being mined through by the longwall. The unusually low water levels measured in BMP-9 (**Figure 9-35**) in 2012 and 2013 are considered likely to be in error, as nearby well BMP-56 does not show a similar trend. As illustrated in **Figure 9-35** water levels in underburden well BMP-6 show a slight decreasing trend after 2007, but recovered in response to the high precipitation in 2011. Currently water levels are approximately two to three feet lower than premining levels, and five feet lower than 2004 through 2007 levels. The decrease in water level in BMP-6 is similar to the response seen in Mammoth coal well BMP-5 (**Figure 9-28**) and is likely related to mine drawdown.

Well BMP-39 (**Figure 9-36**), located directly under the main entries and less than 1,500 feet from longwall Panel 2 has shown no water level response to mining. Two other upper underburden wells, BMP-31 and BMP-42 (**Figure 9-36**), located within one and one half mile west of longwall Panel 1 also show no evidence of mining related water level changes, indicating that drawdown does not extend far to the west of mining. Underburden well BMP-31 is co-located with Mammoth coal well BMP-30 (**Figure 9-29**), but the underburden well shows water level fluctuations not observed in the Mammoth coal well indicating a hydraulic separation between the hydrologic units at this location. The water level fluctuations in underburden well BMP-31 do not appear to be related to mining and recent water levels have been similar to those first observed in 2003. **Figure 9-37** shows upper underburden wells located to the east (BMP-79, BMP-15, and BMP-83) and **Figure 9-38** shows wells to the south (BMP-85 and BMP-120) of the mine area which have not been affected by mine drawdown. The wells east of the mine are in similar locations as Mammoth coal wells BMP-74 and BMP-14 (**Figure 9-31**), and BMP-82 (**Figure 9-30**) and show similar slightly increasing water level trends. BMP-120 (**Figure 9-38**) shows generally steady water levels with an increase in 2011, similar to the trend observed in its paired Mammoth coal well BMP-119 (**Figure 9-30**). Well BMP-85 (**Figure 9-38**), southwest of the permit area shows limited saturation and variable water levels, similar to Mammoth coal wells in the same area.

Underburden wells BMP-38 and BMP-55 (**Figure 9-39**) show no effects of mining related drawdown, and the wells mimic the water level responses of the Rehder Creek alluvium observed in nearby wells BMP-33 (**Figure 9-2**) and BMP-53 (**Figure 9-12**) indicating that the underburden is hydraulically connected to the alluvium near these locations.

Due to the hydraulic connections between the Mammoth coal and the upper underburden, the future effects of mining on upper underburden water quantity are expected to be similar to those described for the Mammoth coal (**Section 9.2.6.4**).

Baseline water quality of the upper underburden aquifer is similar to water quality observed between 2003 and 2015. Currently there is no evidence that mining has affected the water quality of the upper underburden aquifer. Water quality graphs show no persistent trends or changes in the water quality of the underburden aquifer even in areas where the potentiometric surface of the upper underburden has been affected by mining (**Figure 9-33**). Consistent water quality has been recorded in most of the upper underburden wells shown in **Figure 9-34**, **Figure 9-35**, **Figure 9-36**, **Figure 9-37**, and **Figure 9-38** indicating they have remained unaffected by mining. Even well BMP-39 (**Figure 9-36**), located under the main entries and near longwall mining, shows no substantial changes in water quality from the baseline period. Water quality in well BMP-85 (**Figure 9-38**) has been variable, consistent with the trends generally seen in wells influenced by precipitation. Few exceedances of DEQ-7 water quality standards have been reported in the upper underburden wells and none are attributable to mining (**Section 9.2.6.7**).

Similar to the Mammoth coal, water quality in the upper underburden aquifer may be locally affected by migration of groundwater from the mine gob after mining is completed and water levels in the mine area recover. These potential effects are discussed in **Section 9.2.6.6**.

By contrast with the upper underburden, the relatively deep sandstones of the deeper underburden are hydraulically isolated from the Mammoth coal and upper underburden. Aquifer test data (Hydrometrics, 2009) associated with the Office Supply Well (OSW) confirm that confined conditions exist in these relatively deep sandstones (355-405 feet) and that the nearest domestic well, a distance of approximately 4,200 feet from the OSW, will not be adversely impacted by continuously pumping the OSW at approximately 6 gpm. During a pump test, observation well 62614-100-UB (BMP-121), located 3,346 feet from OSW, recorded 1.4 feet of drawdown. Projected drawdown shows 3.3 feet of drawdown in monitoring well BMP-121 and three feet of drawdown in the nearest private well after 20 years of continuous pumping. In reality, the OSW is not pumped continuously and the resultant drawdowns will be much less than these predictions. These relatively deep sandstones are the source of domestic use and are isolated from the effects of mining. Water levels in the deeper underburden have a limited record of monitoring (**Figure 9-40**) but have been consistent over time. BMP-121 has shown no water level effects from mining or pumping at the OSW. The only deeper underburden well monitored before mining was 62720-03 (BMP-64), and BMP-64 water levels were never able to be monitored due to pump equipment in the well (this well was converted to a stockwater supply after the initial cessation of mining) before this well was mined through. Well BMP-128 was installed approximately one mile from BMP-64 and show similar water levels in the deeper underburden as existed before mining.

No future water quantity impacts to the deeper underburden are anticipated from mine drawdown due to the hydraulic separation between the deeper underburden and the mine. Based on the results of the investigation presented in the Bull Mountains Mine No. 1 Permit, Appendix 314-7, (Nicklin, 2014) water quantity in the deeper underburden in sufficient to provide for the use at the OSW and any mitigation wells which may become necessary in the future.

Deeper underburden wells BMP-64, BMP-131, and BMP-132 have shown concentrations of arsenic over the DEQ-7 HHS. Arsenic concentration in the deeper underburden range from non-detect to 0.0679 mg/L. The exceedance at BMP-64 (then 62720-03) occurred before any mining occurred in the vicinity. The OSW, also completed in the deeper underburden, has shown no exceedances of the arsenic HHS and is permitted as a public water supply. Because of the isolation of the deeper underburden groundwater from any potential mining impacts, these Arsenic concentrations are considered representative of the natural condition, and do not indicate any material damage even where they occur outside the permit boundary. Because the deeper underburden is designated as the replacement water source if unexpected impacts to a water supply occur, SPE has committed to provide for treatment of deeper underburden groundwater in the event it is necessary. The suitability of deeper underburden groundwater quality for beneficial uses is described in **Section 7.2.5** and **Section 8.0**. No exceedances of HHS for any other parameters have been reported in deeper underburden wells.

No future water quality effects on the deeper underburden groundwater after mining are expected due to the hydraulic separation between the deeper underburden and the mine, thus material damage to the deeper underburden groundwater is not anticipated.

9.2.6.6 Gob

After mining water quantity in the initially dry gob is expected to increase due to the natural recharge from overlying water bearing zones in the overburden. In some locations this water level recover may be accelerated by drainage through fractures created as a result of subsidence. Predicted water levels in the gob and surrounding Mammoth coal 50 years after the end of mining are shown in **Figure 9-8**, and demonstrate that the postmine water quantity and flow approximates the premine condition (**Figure 7-4**).

Post mining groundwater quality within the gob is expected to be higher in dissolved solids after coming into contact with fresh rock surfaces exposed in subsidence fractures and mineralized rubble or gob. Oxidizing conditions are anticipated until after mining is complete and resaturation of the collapsed material has occurred. These conditions may result in increased sulfide oxidation, cation exchange, leaching, and weathering, which together may cause an increase in the concentrations of calcium, magnesium, sulfate, and sodium ions. This prediction is consistent with the PHC: “A general increase in total dissolved solids, sodium and sulfate concentration is anticipated in the groundwater that flows through the gob and potentially in the highly fractured zones immediately above the mined out area”

(Nicklin 2016[1], Section 6.2). Due to the buffering capacity of the alkaline mineralogy of the overburden and shallow underburden, development of acidic conditions in water present in the gob is extremely unlikely.

Water quality samples were collected from the mine gob in longwall Panels 3 and 5 in 2015. These samples represent partial saturation of the gob, which is likely to yield higher concentrations than are expected after complete saturation of the gob, but give insight into the potential water quality in the mine area after mining. The gob water quality samples had TDS concentrations of 3,220 mg/L and 3,320 mg/L, sulfate concentrations of 1,430 mg/L and 1,470 mg/L, and SC of 4,450 μS/cm and 4,730 μS/cm. As expected, these values are elevated relative to median baseline concentrations in the Mammoth coal and overburden groundwater. However, all parameter concentrations in the gob samples are within baseline ranges except for sodium and nickel. The eventual groundwater quality within the mined-out area or caved cone may become similar to the groundwater quality within abandoned coal mines near Roundup, Montana where the average TDS, sulfate, and SC concentrations are 2,042 mg/L, 1,106 mg/L, and 3,038 μS/cm, respectively. However, the groundwater quality within the caved zone may remain higher than these concentrations since the groundwater in the abandoned mines near Roundup does not come into contact with fractured gob material. Long term groundwater quality in the mine gob is likely to fall between the quality of the current gob samples and the quality of the Roundup mines.

As described in Section 6.2.3 of the PHC, Madison well water used in the underground mine workings is expected to constitute less than 0.1 percent of the total water in the mine gob voids. Because of this, the use of Madison well water in the underground mine workings is not expected to have any measurable impact on the quality of mine gob water.

Nickel concentrations in both gob water quality samples were elevated relative to baseline concentrations (typically non-detect), and one sample exceeded the DEQ-7 human health standard. No anthropogenic sources of nickel within the mine can be identified, thus it is likely that these exceedances are the result of mobilization of nickel naturally present in the overburden rocks which make up the gob material. Nickel mobility in groundwater is highly dependent on oxidation potential. The increased presence of oxygen in the partially saturated mine gob could cause de-sorption of nickel from the solid state into the groundwater. After mining, oxygen levels in the gob water will decrease as saturation increases and nickel concentrations are expected to decrease. Furthermore, as any gob water moves out of the mine workings and into the low-oxygen conditions in the Mammoth coal nickel is expected to become immobilized and precipitate. Thus migration of nickel concentrations exceeding numeric standards outside the permit boundary is not anticipated, and material damage is not expected to occur. No other parameters in the gob water samples exceeded DEQ-7 standards.

Groundwater quality in the mine gob is expected to be higher in dissolved constituents relative to natural water quality, however, due to the slow water movement in the Mammoth coal and upper underburden, gob water is not expected to migrate outside the permit boundaries in sufficient quantities to cause changes in water quality which would be harmful, detrimental, or injurious to the listed beneficial uses for baseline Mammoth coal groundwater. Based on groundwater flow rates predicted by the postmine groundwater model the groundwater flow from the mine gob into the Mammoth coal after mining is 1.89 gpm. The vertical infiltration from the overburden to the Mammoth coal between the mine workings and the northern permit boundary is predicted to be 3.73 gpm. The median concentration for SC in the lower overburden wells within one mile of the northern permit boundary is 1,700 μS/cm. The median concentration of the gob water quality samples is 4,590 μS/cm.

Using these values a simple mixing calculation results in a predicted SC value of 2,674 μS/cm in the Mammoth coal at the northern permit boundary as a result of dilution alone.

As discussed in **Section 9.2.6.1**, the natural processes of dispersion and sorption also are expected to reduce solute concentrations along the predicted flowpath between the mine workings and the permit boundary. Dispersion is caused by the variable paths (on a microscopic scale) that water takes as it travels through a porous media, and has the effect of spreading out a solute plume over space. Dispersion has two relevant effects on solute transport: The first is to spread out the arrival time of a solute plume symmetrically around that predicted by the mean groundwater velocity, meaning that some of the solute will arrive before the predicted advective travel time and some after the predicted time. The second effect is to reduce the maximum concentration of a solute as the total mass of the solute is spread over a larger area. Sorption is two similar and closely related processes, adsorption and absorption. Adsorption is attachment of a solute to the outside surfaces of mineral grains whereas absorption is capture of the solute inside the mineral structure. Adsorption is generally the most common mechanism occurring in groundwater. Both forms of sorption have the effect of slowing solute transport and reducing solute concentrations. Sorption is a dynamic process, with molecules of the solute continually attaching and detaching from minerals in the porous media. Because the solute molecule does not move during the time it is attached, this slows the movement of the solute relative to the water. The degree to which any given solute's movement is slowed is dependent on the nature of the solute, the minerals present in the porous media, and interactions with other solutes. Movement of solutes can range from barely slower than the movement of water to orders of magnitude slower. Generally, larger and positively charged molecules move more slowly than smaller and negatively charged molecules. Porous media containing more clay minerals, which have more surface area available for solutes to attach to, also tend to increase sorption and slow solute transport. Sorption also reduces the concentration of a solute because some molecules become permanently attached to the porous media and cease altogether to move with the groundwater.

Because of the complexity of these processes, calculating exact results for solute travel time and concentration is not possible. The net effect of dispersion and sorption on transport of gob water into the Mammoth coal seam north of the mine workings will be that arrival of increased SC water at the permit boundary will likely take greater than the 138 years predicted by particle tracking, and concentrations will likely be less than the 2,670 μS/cm calculated above. The median SC of samples from the three Mammoth coal wells north of the permit boundary is 2,550 μS/cm, and measured values range from 1,500 μS/cm to 3,900 μS/cm. The most reliable Mammoth coal well in this area with the longest period of monitoring (BMP-5) has a median SC of 2,605 μS/cm. **Figure 9-41** illustrates the natural range of water quality Mammoth coal groundwater near the northern boundary of the mine, the mixing process described above, and the resulting predicted post mine condition. As shown in **Figure 9-41**, the expected postmine water quality transitions in the Mammoth coal north of the mine are minor. After considering all relevant factors, it is highly unlikely any changes in water quality in the Mammoth coal will be able to be distinguished from the natural variability present in the Mammoth coal groundwater.

The water quality changes described above are expected to persist into the foreseeable future. Water quality in the gob is likely to improve gradually over time as the fresh rock surfaces of the gob are weathered and the available soluble ions decrease. However, thus is a slow process and concentrations of TDS and other water quality parameters in the mine workings will likely remain elevated relative to the premine condition for centuries. Concurrent with the gradual improvement in water quality in the mine gob, the minor off site water quality changes will also decrease over time.

Figure 9-42 compares the natural range of water quality in the Mammoth coal groundwater near the northern boundary of the mine, gob water quality, and the predicted post mine water quality in the Mammoth coal at the northern permit boundary to relevant guidelines for uses. As expected, **Figure 9-42** shows that gob water quality is predicted to be less suitable for livestock drinking water than natural Mammoth coal groundwater. **Figure 9-42** shows that based on TDS both premine and postmine Mammoth coal groundwater are unsuitable for human drinking water, suitable for livestock drinking water, marginally suitable for irrigation of alfalfa and grasses, and suitable for irrigation of wheat. Any changes in water quality outside the permit boundary due to mining will have no measurable effect on existing or anticipated uses and the groundwater in the Mammoth coal outside the permit boundary will remain equally suitable for all listed beneficial uses of Class II and Class III groundwater as it was prior to mining. Due to the fact that the expected changes in overall TDS are so minor, no changes in individual parameters are expected to result in exceedances of DEQ-7 numeric standards. Because of this no material damage in Mammoth coal groundwater from migration of gob water is expected to occur as a result of AM3 mining.

Because the upper underburden exhibits some hydraulic connection with the Mammoth coal, gob water migration into the upper underburden is also possible. However, due to the lower conductivity of the upper underburden compared to the Mammoth coal any impacts in the upper underburden are expected to be less than those observed in the Mammoth coal. Therefore, for the reasons discussed above regarding the Mammoth coal no material damage to upper underburden groundwater from migration of gob water is anticipated as a result of AM3 mining.

9.2.6.7 Exceedances of Numeric Water Quality Standards

Water quality samples that have an analyte that exceeds the human health standards (HHS) established in Circular DEQ-7 are listed in **Table 9-9**. Analyses are conducted per the requirements of the monitoring and sampling plan for each mine. Groundwater sample results are reported as dissolved concentrations. **Section 9.2.6.7.1** through **Section 9.2.6.7.6** discusses the exceedances listed in those tables. Parameters not discussed in the following section have had no documented exceedances of DEQ-7 HHS. As discussed in **Section 9.2.6.2** through **Section 9.2.6.6** no future exceedances of DEQ-7 HHS are anticipated.

9.2.6.7.1 **Arsenic**

The HHS for arsenic is 0.01 mg/L. There were 18 exceedances of this standard in groundwater samples in seven wells. Each of the locations with arsenic HHS exceedances is discussed below.

- Well 06-2 had three exceedances with concentrations of 0.015 mg/L and 0.016 mg/L from 1989 to 1990. This well is a lower overburden well located over longwall Panel 6, which was replaced by BMP-7. All of the arsenic exceedances are part of the baseline data at this well, and arsenic concentrations in all subsequent samples at 06-2 and BMP-7 have been non-detect.
- Well 08-4 had one exceedance in 1989 with a concentration of 0.011. This well is an upper underburden well located under longwall Panel 4 which was replaced by BMP-12. The arsenic exceedance occurred during the baseline period and arsenic has not been detected since in 08-4 or BMP-12, except for a single detection at a concentration of 0.0006 mg/L in 2014.
- Well 09-4 had one exceedance in 1989 with a concentration of 0.012 mg/L. This well is an upper underburden well located east of the AM3 permit boundary which was replaced by BMP-15. This arsenic exceedance occurred during the baseline period and only three other arsenic detections have occurred at this location, all below the HHS.

- Well 62720-03 had one exceedance in 1992 with a concentration of 0.017 mg/L. This well is a deeper underburden well located under longwall Panel 3 and was replaced by BMP-64. The occurrence of arsenic in deeper underburden wells is discussed in **Section 9.2.6.5**.
- Well BMP-10 had seven exceedances from 2006 to 2009. Exceedances at this overburden well are discussed in more detail in **Section 9.2.6.3**.
- New deeper underburden wells BMP-128 and BMP-129 have had five exceedances in 2014 and 2015. The occurrence of arsenic in deeper underburden wells is discussed in **Section 9.2.6.5**.

Arsenic occurs naturally at concentrations which can exceed human health standards in groundwater in the Fort Union Formation. Based on the above discussion of samples with arsenic exceedances there is no indication that mining has caused or created a situation that has contributed the occurrence of arsenic inside or outside the mine area. None of the exceedances reported for arsenic may be attributed to mining operations, and do not constitute material damage.

9.2.6.7.2 **Barium**
There have been two exceedances of the HHS standard for barium (1 mg/L) in monitoring wells in the Bull Mountains. Both of these exceedances occurred during the baseline period in 1989 and are not related to mining or considered material damage.

9.2.6.7.3 **Cadmium**
The HHS for cadmium is 0.005 mg/L and has been exceeded only three times in Bull Mountains monitoring wells. All of these exceedances occurred in the baseline period from 1989 to 1991. None of the exceedances for cadmium may be attributed to mining operations or are considered to represent material damage.

9.2.6.7.4 **Lead**
The HHS for lead is 0.015 mg/L. Fifty-nine groundwater samples from 41 wells have exceeded this limit, all from analyses from 1989 to 1996. The wells that yielded the exceedances do not have recent concentrations that approach the human health limits, suggesting that there is not a persistent problem. The reports of lead concentrations above the human health limit likely represent the imprecision of laboratory analysis for lead using older methods. Samples for lead since the mine reopened in 2003 have shown no exceedances for lead and have overwhelmingly been non-detect. None of the lead exceedances are attributed to mining operations and no material damage is indicated.

9.2.6.7.5 **Zinc**
Two exceedances of the zinc HHS of 2 mg/L in groundwater are reported in the Bull Mountains Mine database. Both exceedances were from samples taken during the baseline period in 1990 and 1991 and are not attributed to mining operations or considered to represent material damage.

9.2.6.7.6 **Nitrite-Nitrate**
Two samples from the Bull Mountains Mine monitoring wells have had nitrate concentrations above the HHS of 10 mg/L. One exceedance was in an overburden well southeast of the mine during the baseline period in 1989. The second exceedance occurred in 2011 in a PM Draw alluvial well, and is discussed in **Section 9.2.3.2**. Neither of these exceedances is attributable to mining or is considered material damage.

9.2.7 Cumulative Impact of Historic, Current and Proposed Mining

Cumulative or synergistic impacts from previous mining are negligible, as previous mines in the CIA were very small in comparison to the Bull Mountains mine and had little to no impact on the hydrologic balance. There are no other current mines operating in the Bull Mountains area. Anticipated mining is limited to the construction and operation of WDA2, as discussed in **Section 3.3** and **Section 9.2.3**. Because of the limited nature of the expected impacts to the hydrologic balance from the construction and operation of WDA2, no impacts from WDA2 are anticipated to interact with the impacts from the proposed operation of AM3.

9.3 Non-Mining Impacts

The primary non-mining impact on the hydrologic balance in the Bull Mountains is from agriculture. Cattle grazing impacts the quantity and quality of surface water resources, and springs are impacted by alterations to their issue points to support cattle watering. These impacts are discussed in **Section 7.1.3**.

10.0 Conclusion

The above sections of this CHIA represent an in depth analysis of impacts to the hydrologic balance from mining that includes an assessment of existing or probable changes to the hydrologic balance inside and outside the permit area resulting from the proposed operation of AM3 and an evaluation of material damage outside the permit area where impacts to the hydrologic balance resulting from AM3 may interact with previous, existing, and anticipated mining. A summary of the conclusions of this analysis is presented below.

10.1.1 Surface Water

Potential impacts to surface waters are generally confined to those impacts resulting from land subsidence, facilities area and WDA disturbance, and peripheral infrastructure (permit areas not including the main facilities and WDAs). These potential impacts are evaluated by monitoring water quantity and quality from a network of spring, stream and pond monitoring stations.

Surface streamflow in the area is ephemeral and driven by storm events and extended periods of wet weather that act to recharge perched aquifers. Perched aquifers, in turn, supply spring flow and dry up during extended periods of below normal precipitation. Spring-flow may be impacted through subsidence processes related to undermining of the overburden aquifers, potentially interrupting, and/or altering subsurface flow-paths. Springs and seeps are monitored regularly in order to assess impacts from mining. Where flows from springs and seeps are impacted, water quantity and water rights have the potential to be impacted. Impacts to water rights are assessed and evaluated with respect to regional and local impacts to spring systems that feed surface water resources. **Section 9.2.4** describes anticipated and observed impacts to surface waters from subsidence.

As underground mining thus far has progressed through Panel 4 and part of Panel 5, potential impacts to surface waters have been confined to springs located within the permit area over or proximal to undermined areas. As described in **Section 9.2.4**, impacts due to subsidence include diminution of spring flows at spring 17145, and increases in specific conductivity at spring 17275. SPE has begun to implement remedial mitigation measures at spring 17145, and continues to monitor water quality and quantity to assess whether recently identified impacts are temporary in nature, or will require more permanent solutions. Impacts identified thus far are anticipated and mitigations measures have been implemented as prescribed in the operating permit, in response to these anticipated changes.

To date, no material damage to surface waters from undermining and subsidence is evident. Impacts are limited to springs over mined areas, and no subsidence impacts to surface waters has been observed or recorded outside of the permit boundary. As the current mining activity is proposed throughout the permit area, impacts similar to those observed are expected to occur as mining continues. As impacts occur, mitigation procedures as described in Section 314-3 of the permit will be employed to remediate affected resources.

Surface water runoff in the facilities area and WDA is controlled through a series of ponds and diversion structures and regulated through DEQ's MPDES program. Discharges to surface waters are very infrequent with the first discharges in 20 years occurring during extreme wet periods in 2011, 2013, and 2014. **Section 9.2.3** describes expected and observed hydrologic impacts and water management operations in the facilities and WDA.

Water management controls on peripheral infrastructure and facilities (permit lands not including the main facilities and WDAs) include structures to control runoff from mine roads, pads, and other land surface disturbances, and are managed through the implementation of Best Management Practices. Best Management Practices typically include a variety of design considerations (culvert sizing, berming, placement of structures, etc.) and are described in detail in SMP C1993017, Vol. 3, Section 314, 3.0, Surface Water and Groundwater Control and Treatment Plan. Evaluation of impacts relating to surface water runoff and management are therefore evaluated with respect to adherence to approved design plans and permit conditions in controlling and managing surface runoff. **Section 9.2.3** describes potential impacts and hydrologic controls implemented to minimize hydrologic impacts of peripheral facilities and infrastructure. Monitoring of water quality and quantity do not show any violations of water quality standards off the permit area, and confirm that AM3 is designed to minimize impacts to the hydrologic balance and prevent material damage to surface water quality and quantity from facilities infrastructure and WDA development.

10.1.2 Groundwater

The two main potential impacts to groundwater from mining are reductions in available water quantity at wells due to drawdown and migration of lower quality water off site. These potential impacts are evaluated by monitoring water levels and quality in a network of 105 monitoring wells installed in the alluvium, overburden, Mammoth coal, upper underburden, and deeper underburden. Evaluation of potential future impacts is also assisted by the use of a groundwater model.

Alluvial groundwater quality changes have been noted in a well (BMP-33) immediately down gradient of one sediment pond. It is unclear if the changes observed in BMP-33 have been affected by storage of water in this sediment pond. Similar water quality changes in the alluvial groundwater occurred throughout the area in response to an unusually wet year in 2011. SPE has changed their water management procedures to limit the storage of water in this pond. Continued monitoring will be used to evaluate any further changes in water quality in BMP-33, and further action will be taken if necessary to prevent adverse impacts to alluvial groundwater. Comparisons of alluvial groundwater levels and quality in drainages undermined by the longwall to those in undisturbed drainages indicate that undermining has had no effect on alluvial groundwater quantity or quality. Because of these observations and the similar nature of the alluvial groundwater which will be undermined in the future, no future impacts to alluvial groundwater are anticipated and AM3 is designed to prevent material damage to alluvial groundwater quantity and quality.

Monitoring wells completed in the overburden indicate that declines in water level in overburden groundwater only occur immediately before undermining by the longwall. Drawdown in the overburden as a result of mining does not extend very far from the mined area. No water quality changes have been observed in overburden monitoring wells which have been undermined or are near the mining area. Future water quantity impacts are expected to be similar to the observed impacts to date, and limited to the immediate mining area. Because fracturing associated with subsidence does not significantly change the availability of dissolved ions, no changes in overburden groundwater quality are expected in future undermined areas. No future impacts to overburden groundwater quantity or quality outside of the permit area are expected, thus AM3 is designed to prevent material damage to overburden groundwater quantity and quality.

Monitoring indicates that water levels in the Mammoth coal around the mined area are decreasing to form a cone of depression as predicted in the PHC and groundwater model. The current maximum drawdown of approximately 50 feet occurs at well BMP-8 in the mine area. After mining is completed, the Mammoth coal within the mine area is replaced by the fractured overburden material (gob) which collapses into the mine void. Water levels in the gob and Mammoth coal are expected to slowly recover. The groundwater model predicts water levels will reach near-stable post mine levels within 50 years after mining. Water levels are predicted to be similar to premining conditions, except in the south portion of the mine area, where some residual drawdown is expected to be permanent due to the changes in permeability from coal to gob. Because drawdown is not expected to adversely impact any Mammoth coal groundwater users outside the permit boundary, AM3 is designed to prevent material damage to Mammoth coal groundwater quantity.

No changes to Mammoth coal groundwater quality have been observed, even in areas where drawdown is occurring. Because of the increased availability of dissolved ions from the fractured mine gob, water quality in the gob groundwater is expected to be poorer than baseline water quality in the Mammoth coal. Initial water quality samples were collected from the mine gob in longwall panels 3 and 5 in 2015, and had a median specific conductance of 4,590 μS/cm. Water quality sample from older mines near Roundup have shown a median specific conductance of 3,038 μS/cm. It is likely the eventual specific conductance in the Bull Mountains Mine gob will be lower than the initial samples, but not as low as the Roundup mines due to the different mining methods used. Using the quantities of water flowing into the coal north of the mine after mining (as predicted by the groundwater model), the sampled gob water quality, and the median overburden water quality in the area near the north edge of the mine, a simple mixing calculation results in a specific conductance at the north permit boundary of 2,674 μS/cm. Due to the effects of dispersion and sorption, two natural processes which tend to reduce solute concentrations, the actual specific conductance at the permit boundary after mining is likely to be less than this calculated value. Baseline Mammoth coal water quality in this area ranges in specific conductance from 1,500 to 3,900 μS/cm with a median of 2,550 μS/cm. The most reliable Mammoth coal well north of the mine with the longest period of record has a median specific conductance of 2,605 μS/cm. **Figure 9-41** illustrates that any changes in water quality outside of the permit boundary due to migration of gob water into the Mammoth coal will be minor.

Figure 9-42 shows that post mine Mammoth coal water quality outside of the permit boundary will be equally suitable for beneficial uses as the natural Mammoth coal groundwater. This water quality would persist over time. Furthermore, analysis of the factors contained in ARM 17.30.715(2) does not indicate that significant degradation would occur. As indicated in **Section 9.2.7**, cumulative or synergistic impacts are negligible. Salinity is not subject to decomposition or chemical breakdown. No loading or flow changes would create significant impact. No other information provided by public comment or otherwise would indicate significance. Based on all available information and the above predictions and analysis it is unlikely that mining will cause any measureable changes to existing or anticipated uses, cause changes in water quality outside the permit area which are harmful, detrimental, or injurious to the beneficial uses of Mammoth coal groundwater, or cause any numeric standard to be violated. For these reasons, AM3 is designed to prevent material damage to Mammoth coal groundwater quality.

Observations of water quantity and quality in the upper underburden indicate some hydraulic connectivity between the upper underburden and the Mammoth coal, and drawdown observed in the upper underburden is similar to that in the Mammoth coal. Water level recovery after mining in the upper underburden is expected to occur similarly to that described for the Mammoth coal above. Because drawdown is not expected to adversely impact any upper underburden groundwater users outside the permit boundary, AM3 is designed to prevent material damage to upper underburden groundwater quantity.

No water quality impacts attributable to mining have been observed in the upper underburden. Because the upper underburden exhibits some hydraulic connection with the Mammoth coal, gob water migration into the upper underburden after mining is also possible. However, due to the lower conductivity of the upper underburden compared to the Mammoth coal any impacts in the upper underburden are expected to be less than those observed in the Mammoth coal and described above, thus AM3 is designed to prevent material damage to upper underburden groundwater quality.

Monitoring of the deeper underburden has shown no effects on water quality or quality due to mining. Due to its isolation from the Mammoth coal and upper underburden by thick layers of low permeability rocks, no water quantity or quality impacts to the deeper underburden are expected as a result of mining, thus AM3 is designed to prevent material damage to deeper underburden groundwater quantity and quality.

10.1.3 Material Damage Determination

The conclusion of the analysis is that the proposed operation of the mining operation of AM3 is designed minimize disturbance to the hydrologic balance both inside and outside the permit area and to prevent material damage outside the permit area.

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MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY

Permitting and Compliance Division

MONTANA POLLUTANT DISCHARGE ELIMINATION SYSTEM (MPDES)

Permit Fact Sheet

Permittee: Western Energy Company
Castle Rock Road
Colstrip, MT 59323

Location: Rosebud County
Latitude 45.87324N, Longitude, -106.77748W (Area C Office)

Permit No.: MT0023965

Receiving Waters: East Fork Armells Creek, Stocker Creek, Lee Coulee, West Fork Armells Creek, Black Hank Creek, Donley Creek, Cow Creek, Spring Creek, Pony Creek

Facility Information:

Name: Rosebud Mine

Contact: Kent Salitros, Vice-President and General Manager

Fee Information:

Type: Privately Owned Treatment Works – Major
(SIC 1221)

Number of Outfalls: 9 (for fee determination only)

BASIS FOR PERMIT MODIFICATION

On January 16, 2015, Western Energy Company (hereinafter permittee) submitted an application for modification to Montana Pollutant Discharge Elimination System (MPDES) permit No. MT0023965 (hereinafter permit) for the Rosebud Mine (hereinafter facility). The following modifications are requested:

A. Reevaluation of effluent limitations applied to outfalls discharging to a specific reach of East Fork Armells Creek that has been studied and reported to have intermittent portions. The entire reach subject to the permit was previously determined to have an ephemeral hydrologic condition with effluent limitations reflecting that condition;
B. Addition of six new Western Alkaline Standards outfalls to the permit and transfer of one existing outfall to Western Alkaline Standards;
C. Removal of Outfall 10C;
D. Reevaluation of effluent limitations assigned to Outfall 010; and
E. Reassignment of certain representative monitoring outfalls due to changes in drainage control and mine-related activity.

This fact sheet identifies the legal requirements and technical rationale that serve as the basis for the modification to requirements of this permit. Pursuant to ARM 17.30.1361(1) and ARM 17.30.1365(4)(b) only those permit conditions being considered for modification are reopened and addressed by this fact sheet. All other permit conditions remain in full effect and are not changed by this modification.

A. East Fork Armells Creek Intermittent Reach

The current and previous MPDES permits for the facility identified the entire reach of East Fork Armells Creek within the mine permit boundary and subject to this permit as having an ephemeral hydrologic condition. As defined by ARM 17.30.602(10), an ephemeral stream is a stream or part of a stream which flows only in direct response to precipitation in the immediate watershed or in response to the melting of a cover of snow and ice and whose channel bottom is always above the local water table. Two recent studies of East Fork Armells Creek have identified a reach that meets the definition of intermittent (Arcadis, 2014; NEW, 2014). As defined by ARM 17.30.602(13), an intermittent stream is a stream or reach of a stream that is below the local water table for at least some part of the year, and obtains its flow from both surface run-off and ground water discharge.

As summarized by the 2014 Nicklin Earth and Water (NEW) study, investigations of the area during the 1970s and 80s reached conflicting conclusions on whether hydraulic communication between the stream channel and alluvial aquifer (ground water) was representative of an intermittent stream (NEW, 2014). NEW evaluated decades of alluvial well monitoring data in the vicinity of the East Fork Armells Creek intermittent reach against mining and climate historical data. Surface mining in the early 1980s initially resulted in a drawdown of alluvial aquifers below the stream channel base. Aquifer levels gradually recovered to pre-mine levels during the 1990s and 2000s. However, starting in 2011, aquifer levels rose well above pre-mine levels, likely due to several years with substantial precipitation and a corresponding increase in discharges from MPDES outfalls near the studied reach.

The entire segment of East Fork Armells Creek within the mine permit area was determined by the current and previous MPDES permits to be ephemeral, with effluent limitations assigned to reflect this hydrologic condition. While the stream segment within the mine permit area remains predominantly ephemeral, the presence of an intermittent reach requires the assignment of effluent limitations protective of the intermittent condition of this reach.

1. Identification of Outfalls Associated with the Intermittent Reach of East Fork Armells Creek

Based on aerial photo interpretation coupled with well and climate data, the 2014 NEW study reports that East Fork Armells Creek transitions from an ephemeral to an intermittent stream somewhere between Outfalls 021 and 020 (see Appendix 1). While Outfalls 021 and 022 discharge to the upstream ephemeral reach of East Fork Armells Creek, effluent discharged from these outfalls is likely to reach the downstream intermittent reach. Effluent discharged from outfalls upstream of Outfalls 021 and 22 is unlikely to reach the intermittent segment due to the presence of an in-channel dam between Outfalls 022 and 023 (see Appendix 1). Therefore, the outfalls associated with the East Fork Armells Creek intermittent reach and addressed by this permit modification are Outfalls 009, 09A, 011, 012, 013, 13A, 014, 015, 016, 016A, 018, 019, 020, 021and 022.

2. Discharge History

Monthly discharge monitoring reports (DMRs) submitted by the permittee indicate 28 discharges associated with intermittent reach outfalls took place between January 1, 1999 and December 31, 2014. All applicable effluent limitations were met. Nineteen of these discharges were "dry weather", meaning the discharge resulted from the dewatering of sediment ponds via pumping to maintain capacity. The remaining nine discharges were "wet weather" discharges, meaning that precipitation or snowmelt events caused sediment ponds to overtop. Seven of the nine wet-weather discharges were caused by precipitation events exceeding the 10-year, 24-hour event size that the ponds are designed to contain and treat. A summary of discharge event data is presented in Table 1.

Table 1. Intermittent Reach Outfalls Discharge History (1999-2014)

Parameter	Units	Permit limits(1)	Number of Samples(2)	Min. Value	Max. Value
Aluminum, dissolved	µg/L	Monitor only	4	40	1940
Arsenic, total	µg/L	Monitor only	4	1	28
Boron, total	mg/L	0.7/1.1	24	<0.15	0.52
Cadmium, total	µg/L	Monitor only	4	<1	0.82
Chloride	µg/L	Monitor only	4	31000	77000
Chromium, total	µg/L	Monitor only	4	<5	70
Copper, total	µg/L	Monitor only	4	<5	64
Discharge Volume	acre-feet	Monitor only	25	<0.001	127
Electrical Conductivity, field	uS/cm	Monitor only	5	761	3730
Electrical Conductivity, lab	µmhos/cm	Monitor only	3	680	2980
Flow Rate	mgd	Monitor only	13	0.03	2.07
Iron, total	mg/L	3.5/7.0(3)	24	0.03	63.9

Parameter	Units	Permit limits(1)	Number of Samples(2)	Min. Value	Max. Value
Lead, total	µg/L	Monitor only	4	<1	57
Mercury, total.	µg/L	Monitor only	4	<0.1	0.11
Nickel, total	µg/L	Monitor only	4	<5	63
Nitrate + nitrate, as N	mg/L	Monitor only	4	0.02	2
Oil and Grease	mg/L	--/10	23	<5.3	2.0
pH, field	s.u.	Between 6.0 and 9.0	17	6.4	8.45
pH, lab	s.u.	Monitor only	24	6.44	8.60
Selenium, total	µg/L	Monitor only	3	1	3
Settleable solids (SS)	ml/L	--/0.5(4)	18	<0.5	6.0
Silver, total	µg/L	Monitor only	3	<2	2
Sodium Adsorption Ratio	unitless	Monitor only	3	0.26	1.49
Sulfate	mg/L	2050/3075	24	5	1770
Temperature, field	°C	Monitor only	5	2.5	25.4
Total Dissolved Solids (TDS)	mg/L	3000/4500	24	394	2820
Total Suspended Solids (TSS)	mg/L	35/70(4)	22	<10	406
Zinc, total	µg/L	Monitor only	4	<10	314

Footnotes:
(1) Permit limits are expressed as average monthly/maximum daily limits.
(2) Includes both quantified and non-quantified results.
(3) Permit limit is not applicable to discharges caused by precipitation events per 40 CFR 434.63. Maximum reported values therefore do not demonstrate noncompliance.
(4) Permit limit is not applicable to discharges caused by precipitation events greater than the 10-year, 24-hour event size (40 CFR 434.63).

3. Receiving Water Characteristics

Some numeric standards are dependent on characteristics of the receiving water such as pH, temperature, and hardness. Data used to characterize receiving water quality were collected at surface water monitoring station SW-75, which is maintained in accordance with the mine's surface mining permit. SW-75 is located outside of the mine permit boundary and upstream of mining, and is therefore the sampling location most reflective of current background water quality in areas not impacted by mining activity. Data from 2010-2014 Annual Hydrology Reports submitted in accordance with the surface mining permit are summarized and presented in Table 2.

Table 2. Receiving Water Characteristics

East Fork Armells Creek (Station SW-75)	
Class of Receiving Water	C-3
25th Percentile Receiving Water Hardness Value (mg/L as CaCO3) (minimum and/or default is 25 mg/L, and maximum is 400 mg/L)	400
25th Percentile Receiving Water pH Value (default is 6.5 s.u.)	7.64
75th Percentile Receiving Water pH Value (default is 9.0 s.u.)	8.22
75th Percentile Receiving Water Temperature (°F) (default is 86°F)	65.8

a. Impaired Waters

The State of Montana 2014 Integrated 303(d) List and 305(b) Water Quality Report lists East Fork Armells Creek segment MT42K002_170, from the headwaters to Colstrip, as a category 4C water body, indicating the non-attainment of any applicable water quality standard for the segment is not caused by a pollutant. Alteration in stream-side or littoral vegetative covers is identified as a probable cause of impairment and surface mining is identified as a probable source. While this segment is not supporting aquatic life, total maximum daily loads (TMDLs) are not required as no pollutant-related use impairment is identified.

East Fork Armells Creek segment MT42K002_110 from Colstrip to the mouth is listed as a category 5 water body, indicating that one or more beneficial uses have been assessed as being impaired or threatened and a TMDL is required. This segment of East Fork Armells Creek is listed as not supporting aquatic life. The probable causes of impairment are nitrate plus nitrite, electrical conductivity, total dissolved solids, and total nitrogen, with agriculture, coal mining, and transfer of waters as probable sources of impairment. As this segment is directly downstream of the mine, the permit contains monitoring requirements or limitations for electrical conductivity, TDS, total nitrogen, and nitrate plus nitrite to address the discharge of these pollutants from the facility. When a TMDL is adopted and approved for any of these pollutants, the Permit may be modified to include effluent limitations based on appropriate wasteload allocations (WLAs) to control each parameter and protect beneficial uses.

b. Beneficial Uses

East Fork Armells Creek is tributary to the Yellowstone River and belongs to the Lower Yellowstone-Sunday hydrologic unit (HUC 10100001). East Fork Armells Creek falls under the C-3 Water-Use Classifications for the Yellowstone River drainage from the Billings water supply intake to the North Dakota state line [ARM 17.30.611(1)(c)]. The beneficial uses applicable to C-3 waters are summarized in Table 3.

Table 3. Beneficial Uses of Receiving Waters

Classification	Beneficial Uses	Regulatory Citation
C-3	• Bathing, swimming, and recreation • Growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl, and furbearers • Natural water quality is marginally suitable for drinking, culinary and food processing purposes, agriculture, and industrial water supply.	ARM 17.30.629

c. Numeric and Narrative Standards

Montana Water Quality Standards (WQS) include both specific WQS and general provisions that protect the beneficial uses set forth in the water use classifications. General treatment standards in ARM 17.30.635 and ARM 17.30.637 apply to all discharges from the permittee's facility.

In addition to the general prohibitions in ARM 17.30.635 and 17.30.637, discharges to non-ephemeral C-3 waters must comply with the specific WQS in ARM 17.30.629, as well as numeric WQS in Department Circulars DEQ-7 and DEQ-12A. Degradation which will impact established beneficial uses will not be allowed. For new or increased sources, the non-degradation policy requires that, for all state waters, existing and anticipated uses and the water quality necessary to protect those uses must be maintained and protected [ARM 17.30.705(2)(a)].

d. Nondegradation

The Montana Water Quality Act includes a nondegradation policy in 75-5-303 MCA. This policy is applied during the permit application process through a nondegradation review of any new or expanding discharge. Outfalls associated with the East Fork Armells Creek intermittent reach were permitted prior to April 29, 1993 and are not new or increased sources as defined at ARM 17.30.702(18). Therefore, discharge at these outfalls is not subject to nondegradation review.

e. Mixing Zone

75-5-301(4) MCA requires the Board of Environmental Review to adopt rules governing the granting of mixing zones. DEQ adopted such regulations and codified them at ARM 17.30, Subchapter 5.

Mixing zones are granted by DEQ only when a permittee has *applied* for a mixing zone, where they are *needed* (where a discharger cannot meet the applicable numeric WQS at the point of discharge), and where they are *appropriate* (based on the criteria specified in the regulations).

The receiving water segment for intermittent reach outfalls has a critical low flow of 0 cubic feet per second (cfs), providing no dilution water for a mixing zone. Therefore, a mixing zone is not authorized by the permit.

4. Rationale for Effluent Limitations

There are two principal bases for effluent limitations: technology-based effluent limitations (TBELs) that attain technology-based standards and limitations specified in the federal regulations and water quality-based effluent limitations (WQBELs) that attain and maintain applicable numeric and narrative WQS within Montana's water quality standards. TBELs are based on implementing available technologies to reduce or treat pollutants while WQBELs are designed to protect the beneficial uses of the receiving water. The federal regulations at 40 CFR 122.44(a)(1) [incorporated into ARM 17.30.1344(2)(b) by reference] require that MPDES permits include conditions that meet all applicable technology-based standards and limitations, at a minimum, and any more stringent effluent limitations necessary to meet applicable WQS.

a. Applicable TBELs

TBELs are based on federal or State technology-based standards and reflect a minimum level of treatment or control for point source discharges. These standards are developed based on the performance of current available treatment and control technologies. USEPA has established effluent guidelines for the coal mining industry at 40 CFR Part 434, Effluent Limitations Guidelines for the Coal Mining Point Source Category (ELGs). Subparts B – Coal Preparation Plants and Coal Preparation Plant Associated Areas; D – Alkaline Mine Drainage; and F – Miscellaneous Provisions are applicable effluent guidelines for intermittent reach outfalls. In accordance with 40 CFR 434.61, for commingled waste streams, the most stringent TBELs for a pollutant apply.

The Clean Water Act (CWA) requires that TBELs for non-POTWs (industrial and commercial facilities) be based on several levels of control:

1. Best practicable treatment control technology (BPT) represents the average of the best performance by plants within an industrial category or subcategory. BPT standards apply to toxic, conventional, and non-conventional pollutants.
2. Best available technology economically achievable (BAT) represents the best existing performance of treatment technologies that are economically achievable within an industrial point source category. BAT standards apply to toxic and non-conventional pollutants.
3. Best conventional pollutant control technology (BCT) represents the control from existing industrial point sources of conventional pollutants including Biochemical Oxygen Demand (BOD), TSS, fecal coliform, pH, and oil and grease. The BCT standard is established after considering the “cost reasonableness” of the relationship between the cost of attaining a reduction in effluent discharge and the benefits that would result, and also the cost effectiveness of additional industrial treatment beyond BPT.
4. New source performance standards (NSPS) represent the best available demonstrated control technology standards. The intent of NSPS guidelines is to set limitations that represent state-of-the-art treatment technology for new sources.

The CWA also requires the development of effluent guidelines representing application of BPT, BAT, BCT, and NSPS. Effluent guidelines are promulgated by USEPA under the authority of Sections 301, 304, 306, 307, 308, 402, and 501 of the CWA (33 U.S.C. 1311, 1314, 1316, 1318, 1342, and 1361).

Coal Preparation Plants and Coal Preparation Plant Associated Areas

The provisions described in 40 CFR Part 434, Subpart B are applicable to discharges from coal preparation plants and associated areas. These include discharges that are pumped, siphoned, or drained from preparation plant water circuits, coal storage, refuse storage, and ancillary areas related to the cleaning or beneficiation of any rank of coal. When discharges from these areas normally exhibit a pH equal to or greater than 6.0 prior to treatment, the TBELs in Table 4 apply.

Table 4. TBELs – Coal Preparation Plant Area and Associated Areas

Parameter	Units	30-day Average Limitation	Daily Maximum Limitation	Category
Iron, Total	mg/L	3.5	7.0	BPT, BAT
TSS	mg/L	35	70	BPT
pH	s.u.	6.0 – 9.0		BPT

Alkaline Mine Drainage
The provisions described in 40 CFR Part 434, Subpart D are applicable to alkaline mine drainage from existing sources. Alkaline mine drainage is water, drainage, or discharges that normally exhibit a pH equal to or greater than 6.0 and total iron concentration of less than 10 mg/L. Pursuant to 40 CFR 434.40, TBELs for alkaline mine drainage are applicable to drainage from an active mining area of coal of any rank. TBELs presented in Table 5 are applicable to discharges of alkaline mine drainage.

Table 5. TBELS – Alkaline Mine Drainage

Parameter	Units	30-day Average Limitation	Daily Maximum Limitation	Category
Iron, Total	mg/L	3.5	7.0	BPT, BAT
TSS	mg/L	35	70	BPT
pH	s.u.	Between 6.0 and 9.0		BPT

Precipitation Driven Discharges
For discharges driven by precipitation events, alternative effluent limitations are established in the permit, based on 40 CFR 434.63, instead of otherwise applicable effluent limitations.

1) Precipitation Events Less than or Equal to the 10-year, 24-hour Event.
TBELS presented in Table 6 are applicable to any discharge or increase in the volume of discharge caused by precipitation within any 24-hour period less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume). The National Oceanographic and Atmospheric Administration (NOAA) Atlas 2, Volume 1 (1973) defines the 10-year, 24-hour precipitation event as 2.4 inches.

Table 6. TBELs - Precipitation Events Less Than or Equal to the 10-yr, 24-hr Event

Parameter	Units	30-day Average Limitation	Daily Maximum Limitation
Settleable Solids	mg/L	--	0.5
pH	Standard units	Between 6.0 and 9.0	

2) Precipitation Events Greater than the 10-yr, 24-hr Precipitation Event.
TBELs presented in Table 7 are applicable to any discharge or increase in the volume of discharge caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume).

Table 7. TBELs - Precipitation Events Greater Than the 10-yr, 24-hr Event

Parameter	**Units**	**30-day Average**	**Daily Maximum**

		Limitation	Limitation
pH	Standard units	Between 6.0 and 9.0	

b. Determining the Need for WQBELs

USEPA regulations at 40 CFR 122.44(d) require that all discharges be assessed by the permitting authority to determine the need for WQBELs in the permit. Specifically, 40 CFR 122.44(d)(1)(i) states that limitations must be established in permits to control all pollutants or pollutant parameters that are or may be discharged at a level that will cause, have the reasonable potential to cause, or contribute to an excursion above any state WQS. Thus, a "reasonable potential analysis" (RPA) is used to determine whether a discharge, alone or in combination with other sources of pollutants to a water body and under a set of conditions arrived at by making a series of reasonable assumptions, could lead to an excursion above an applicable WQS.

Pollutants of concern for discharges from outfalls associated with the intermittent reach of East Fork Armells Creek include total iron, total suspended solids (TSS), settleable solids (SS), and pH. These pollutants and parameters are identified as pollutants of concern because they are regulated under the applicable ELGs for coal mines found at 40 CFR Part 434. Thus, the MPDES permit for the facility must include TBELs for these pollutants and parameters and they should be evaluated to determine the need for WQBELs. In addition, pollutants of concern include aluminum, arsenic, boron, cadmium, chloride, chromium, copper, electrical conductivity (EC), lead, mercury, nickel, nitrogen as nitrate plus nitrite, selenium, silver, sodium adsorption ratio (SAR), sulfate, total dissolved solids (TDS), and zinc. These parameters are identified as pollutants of concern because the current permit requires they be monitored. Nitrogen and phosphorus are also pollutants of concern, as DEQ recently adopted WQS for nutrients applicable to wadeable streams (Circular DEQ-12A). Pollutants of concern will be evaluated against numeric water quality criteria (where applicable) to determine the need for WQBELs.

Effluent quality data collected from discharges during the period of January 1, 2010, through December 31, 2014, and summarized in the facility's DMRs, were used to evaluate reasonable potential for discharges to cause or contribute to an excursion above WQS. Using the most recent five years of data is preferred because it is most reflective of current operations and conditions at the facility. Discharge effluent data were combined, using data from all outfalls where discharges occurred. A summary of effluent data is contained in Appendix II; RPA methods are detailed in Appendix III.

Table 8 presents a summary of the RPA. Reasonable potential (RP) could not be analyzed for TSS, SS, pH, boron, chloride, EC, SAR, sulfate and TDS due to a lack of numeric water quality criteria applicable to the parameters. Additionally, RP could not be analyzed for nitrogen and phosphorus due to lack of available effluent data. Monitoring will be required for these parameters for future analysis of RP.

Reasonable potential to exceed applicable numeric standards was determined not present for nitrate + nitrite as nitrogen and the following total metals: arsenic, chromium, mercury, nickel and silver. Monitoring requirements will be maintained for these parameters. RP was determined to be present for dissolved aluminum and total iron.

Therefore, WQBELs will be calculated and compared to previous permit limits (where applicable), with the most stringent limitations retained.

Table 8. Summary of RPA Results

Parameter	Units	Lowest Applicable Numeric Standard (C)[1]	Projected Maximum Effluent Concentration (C_d)[2]	Projected Receiving Water Concentration (C_r)[3]	RPA Result – Need Limit?	Reason
Aluminum, dissolved	µg/L	87	165	165	Yes	C_r>C
Arsenic, total	µg/L	10	3.6	3.6	No	C_r<C
Cadmium, total	µg/L	0.756	0.405	0.405	No	C_r<C
Chromium, total	µg/L	268	36	36	No	C_r<C
Copper, total	µg/L	30.5	14.5	14.5	No	C_r<C
Iron, total	µg/L	1000	2564	2564	Yes	C_r>C
Lead, total	µg/L	18.58	9.37	9.37	No	C_r<C
Mercury, total	µg/L	0.05	0.067	0.067	TBD[4]	Add’l Monitor Req’d
Nickel, total	µg/L	168.5	15.1	15.1	No	C_r<C
Nitrate +Nitrite as N	µg/L	10000	416	416	No	C_r<C
Selenium, total	µg/L	5	2.9	2.9	No	C_r<C
Silver, total	µg/L	44	0.3	0.3	No	C_r<C
Zinc, total	µg/L	388	133	133	No	C_r<C

Footnotes:
(1) For metals with WQS (C) that are calculated using the receiving water hardness, a hardness of 400 mg/L as $CaCO_3$ was used.
(2) See Appendix III for a summary of C_d calculations.
(3) Because the critical low flow is 0 cfs, dilution (D) = 0 and C_d=C_r.
(4) The majority of total mercury measurements were not at a resolution capable of comparison with water quality standards. Additional monitoring will be required at the required reporting value indicated in Circular DEQ-7.

c. Whole Effluent Toxicity

DEQ interprets the prohibition against discharges that will create concentrations or combinations of materials which are toxic or harmful to human, animal, plant, or aquatic life in terms of acute and chronic whole effluent toxicity (WET).

DEQ determines the need for WET limitations by directly comparing WET testing data submitted in a permit application (or as a result of monitoring requirements in the previous permit) to these definitions of acute and chronic effluent toxicity.

The existing permit contains monitoring requirements for WET testing, which are not altered by this modification. WET testing is required for any outfall where activities that meet the definition of "coal preparation plant," "coal preparation plant associated areas," and "coal plant water circuit," as defined in 40 CFR 434.11 are conducted or are located. For outfalls associated with the intermittent reach of East Fork Armells Creek this includes Outfalls 009, 09A, and 16A.

Outfall 021 was previously identified as being associated with a coal preparation plant area. However, information submitted in the permit modification application indicates that a recent evaluation of Outfall 021 shows there is no area within the drainage boundary that would be considered a coal preparation plant," "coal preparation plant associated areas," or a "coal plant water circuit," as defined in 40 CFR 434.11. This reclassification of Outfall 021 removes it from the list of outfalls requiring WET monitoring.

5. Final WQBELs

Reasonable potential to exceed numeric WQS was recognized for dissolved aluminum and total iron. As the critical low flow condition for the intermittent receiving waters is 0 cfs, instream dilution of pollutant concentrations is not available and no mixing zone is allowed. Therefore, WQBELs are set as "end of pipe" limits based on numeric WQS contained in Circular DEQ-7. Chronic WQS are applied as average monthly limitations (AML) and acute WQS are applied as maximum daily limitations (MDL). Circular DEQ-7 does not contain an acute WQS for total iron; therefore, there is no corresponding maximum daily effluent limitation (MDL).

Existing narrative WQBELs and effluent limitations for oil and grease are not changed by this modification. WQBELs based on nondegradation and established by previous permits for boron, sulfate and total dissolved solids (TDS) are retained and not changed by this modification.

Table 9. Final WQBELs – Outfalls 009, 09A, 011, 012, 013, 13A, 014, 015, 016, 016A, 018, 019, 020, 021 and 022

Parameter	Units	Effluent Limitations	
		Average Monthly	Maximum Daily
Aluminum, dissolved	µg/L	87	750
Boron, total	mg/L	0.70	1.1
Iron, total(1)	µg/L	1000	n/a
Oil and Grease	mg/L	n/a	10
Sulfate	mg/L	2050	3075
Total Dissolved Solids (TDS)	mg/L	3000	4500

Footnotes:
(1) Circular DEQ-7 does not contain an acute WQS for total iron.

6. Final Effluent Limitations

WQBELs were calculated for dissolved aluminum and total iron. Existing permit limits, applicable TBELs, and calculated WQBELs were compared, with the most stringent retained as the final effluent limitation. The resulting final effluent limitations are presented in Tables 10 and 11.

Table 10. Final Effluent Limitations – Outfalls 009, 09A, 011, 012, 013, 13A, 014, 015, 016, 016A, 018, 019, 020, 021 and 022

Parameter	Units	Effluent Limitations		Basis
		Average Monthly	Maximum Daily	
Aluminum, dissolved	µg/L	87	750	Protection of Aquatic Life
Boron	mg/L	0.70	1.1	Previous Permit
Iron, total	µg/L	1000	6000	Protection of Aquatic Life (Average monthly) 40 CFR 434 (Maximum daily)
Oil and Grease	mg/L	--	10	ARM 17.30.637(1)(b)
pH	s.u.	Between 6.0 and 9.0 at all times		40 CFR 434
Sulfate	mg/L	2050	3075	Previous Permit
Total Dissolved Solids (TDS)	mg/L	3000	4500	Previous Permit
Total Suspended Solids (TSS)	mg/L	35	70	40 CFR 434

Alternate final effluent limitations applicable to precipitation-driven discharge events are summarized Table 11; these limitations may be applied instead of otherwise applicable effluent limitations. The permittee has the burden of proof that the discharge was a result of a precipitation-driven pond overflow, and that the alternate limitations presented here are applicable. The permit requires precipitation monitoring in each drainage basin to generate data demonstrating discharges were precipitation driven. Only maximum daily (and not average monthly) effluent limits are applicable to discharges due to precipitation events because these discharges are likely intermittent and infrequent in nature.

Table 11. Alternate Final Effluent Limitations for Precipitation Events – Outfalls 009, 09A, 011, 012, 013, 13A, 014, 015, 016, 016A, 018, 019, 020, 021and 022

Parameter	Units	Effluent Limitations		Basis
		Average Monthly	Maximum Daily	
Aluminum, dissolved	µg/L	--	750	Protection of Aquatic Life
Boron	mg/L	--	1.1	Previous Permit
Oil and Grease	mg/L	--	10	ARM 17.30.637(1)(b)

Parameter	Units	Effluent Limitations		Basis
		Average Monthly	Maximum Daily	
pH	s.u.	Between 6.0 and 9.0 at all times		40 CFR 434
Settleable Solids (SS)(1)	ml/L	--	0.5	40 CFR 434
Sulfate	mg/L	--	3075	Previous Permit
Total Dissolved Solids (TDS)	mg/L	--	4500	Previous Permit
Footnotes: (1) Applicable to discharges caused by precipitation within any 24-hour period less than or equal to the 10-year, 24-hour precipitation event.				

a. Narrative Effluent Limitations Applicable to All Discharges (ARM 17.30.637):
There shall be no discharge from any outfall that will:

i. settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines;
ii. create floating debris, scum, a visible oil film, or globule of grease or other floating materials;
iii. produce odors, colors, or other conditions that create a nuisance or render undesirable tastes to fish flesh or make fish inedible;
iv. create conditions that produce undesirable aquatic life; or
v. create concentrations or combinations of materials which are toxic or harmful to human, animal, plant, or aquatic life.

7. Monitoring Requirements

Monitoring requirements for discharges at intermittent reach outfalls are summarized in Tables 12 and 13. All monitoring shall be conducted at the overflow structure where effluent discharges as overflow from the sediment control structure, or at the end of the discharge pipe when pumped or drained, and prior to contact with the receiving water.

a. Whole Effluent Toxicity Testing

Whole effluent toxicity (WET) monitoring is required by the permit for any outfall where activities that meet the definition of “coal preparation plant”, “coal preparation plant associated areas” and “coal plant water circuit”, as defined in 40 CFR 434.11 are conducted or are located. Within the intermittent reach, Outfalls 009, 09A, and 16A meet this requirement and annual WET monitoring is required at these outfalls.

Table 12. Summary of Monitoring Requirements – Outfalls 009, 09A, 011, 012, 013, 13A, 014, 015, 016, 016A, 018, 019, 020, 021and 022

Parameter	Units	Minimum Monitoring Frequency	Basis
Aluminum, dissolved	µg/L	1/Week	Effluent Limitations Compliance
Boron	mg/L	1/Month	Effluent Limitations Compliance
Cadmium, total	µg/L	1/Month	Effluent Characterization
Chloride	µg/L	1/Month	Effluent Characterization
Copper, total	µg/L	1/Month	Effluent Characterization
Electrical Conductivity (EC)	µS/cm	1/Month	Effluent Characterization
Flow	gpd	1/Day	Effluent Characterization
Iron, total	µg/L	1/Week	Effluent Limitations Compliance
Lead, total	µg/L	1/Month	Effluent Characterization
Metals, Total Recoverable(1)	µg/L	1/Year	Effluent Characterization
Nitrogen, total	µg/L	1/Month	Effluent Characterization
Nitrate + Nitrite (as N)	mg/L	1/Month	Effluent Characterization
Oil and Grease	mg/L	1/Week	Effluent Limitations Compliance
pH	s.u.	1/Day	Effluent Limitations Compliance
Phosphorus, total	µg/L	1/Month	Effluent Characterization
Sodium Adsorption Ratio (SAR)	Unitless	1/Month	Effluent Characterization
Selenium, total	µg/L	1/Month	Effluent Characterization
Sulfate	mg/L	1/Week	Effluent Limitations Compliance
Total Dissolved Solids	mg/L	1/Week	Effluent Limitations Compliance
Total Suspended Solids (TSS)	mg/L	1/Day	Effluent Limitations Compliance
Whole Effluent Toxicity, Acute(2)	% Effluent	1/Year	Effluent Characterization
Zinc, total	µg/L	1/Month	Effluent Characterization

Footnotes:

(1) Metals include those metals with aquatic life numeric standards contained in the Montana Circular DEQ-7 Montana Numeric Water Quality Standards: arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc as total recoverable.

(2) Whole effluent toxicity testing is required for any outfall where activities that meet the definition of “coal preparation plant”, “coal preparation plant associated areas”, and “coal plant water circuit”, as determined in 40 CFR 434.11 are conducted or are located. For intermittent reach outfalls this includes Outfalls 009, 09A, and 16A.

Table 13. Summary of Alternate Monitoring Requirements for Precipitation Events – Outfalls 009, 09A, 011, 012, 013, 13A, 014, 015, 016, 016A, 018, 019, 020, 021and 022

Parameter	Units	Monitoring Frequency	Basis
Aluminum, dissolved	µg/L	1/Discharge	Effluent Limitations Compliance
Boron	mg/L	1/Discharge	Effluent Limitations Compliance
Cadmium, total	µg/L	1/Discharge	Effluent Limitations Compliance
Chloride	µg/L	1/Discharge	Effluent Characterization
Copper, total	µg/L	1/Discharge	Effluent Limitations Compliance
Electrical Conductivity (EC)	µS/cm	1/Discharge	Effluent Characterization
Flow	gpd	1/Discharge	Effluent Characterization
Iron, total	µg/L	1/Discharge	Effluent Limitations Compliance
Lead, total	µg/L	1/Discharge	Effluent Limitations Compliance
Metals, Total Recoverable(1)	µg/L	1/Year	Effluent Characterization
Nitrate + Nitrite (as N)	mg/L	1/Discharge	Effluent Characterization
Nitrogen, total	µg/L	1/Month	Effluent Characterization
Oil and Grease	mg/L	1/Discharge	Effluent Limitations Compliance
pH	s.u.	1/Discharge	Effluent Limitations Compliance
Phosphorus, total	µg/L	1/Month	Effluent Characterization
Sodium Adsorption Ratio (SAR)	Unitless	1/Discharge	Effluent Characterization
Selenium, total	µg/L	1/Discharge	Effluent Limitations Compliance
Settleable Solids	mL/	1/Discharge	Effluent Limitations Compliance
Sulfate	mg/L	1/Discharge	Effluent Limitations Compliance
Total Dissolved Solids	mg/L	1/Discharge	Effluent Limitations Compliance
Whole Effluent Toxicity, Acute(2)	% Effluent	1/Year	Effluent Characterization
Zinc, total	µg/L	1/Discharge	Effluent Limitations Compliance

Footnotes:

(1) Metals include those metals with aquatic life numeric standards contained in the Montana Circular DEQ-7 Montana Numeric Water Quality Standards: arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc as total recoverable.

(2) Whole effluent toxicity testing is required for any outfall where activities that meet the definition of “coal preparation plant”, “coal preparation plant associated areas”, and “coal plant water circuit”, as determined in 40 CFR 434.11 are conducted or are located. For intermittent reach outfalls this includes Outfalls 009, 09A, and 16A.

B. Addition of Western Alkaline Standards Outfalls

Due to progression of reclamation at the facility, six new outfalls are added to the permit. New Outfalls 028-1A, 028-2A, 028A, 028B, 113D, and 120A are all internal outfalls associated with reclaimed drainages in mine Area C-North (see Appendix IV for a map). The addition of new outfalls is necessary due to the configuration of drainages in the reclaimed post-mine topography of C-North. Due to the progression of reclamation in Area D, the drainage associated with Outfall 080 also meets the requirements for transfer to Western Alkaline Standards, as described below.

40 CFR 434, Subpart H applies to "alkaline mine drainage at western coal mining operations from reclamation areas, brushing and grubbing areas, topsoil stockpiling areas, and regraded areas" (40 CFR part 434.81). In accordance with the requirements established by Subpart H, or "Western Alkaline Standards," the permittee has submitted a Sediment Control Plan (SCP) to include the outfalls listed in Table 14 for coverage under Western Alkaline Standards. Included in the SCP are best management practices (BMPs) implemented by the permittee to control sediment and erosion and minimize disturbance to the prevailing hydrologic balance. The SCP also summarizes design and construction specifications, inspection criteria, and maintenance schedules. Sediment Control Plans for Outfalls 028-1A, 028-2A, 028A, 028B, 113D, 120A, and 080 were submitted previously (April 2011 and February 2013) and approved by DEQ.

Modeling results indicate that the average annual sediment yields from the post-mining watersheds above outfalls covered by the SCP are less than or equal to the average annual sediment yield from their respective pre-mining watersheds (Table 14). Sediment yield data demonstrate that the BMPs used by the permittee at different stages of reclamation are successful at minimizing erosion and consequent sediment loads from the reclaimed mine-lands. The stages of reclamation analyzed included the following:

- Post-mining with the inclusion of a small depression;
- Post-mining with the removal of the small depression following the establishment of vegetative cover and installation of silt fence; and
- Post-mining with the removal of silt fence and establishment of adequate (60-80%) vegetative cover.

SCP results demonstrate that upon completion of the reclamation activities and successful establishment of the revegetation community, sediment ponds are no longer the best practicable control technology available for minimizing sediment loads, and the sediment ponds should be removed and reclaimed.

DEQ has concluded that the SCP has been submitted in accordance with the requirements of 40 CFR Part 434, and that the SCP meets all minimum requirements to demonstrate that average annual sediment yields will not be greater than sediment yield levels from pre-mined, undisturbed conditions. Therefore, DEQ approves the SCP consistent with the Requirements of Western Alkaline Standards. Additionally, in accordance with Western Alkaline Standards, the permit requires that the approved SCP be incorporated into the permit as an effluent limit, and requires that the permittee design, implement, and maintain the BMPs in the manner specified in the SCP.

Table 14. Summary of Estimated Average Annual Sediment Yields for Western Alkaline Outfalls Added by this Modification.

Outfall	Sub-watershed Name(s)	Mine Area	Receiving Water	Estimated Average Annual Sediment Yield (tons/acre/year)			
				Pre-mining	Post-mining + small depression	Post-mining + silt fence	Post-mining + adequate vegetation(1)
028-1A	C028-1	C-North	West Fork Armells Creek	0.071	0.03	0.006	0.001
028-2A	C028-2	C-North	West Fork Armells Creek	0.010	0.006	0.008	0.002

Outfall	Sub-watershed Name(s)	Mine Area	Receiving Water	Estimated Average Annual Sediment Yield (tons/acre/year)			
				Pre-mining	Post-mining + small depression	Post-mining + silt fence	Post-mining + adequate vegetation[(1)]
028A	C028-A	C-North	West Fork Armells Creek	0.016	0.014	0.009	0.002
028B	C028-B	C-North	West Fork Armells Creek	0.016	0.016	0.011	0.001
113D	C113	C-North	West Fork Armells Creek	0.002	0.002	0.002	0.001
120A	C120	C-North	West Fork Armells Creek	0.004	0.002	0.004	0.001
080	D080A	D	Spring Creek	0.160	(2)	(2)	0.018
	D080B			0.239	0.209	0.024	0.024
	D080C			0.038	0.036	0.038	0.006
	D080D			0.038	0.036	0.036	0.010
	D080E			0.988	(2)	(2)	0.221

Footnotes:
(1) “Adequate” vegetative cover (%) is:
60% for Outfalls 028A, 028B, 028-1A, 120A, and drainage 080E.
80% for Outfalls 028-2A, 113D, and drainages 080A-080D.
(2) Flow is not concentrated. Use alternate BMPs.

C. Removal of Outfall 10C from the Permit

Recent changes in drainage control at Outfall 10C have made permitting this feature unnecessary. Currently, drainage from Outfall 10C flows through a culvert under State Highway 39 down to Outfall 010. The sediment control pond associated with Outfall 010 is the ultimate sediment control for discharges from Outfall 10C; therefore, permitting outfall 10C is unnecessary and it is removed from the permit per this modification.

D. Reassignment of Outfall 010 Effluent Limitations

As discussed above in Section C, recent changes in drainage control route discharges from Outfall 10C to Outfall 010; therefore, Outfall 10C is no longer required and is removed from the permit. These changes in drainage control also require a change in the effluent limitations assigned to Outfall 010. As currently permitted, Outfall 010 is a Western Alkaline Standards outfall subject to the effluent limitations guidelines of 40 CFR 434 Subpart H. Western Alkaline Standards require that 100% of the drainage from an outfall be associated with reclamation areas, brushing and grubbing areas, topsoil stockpiling areas, and regraded areas. Previously, Outfall 010 was wholly associated with reclaimed Mine Area E. However, recent changes in drainage control route runoff from Mine Area B Outfall 10C to Outfall 010. Because mining activities are occurring in the drainage associated with Outfall 10C, its discharge does not meet Western Alkaline Standards requirements and is instead regulated by effluent limitations guidelines for Alkaline Mine Drainage found in 40 CFR 434 Subpart D. The permit is therefore being modified to apply the technology-based effluent limitations (TBELs) listed in Table 15 to Outfall 010 instead of the previously-applied Sediment Control Plan.

Table 15. TBELs – Alkaline Mine Drainage

Parameter	Units	30-day Average Limitation	Daily Maximum Limitation	Category
Iron, Total	mg/L	3.5	7.0	BPT, BAT
TSS	mg/L	35	70	BPT
pH	s.u.	Between 6.0 and 9.0		BPT

E. Reassignment of Representative Monitoring Outfalls

Due to the number of outfalls at the facility and inaccessibility of remote outfalls, representative monitoring is permitted for discharges resulting from precipitation events. The following changes to the representative monitoring program are included with this permit modification:

1. Outfall 083

In a 2014 permit modification, Area D Outfall 083 was transferred from the Alkaline Mine Drainage ELG category (40 CFR 434 Subpart D) to the Western Alkaline Standards ELG category (40 CFR 434 Subpart H). The transfer was necessary due to progression of reclamation at the mine. Under Western Alkaline Standards, ELGs consist of implementation of an approved sediment control plan. As discharge sampling is no longer required, Western Alkaline Standards outfalls are inappropriate for designation as representative monitoring outfalls. Outfall 083 should have been removed as a representative monitoring outfall in the 2014 modification (Major Modification 1); this detail was mistakenly overlooked and is therefore corrected by this modification (Major Modification 2).

With the transfer of Outfall 080 to Western Alkaline Standards (see Section B, above), Western Alkaline Standards are now applied to all Area D outfalls. Therefore, while Area D Outfall 083 is removed as a representative monitoring outfall, replacement with an alternate representative monitoring outfall is not necessary.

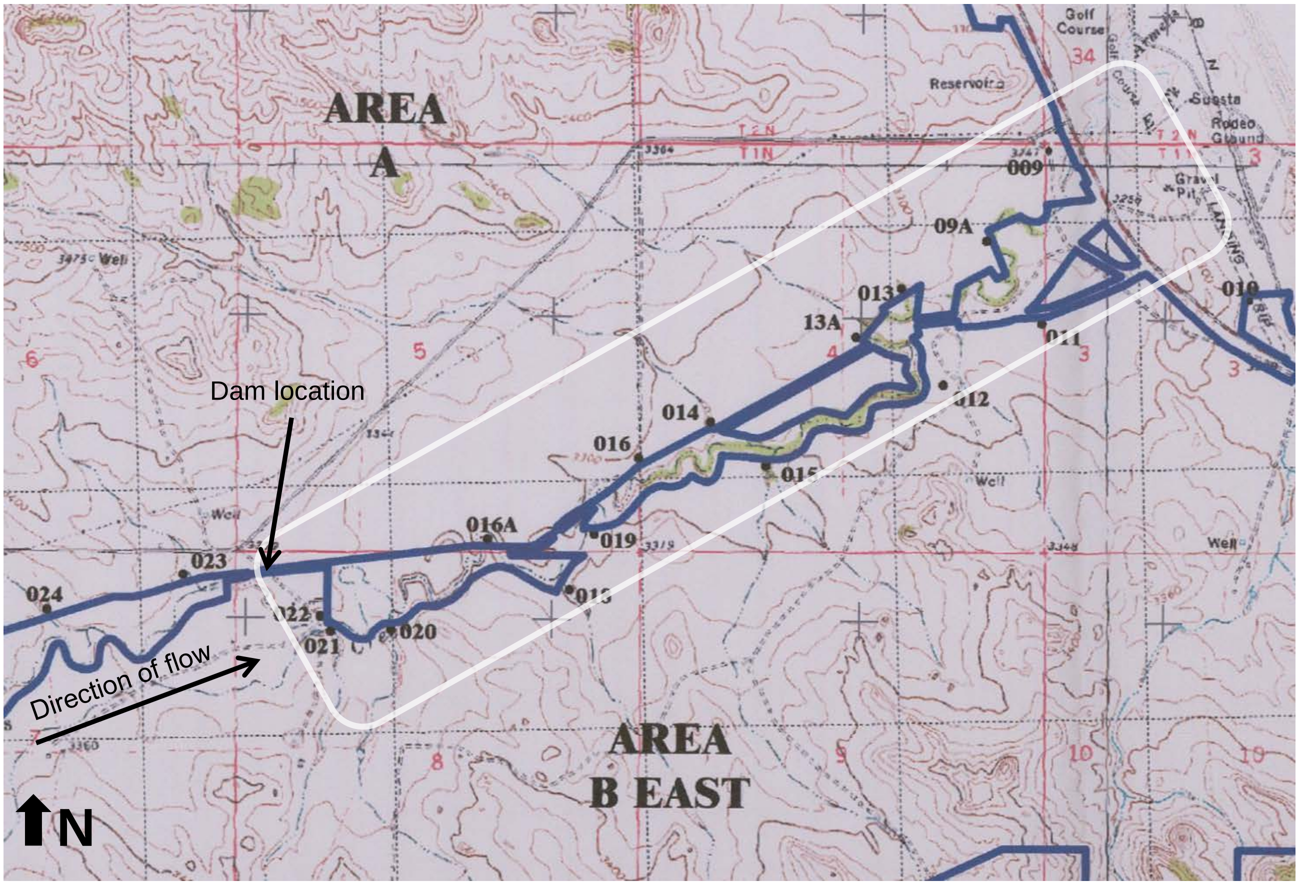
2. Outfall 10C

As described above in Section C, recent changes in drainage control have led to the removal of Outfall 010C from the permit. Therefore, Outfall 010C will be removed from the list of representative monitoring outfalls.

As a replacement, Outfall 130 is added to the permit for representative monitoring. Outfall 130 is selected because mine activity has recently expanded on the south end of Area B-West. Sampling equipment must be installed at Outfall 130 to ensure flow measurement and automatic sample collection regardless of weather and/or site conditions.

Appendix I. East Fork Armells Creek Intermittent Reach Map

The white rectangle encompasses the outfalls associated with the East Fork Armells Creek intermittent reach.



Permit Boundary

Appendix II. Summary of Effluent Data Used in the RPA (2010 through 2014 Period of Record)

Parameter	Units	Number of Samples	Minimum Value	Maximum Value	Average(1)	Standard Deviation(1)	# of Nondetects
Aluminum, dissolved	mg/L	26	<0.009	1.94	0.125	0.3725	9
Arsenic, total	mg/L	22	<0.001	0.028	0.003	0.0057	6
Cadmium, total	mg/L	22	<0.00003	0.001	0.001	0.0005	18
Chromium, total	mg/L	22	<0.005	0.07	0.009	0.0138	18
Copper, total	mg/L	22	<0.005	0.064	0.008	0.0127	12
Iron, total	mg/L	119	0.03	177	4.3	17.86	5
Lead, total	mg/L	22	<0.0003	0.057	0.004	0.0120	14
Mercury, total.	mg/L	22	<0.000005	0.00011	6.736E-05	4.527E-05	19
Nickel, total	mg/L	22	<0.005	0.063	0.008	0.0126	11
Nitrate + nitrate, as N	mg/L	22	<0.01	1.09	0.24	0.2767	3
Selenium, total	mg/L	22	<0.001	0.005	0.002	0.0011	9
Silver, total	mg/L	22	<0.0002	0.001	0.001	0.0004	20
Zinc, total	mg/L	22	<0.008	0.314	0.025	0.0648	19

Footnotes:
(1) For values reported below detection limits, the detection limit was used in the calculation of average and standard deviation.

Appendix III. RPA Procedure

The RPA was performed for the pollutants for which data were available using DEQ procedures for determining critical effluent and receiving water pollutant concentrations. The critical effluent concentration is a projected 95th percentile concentration. The method for projecting the 95th percentile concentration varies depending on the number of effluent pollutant concentration data points available and whether the data are quantified, non-quantified, or a mixture of the two. The critical effluent and receiving water pollutant concentrations were used in the following equation, which is based on a mass-balance equation, to calculate a projected receiving water concentration:

$$C_r = \frac{C_d + DC_s}{(1+D)}$$

where: C_r = projected receiving water concentration
C_d = maximum projected effluent concentration
C_s = critical receiving water (background) pollutant concentration
D = dilution factor for the appropriate effluent flow (design for POTW, maximum daily and maximum monthly average for non-POTWs) and mixing zone; here, D = 0 as receiving waters are ephemeral to intermittent.

Critical Background Receiving Water Pollutant Concentration (C_s)
To determine the value of C_s, the Department:
determines whether there are 10 or more data points available

1. determines the lower bound of the interquartile range (if $\geq$ 10 data points)
2. determines the upper bound of the interquartile range (if $\geq$ 10 data points)
3. determines the 95% confidence interval of the mean (if $\geq$ 30 data points)

Where there are less than 10 data points are available, C_s is undetermined (“U”). Where dilution is considered, additional data are needed to determine a value of C_s in order to determine reasonable potential and calculate WQBELs.

Where there are more than 10 data points, for pollutants with water quality standards expressed as an *absolute value*:

1. If the upper bound of the interquartile range or of the 95% confidence interval of the mean is a quantified value, the Department will use one of these values as the value of C_s
2. If the upper bound of the interquartile range or of the 95% confidence interval of the mean is a non-quantified value and if the water quality standard is less than the required reporting value (RRV), the Department will set C_s = ½ WQS
3. If the upper bound of the interquartile range or of the 95% confidence interval of the mean is a non-quantified value and if RRV < water quality standard, the Department will set C_s = ½ RRV.

Critical Effluent Pollutant Concentration (C_d)
Effluent concentration is used to determine if a WQBEL is necessary based on the reasonable potential analysis using the steady state model. Reasonable potential may also be assessed using non-quantitative methods. Critical effluent concentration is not used to determine the value of a WQBEL. Due to the low frequency of sampling (small sample size) and the non-normal distribution

of most effluents, DEQ estimates the critical effluent concentration based on the 95th percentile of the expected effluent concentration (*Technical Support Document for Water Quality Based Toxic Control*, EPA/505/2-90-001, March 1991).

Where the projected receiving water concentration (C_r) exceeds the lowest applicable numeric standard (C) for the parameter of concern, there is reasonable potential and WQBELs must be calculated. For some parameters, C_r cannot be calculated due to insufficient receiving water data (C_s = U). In these cases, reasonable potential is determined to be absent when the projected maximum effluent concentration (C_d) is below the lowest applicable numeric standard (C). If C_d is equal to or greater than C, additional monitoring will be required at a resolution capable to determine adherence to standards.

Method A. Determining C_d when all measurements are reported as quantified values

***Option #1**: If the total number of measurements in the selected data set is ≥ 10*

Calculate $C_{(d)}$ as: $C_d = C_{95} = EXP(\ln(x)_{avg} + 1.645 \times S_{\ln(x)})$

$\ln(x)_{avg}$ = arithmetic mean of log-transformations of observed concentrations
$S_{\ln(x)}$ = standard deviation of the log-transformations of observed concentrations

***Option #2**: If the total number of measurements in the selected data set is < 10*

Estimate $C_{(d)}$ as:

$$C_d = C_{95(est)} = C_{95\text{-}TSD} = C_{e(max)} \cdot \frac{EXP[z_{0.95} \cdot (\ln(1+CV^2))^{0.5} - 0.5 \cdot \ln(1+CV^2)]}{EXP[z_{(1-0.95)^{(1/n)}} \cdot (\ln(1+CV^2))^{0.5} - 0.5 \cdot \ln(1+CV^2)]}$$

$C_{e(max)}$ = maximum measured and quantified effluent pollutant concentration
CV = coefficient of variation (assumed to be 0.6)
n = number of effluent pollutant concentration measurements in the data set
z_x = the z-statistic for the *x* percentile

Method B. Determining C_d with a mixture of quantified and non-quantified measurements

***Option #1**: If the total number of measurements in the selected data set is ≥ 10 and*
- ***the number of quantified measurements is ≥ 2 and***
- ***the number of quantified measurements is > 5% of the total number of measurements***

Calculate C_d as: $C_d = C_{95}$ = the maximum of:
1) the highest reporting limit or
2) $EXP(\ln(x)_{avg} + z^* \times s_{\ln(x)})$

$\ln(x)_{avg}$ = arithmetic mean of log-transformations of the quantified measurements
$s_{\ln(x)}$ = standard deviation of log-transformations of the quantified measurements
z* = the z-statistic for [0.95-δ)/(1-δ)]
δ = proportion of measurements that are non-quantified

***Option #2**: If the total number of measurements in the selected data set is ≥ 10 and*
- ***the number of quantified measurements is < 2 or***

- ***the number of quantified measurements is $\leq$ 5% of the total number of measurements.***

Estimate C_d as: $C_d = C_{95(est)}$ = highest reporting limit

<u>Option #3</u>: If the total number of measurements in the selected data set is < 10

Estimate $C_{(d)}$ as:

$$C_{95(est)} = C_{95\text{-}TSD} = C_{e(max)} \cdot \frac{EXP[z_{0.95} \cdot (\ln(1+CV^2))^{0.5} - 0.5 \cdot \ln(1+CV^2)]}{EXP[z_{(1-0.95)^{(1/n)}} \cdot (\ln(1+CV^2))^{0.5} - 0.5 \cdot \ln(1+CV^2)]}$$

$C_{e(max)}$	=	maximum measured and quantified effluent pollutant concentration
CV	=	coefficient of variation (assumed to be 0.6)
n	=	number of effluent pollutant concentration measurements in the data set
z_x	=	the z-statistic for the *x* percentile

Method C. Determining C_d when no measurement is reported as a quantified value

<u>Option #1:</u> If the total number of measurements in the selected data set is $\geq$ 30

Calculate C_d as: $C_d = C_{95}$ = "< the highest reporting limit achieved for the data set"

<u>Option #2</u>: If the total number of measurements in the selected data set < 30

Estimate C_d as: $C_d = C_{95(est)}$ * = "< the highest reporting limit achieved for the data set"

*Additional monitoring is required because C_d is estimated from a small data set

Critical Effluent Pollutant Concentration (C_d) Calculations

All parameters for which reasonable potential was assessed met the criteria of Method B, Option #1, above. Therefore, C_d was calculated using the following equation:

$$C_d = EXP(\ln(x)_{avg} + z * \times s_{\ln(x)})$$

Equation terms are summarized in the table below.

Term	Parameter												
	Al (diss)	As (tot)	Cd (tot)	Cr (tot)	Cu (tot)	Fe (tot)	Pb (tot)	Hg (tot)	Ni (tot)	Nitrate + Nitrite (as N)	Se (tot)	Ag (tot)	Zn (tot)
N	26	22	22	22	22	119	22	22	22	22	22	22	22
Nonquantified N	9	6	18	18	12	5	14	19	11	3	9	20	19
% Quantified	65.38	72.73	18.18	18.18	45.45	95.80	36.36	13.64	50	86.36	59.09	9.09	13.64
ln(x)avg	-2.65	-6.37	-8.90	-4.48	-5.02	-0.55	-6.02	-10.54	-4.98	-1.82	-6.35	-8.11	-3.53
sln(x)	1.03	0.91	1.36	1.45	0.97	1.81	1.68	1.26	0.96	1.14	0.60	0.00	2.06
δ	0.35	0.27	0.82	0.82	0.55	0.04	0.64	0.86	0.50	0.14	0.41	0.91	0.86
[(0.95-δ)/(1-δ)]	0.92	0.93	0.73	0.73	0.89	0.95	0.86	0.63	0.90	0.94	0.92	0.45	0.63
z*	0.82	0.82	0.80	0.80	0.81	0.83	0.81	0.74	0.82	0.83	0.82	0.67	0.74
Cd(mg/L)	0.17	0.0036	0.0004	0.04	0.01	2.56	0.01	0.0001	0.02	0.42	0.0029	0.0003	0.13
Cd (µg/L)	165.37	3.63	0.41	36.26	14.54	2564.42	9.37	0.07	15.10	415.72	2.86	0.30	133.05

Appendix IV. Map Illustrating New Western Alkaline Standards Outfalls.