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October 31, 2013

Warren McCullough
Montana Department of Environmental Quality
P.O. Box 200901
Helena, MT 59620-0901

Subject: PPL Montana Colstrip 3&4 EHP Site Report

Dear Mr. McCullough:

Attached is the 3&4 EHP Site Report that PPL Montana is submitting under Article VI Section A. of the Administrative Order on Consent (AOC) relating to the waste water facilities at the Colstrip Steam Electric Station.

After the Department notifies PPLM of the date and place for the public meeting to review this report, PPLM will publish a notice of the meeting in the local newspaper and in the Billings Gazette as required under Article V Section A of the AOC.

If you have any questions on this, please contact me.

Sincerely,

Gordon Criswell

Gordon Criswell
Director, Environmental & Engineering Compliance
PPL Montana

Cc: Jake Kandelin, MDEQ

Enclosure

PPL MONTANA, LLC
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 & 4 EFFLUENT HOLDING POND (EHP) SITE REPORT

Prepared for:

PPL Montana, LLC
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Prepared by:

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October 2013

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EXECUTIVE SUMMARY

On August 3, 2012, PPL Montana (PPLM) and the Montana Department of Environmental Quality (MDEQ) entered into an Administrative Order on Consent (AOC) Regarding Impacts Related to Wastewater Facilities Comprising the Closed-Loop System at the Colstrip Steam Electric Station. As part of the AOC, PPLM committed to prepare Site Reports for the Plant Site, Stage I Evaporation Pond (SOEP) and Stage II Evaporation Pond (STEP), and Units 3&4 Evaporation Holding Pond (3&4 EHP) areas.

Minimum requirements of the AOC Site Reports are: Identification of releases, if any, for each area and the source of the releases; A description of the investigations performed to date, including a list of reports resulting from the investigations and summary of the findings and results from the investigations; groundwater models and results of modeling; A description of completed and ongoing remedial actions (including the sampling parameters and frequency of any ongoing monitoring) and an effectiveness assessment of the remedial actions. For each area that contains a pond, a description of the construction of the ponds and of pond contents through time; For each pond, an estimate of seepage to groundwater beneath the pond; Identification of data gaps, if any; and recommendations for additional site characterization, if any. This report provides information required as listed for AOC Site Reports for the 3&4 EHP.

PPL Montana, LLC (PPLM) is the operator of the Colstrip Steam Electric Station (Colstrip SES), two 333-megawatt, and two 805-megawatt coal-fired steam electric generating units. Units 1&2 have been in service since 1975. Unit 3 has been in service since October 1983. Unit 4 went in to service near the end of 1985. Ponds serving Units 1 & 2 were put into service in 1975. The pond system servicing Units 3&4 has been in use since 1983 located in Colstrip, Montana (Figure 1-1). The Colstrip SES (Plant) is co-owned by PPLM, PacifiCorp, Puget Sound Energy, Inc., Portland General Electric Company, Avista Corporation, and NorthWestern Corporation.

A closed-loop process is used at the Colstrip SES to minimize impacts to water resources in the area. Coal combustion residuals from the generating plants are impounded in ponds designed and constructed to minimize seepage losses. The Plant Site pond system includes ponds that serve all four generating units in various capacities. Ash disposal does not occur at the Plant Site but rather in disposal ponds at separate locations. Ash from Units 3 and 4 are routed to the 3&4 EHP, located about three miles east-southeast of Colstrip.

The 3&4 EHP were originally lined with native soils amended with bentonite below an elevation of 3,200 feet. A bentonite amended plastic concrete cutoff wall was also constructed into bedrock to limit seepage through baked shale that is present in the pond area. PPLM has begun the process of adding geo-synthetic liners to the 3&4 EHP. Since 2005, about 40% of the 3&4 EHP has been lined with a synthetic liner. PPLM's current lining process includes dewatering cells, grading the pond bottom, covering with low permeability paste, and installing liners with an underdrain and leak detection system. Embankments at the 3&4 EHP are constructed to an elevation of about 3,290 feet. A

capacity of about 17,000 acre-feet can be stored at an elevation of 3,280 feet. An additional 1,200 acre-feet of retention space (free board) was available at an elevation of 3,283 feet. Final construction of the dams to an elevation of about 3,290 feet was completed in 2012.

Elevated specific conductance (SC) as well as concentrations of total dissolved solids (TDS), sulfate, boron, and selenium are present in process water liquids/solids within the pond. These parameters or ratios of parameters are used as indicators for process water impacts outside of the ponds. Groundwater monitoring is conducted routinely by PPLM. Data are evaluated and further investigation is conducted in areas with potential problems. Mitigation is implemented as necessary. A description of the investigations performed to date, including a list of reports resulting from the investigations and summary of the findings and results from the investigations are included in Section 3.

Impacted groundwater has been identified downgradient from the 3&4 EHP Main Dam, east of the Saddle Dam, directly south of the 3&4 EHP, in South Fork Cow Creek, and northwest of the pond. Figures 3-5, 3-6, and 3-7 contain SC data, an indicator of overall water quality, that illustrate the extent of impacted groundwater in the 3&4 EHP area. These figures demonstrate that the areas of impacted groundwater are localized around the process ponds. Mitigation activities, including groundwater capture, are currently on-going in these areas using groundwater interception trenches and pumping wells. Water from the capture systems is pumped into the 3&4 EHP. Groundwater capture is having a positive affect. Improvements in SC (an indicator of overall water quality) at individual 3&4 EHP capture locations ranged from 4 to 58 percent. At some locations, targeted groundwater impacts have been eliminated. Other mitigation activities that have been implemented include the installation of composite/synthetic liners in about 40% of the 3&4 EHP and disposal of scrubber slurry as a paste, which reduces free available water by over 90%. Reduced water volumes result in reduced seepage.

Estimates of pond seepage are presented in Section 2. Methods of seepage calculation suited to lined and unlined ponds were selected for the analyses. Flow through unlined ponds was estimated using Darcy Flux calculations parameterized by existing water level, hydraulic gradient, and hydraulic conductivity data. The resulting conservative seepage estimate for unlined ponds was 277 gpm. Similar design calculations were presented by Bechtel (1982) prior to construction of the 3&4 EHP. Design calculations were limited by available data; and several simplifying assumptions were made. However, the design calculations resulted in an initial seepage estimate of 275 gpm, which is very close to the seepage rate calculated using existing conditions. Simulations of groundwater seepage generated using a three-dimensional groundwater flow model were also in agreement with the Darcy Flux calculations. The model predicted seepage of 281 gpm from the 3&4 EHP, using hydrogeologic data from 2012. The groundwater flow model report, developed by Geomatrix (2013) is in Appendix A.

For the current seepage evaluation, equations developed by Giroud (1992, 1997) were adapted to estimate seepage exclusively through lined cells of the 3&4 EHP. Seepage through existing lined ponds was conservatively estimated to range between 1.4 gpm and 7.9 gpm. To date, only cells B, F, and H are lined; but PPLM plans on lining each cell in the

3&4 EHP. Design seepage estimates, assuming all cells are lined, range from 3 gpm to 17 gpm. However, these design calculations are conservative estimates for a single composite liner and do not account for the double-lining strategy that PPLM recently used on H cell and intends to use on future cells. Cell H was recently constructed as a double-lined pond consisting of an upper 45 mil RFP liner, between liner collection, 37 mil RFP underliner, and underliner collection.

A MODFLOW based numerical groundwater model was developed for the 3&4 EHP ponds and surrounding area. The model was calibrated using existing monitoring well information, pumping test data, water level measurements, and capture system pumping rates. Model simulations are used to further evaluate existing interpretations of the hydrogeologic system and to evaluate effectiveness of mitigation activities. Results of the groundwater model predict that the vast majority of groundwater is or will be captured. A complete description of model preparation and results is included in Section 4.

Data gaps are identified in Section 5. These include the need for more accurate flow data and additional hydrogeological information from specific areas. Recommendations to address these areas are included in Section 6. These recommendations include continuation of current groundwater capture activities and expansion, if necessary; further evaluation of the 624D area (north of the main dam); continuation and refinement of groundwater monitoring; continuation of paste deposition; continuation of current lining practice to unlined cells in the pond, and continuation of Best Management Practices (BMPs) to further reduce water volumes and allow for improved water management. Updates to the groundwater model on a periodic basis are also recommended.

PPL MONTANA, LLC
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 & 4 EFFLUENT HOLDING POND SITE REPORT

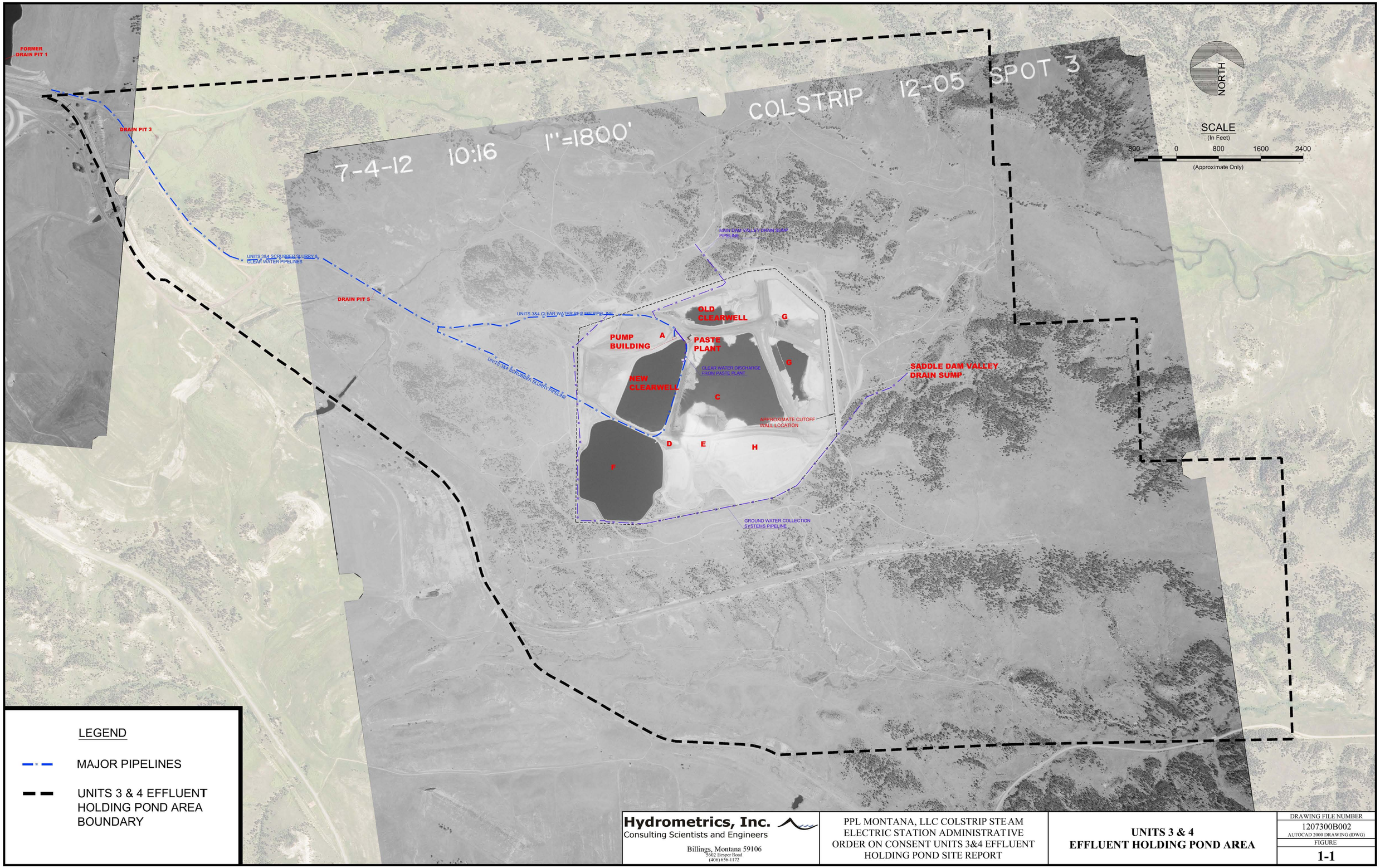
1.0 INTRODUCTION

PPL Montana, LLC (PPLM) is the operator of the Colstrip Steam Electric Station (Colstrip SES), located in Colstrip, Montana (Figure 1-1). The Colstrip SES (Plant) is co-owned by PPLM, PacifiCorp, Puget Sound Energy, Inc., Portland General Electric Company, Avista Corporation, and NorthWestern Corporation.

Colstrip Units 1 & 2, which are two 333-megawatt, coal-fired, steam electric generating units, have been in service since 1975. Colstrip Units 3&4 are 805-megawatt generating units adjacent to Units 1 & 2. Unit 3 has been in service since October 1983. Unit 4 went in to service near the end of 1985. Ponds serving Units 1 & 2 were put into service in 1975. The pond system servicing Units 3&4 has been in use since 1983.

On August 3, 2012, PPLM and the Montana Department of Environmental Quality (MDEQ) entered into an Administrative Order on Consent (AOC) Regarding Impacts Related to Wastewater Facilities Comprising the Closed-Loop System at the Colstrip Steam Electric Station (MDEQ/PPLM Montana, 2012).

As part of the AOC, PPLM is committed to prepare Site Reports for the Plant Site, Stage I Evaporation Pond (SOEP) and Stage II Evaporation Pond (STEP), and Units 3&4 Effluent Holding Pond (3&4 EHP) areas. These site reports are the basis for further remedial activities under the AOC. A fourth category of reporting, involving area process water associated spills or releases not included in one of the previously mentioned areas was also defined. All past spills and releases have fallen into one of the three areas defined earlier in



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PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT

UNITS 3 & 4 EFFLUENT HOLDING POND AREA

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this paragraph. This report provides information regarding past process water spills, pond seepage, and current conditions in accordance with the AOC for the 3&4 EHP Area.

Minimum requirements of the AOC Site Reports are:

- Identification of releases, if any, for each area and the source of the releases;
- A description of the investigations performed to date, including a list of reports resulting from the investigations and summary of the findings and results from the investigations;
- Groundwater models and results of modeling;
- A description of completed and ongoing remedial actions (including the sampling parameters and frequency of any ongoing monitoring) and an effectiveness assessment of the remedial actions;
- For each area that contains a pond, a description of the construction of the ponds and of pond contents through time;
- For each pond, an estimate of seepage to groundwater beneath the pond;
- Identification of data gaps, if any; and
- Recommendations for additional site characterization, if any.

This report provides information required as listed for AOC Site Reports for the 3&4 EHP.

References are cited in the text according to an author-year system; in which, sources are cited in parentheses by author and date (year) published. Each source cited in the text is listed first alphabetically by author and secondarily by date in a Reference section (Section 7) at the end of the text. When two or more sources were prepared by the same author in the same year and same month, the documents are identified using an alphanumeric system; whereby, the first such source is followed by an “a”, the second source is followed by a “b”, and so forth. Where multiple cited sources were prepared by the same author, only the first source is listed in the Reference section. Additional sources by the same author are assigned a blank place holder; and identified first by their date of publication.

2.0 POND CONSTRUCTION AND CLOSED LOOP SYSTEM DESCRIPTION

2.1 CLOSED LOOP SYSTEM

A closed-loop process water/scrubber system is used at the Colstrip SES (Plant) to minimize impacts to water resources in the area. Coal combustion residuals from the generating plants are impounded in ponds designed and constructed to minimize seepage losses. The Plant Site pond system includes ponds that serve all four generating units in various capacities. Flyash disposal does not occur at the Plant Site but rather in disposal ponds at separate locations. Flyash from Units 3 and 4 are routed to the 3&4 EHP, located about three miles east-southeast of Colstrip. Table 2-1 contains descriptions of the 3&4 EHP.

2.1.1 3&4 Effluent Holding Pond

The final design elevation of the Main Dam, Saddle Dam, and 12 Saddle Dikes was 3,290 feet, with a capacity with a capacity of 17,000 acre-feet at an elevation of 3,280 feet. An additional 1,200 acre-feet of retention space (free board) was available at an elevation of 3,283 feet. The dams and dikes were constructed in phases. During the initial phases (1983 and 1984) the 3&4 EHP Main Dam and Saddle Dams were constructed to an elevation of about 3,260 feet and saddle dikes to an elevation of 3,290 feet (Bechtel, February 1985a). Final construction of the dams to an elevation of about 3,290 feet was completed in 2012.

A steep hydraulic gradient was expected from the pond through the 3&4 EHP Main and Saddle Dams. This was expected to result in an estimated 27 gpm flux through the Main Dam and 32 gpm through the Saddle Dam at full pool. A drain system was installed to capture the major portion of seepage through the embankments. Components of the drainage system included a chimney drain, an inclined drain, and a horizontal drainage blanket. Seepage entering the drains is conveyed to either the Main Dam Sump or the Saddle Dam Valley Drain Sump. Water entering the sumps is pumped to the ponds (Bechtel, October 1982).

TABLE 2-1
POND DESCRIPTIONS
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFLLUENT HOLDING POND

Waste Water Facility	Total Capacity (acre-feet)	Surface Area (acres)	Years In Service	Lining	Pond Function/Comments
Units 3 & 4 Effluent Holding Pond w/Clearwell **Inclusive of cells B, F, and H described below.**	17,000	367	1983 - present	A bentonite-amended plastic concrete cutoff wall to bedrock on the perimeter of the pond. The clearwell was relocated to Cell B (New Clearwell) in 2009, A composite/synthetic liner design consisting of 10'+ of dried paste as the bottom liner and 45 mil RFP as the upper liner with leachate collection between. The Old Clearwell is currently being used for paste disposal.	Receives Units 3 & 4 scrubber slurry. Clearwater (scrubber water with fly ash removed) is routed into the clearwell and is returned to the Plant for re-use in the scrubbers. In 1989, a groundwater interception trench was installed down gradient of the main dam. In 2000, 2001, 2002, 2004, and 2010 the groundwater collection system downgradient of the main dam was expanded by adding capture wells and an interception trench. In 1999, a gasket failure on the 3&4 Main Dam Interception Trench failed, resulting in a leak that was repaired. Also in 1999, water was observed issuing to ground surface east of the Saddle Dam and a Saddle Dam groundwater collection system was installed in 2000. This Saddle Dam groundwater collection system was expanded in 2001 by adding collection wells 646D and 647D. A paste plant was constructed at the 3&4 EHP and in late 2003 the scrubber slurry was routed to the plant for thickening and flyash removal. The paste was then pumped to the pond at about 65% solids and the clearwater was sent to the clearwell. A pasting strategy was put in place to help reduce the potential for seepage from the pond. In 2002 and early 2003, the north and south SP-15 trenches were installed west of this pond. Water was observed issuing to ground surface in late 2004 in the South Fork Cow Creek Drainage. In 2004, a groundwater collection system was installed in South Fork Cow Creek (south of this pond). In 2005, the South Fork Cow Creek groundwater collection system was expanded and a groundwater collection system was installed south of the 3&4 EHP. Also in 2005, a 45 mil RFP liner (with underdrain system) was added to Cell F of this pond for impacted groundwater collection storage and water management. In 2003, 2005, 2008 and 2010 the west side groundwater collection system was expanded with the addition of pumping wells and a secondary sump. In 2009, the clearwell was relocated to Cell B (which contains dry paste) and lined with 45 mil RFP and underdrain collection system. Groundwater capture was added to the east side of the ponds in 2009, 2010, 2011, and 2012. In 2009, groundwater collection was expanded on the east side near well 560A. Cell H was synthetically lined and an underdrain installed in 2013. The Main Dam and Saddle Dam were raised to final elevation in 2012.
Units 3 & 4 Effluent Holding Pond Cell F	520	53.6	2005 - present	Cell F was lined 2005 using 10'+ of dried paste slurry as the bottom liner and 45 mil RFP as the upper liner with leachate collection between. It is a water storage cell.	In 2004, a groundwater collection system was installed in South Fork Cow Creek (south of this pond). In 2005, the South Fork Cow Creek groundwater collection system was expanded and a groundwater collection system was installed south of the 3&4 EHP. Also in 2005, a 45 mil RFP liner (with underdrain system) was added to Cell F of this pond for impacted groundwater collection storage and water management. Groundwater capture was added to the east side of the ponds in 2009, 2010, 2011, and 2012. The Main Dam and Saddle Dam were raised to final elevation in 2012.
Add Cell H (New)	614	42	2013 - present	New Cell H was constructed in 2013 using a double-liner consisting of an upper 45 mil RFP liner, between liner collection, 37 mil RFP underliner, and underliner collection system.	Currently receiving water from Cell C.
Units 3 & 4 Effluent Holding Pond Cell B – New Clearwell	638.6	34.5	2009-present	Lined in 2008 with 45-mil RFP and underdrain system. In 2009, the clearwell was relocated to Cell B.	Receives clearwater from the paste plant which in turn is pumped to the Plantsite for reuse.
Units 3&4 Scrubber - EHP <u>Pipeline</u>	NA	NA	1983 - present	NA	Pipeline that transports scrubber slurry to 3&4 EHP. Transports scrubber slurry 3 miles from the scrubbers to the EHP and returns clearwater back to the scrubbers. Line was originally fiberglass, changed out to HDPE from 1988 - 1998. Failure of pipeline reported in 1987, 1988, 1989, 1990, 1992, 1993, 1994, 1995, 1997, and 2000. In 2000, a groundwater collection system was installed downgradient from Drain Pit #3 along the pipeline. In 2001, a groundwater collection system was installed downgradient from Drain Pit #5 along the pipeline.

Prior to construction and the completion of the initial construction phase, the bottom of the pond was treated with bentonite below an elevation of 3,200 feet. Treatment involved in place mixing of the upper six-inches of soil to a level of 10 % minimum WyoBen bentonite. Treatment was conducted after the upper foot of topsoil and subsoil was removed. Spreading and compaction were completed after soil treatment. Portions of the pond floor that were too steep or the ground was too hard for in place mixing, was capped with an 8-inch layer of bentonite treated soil. An underdrain system, consisting of 6-inch slotted corrugated polyethylene was installed above the bentonite. The underdrain system was designed to help dewater the pond in the future. The laterals for the underdrain system were connected to a sump located between what is now the Old Clearwell and Cell C (Bechtel, 1985a).

A bentonite amended plastic concrete cutoff wall (cutoff wall) was installed around the perimeter of the pond to inhibit horizontal flow. The wall was installed through unconsolidated materials (mainly clinker) and at least five feet into "tight" bedrock. The wall was designed with a minimum wall thickness of two feet and maximum permeability of 1×10^{-7} centimeters per second (cm/sec). Laboratory testing was conducted to confirm that permeability specifications were met (Bechtel, February 1985b).

The pond was originally constructed with a series of cells to serve as settling ponds. During original operations, flyash slurry was piped to an "active" cell. Solids would settle and water would decant to an adjacent cell and ultimately to the Old Clearwell, located adjacent to the Main Dam. Clear water (water with solids settled out) was pumped to the Plant and reused in the Units 3&4 Scrubbers.

In late 2003, a paste plant became operational at the 3&4 EHP. Scrubber slurry was piped to the paste plant where a flocculent was added to accelerate settlement of solids. Clear water from the paste plant was routed directly to the Old Clearwell and pumped back to the plant scrubbers for reuse. Paste from the paste plant, was deposited around the perimeter of the pond or on exposed areas of clinker within the boundaries of the pond.

A 45 mil reinforced polypropylene (RFP) liner, with underdrain system, was installed in Cell F in 2005 to serve as a storage pond for collected groundwater. Cell F is currently used to store excess process water and collected groundwater. In 2008, a 45 mil RFP liner, with underdrain system, was installed in Cell B. In 2009, Cell B became the New Clearwell and the Old Clearwell was taken out of service. Paste has since been routed to the exterior of the Old Clearwell. Cell H was recently re-constructed as a double-lined pond consisting of an upper 45 mil RFP liner, between liner collection, 37 mil RFP underliner, and underliner collection. Cell H was recently completed (September 2013) and will be used for water management so the Old Clearwell, Cell G, and Cell C can be lined in the future.

2.1.2 Units 3 & 4 EHP Water Chemistry

Water quality samples are periodically collected from various cells in the 3&4 EHP. Table 2-2 shows average values for common ions and metals, as well as the most recent pond sample collected for each pond. Data for organic constituents or other parameters that are not typically analyzed are included when present. Note that some of the data are for ponds that are not currently in use, or that have been closed. For example, Cell E has been out of service and has not contained free water for storage since about 1999. Additionally, Cell H was originally unlined and was filled with flyash. A new Cell H was recently constructed, using a double synthetic liner system, over the footprint of the original Cell H. Data shown in Table 2-2 is for the original Cell H.

Water quality for Cell C provides a representative range of chemicals typically found in the 3&4 EHP. Note, however, that concentrations of chemical constituents will vary depending on the overall amount of water, amount of precipitation water, the degree that evaporation has reduced water volumes, and number of times water has been recirculated through the scrubber system. Water in Cell C has very elevated specific conductance as well as concentrations of total dissolved solids (TDS), sulfate, boron, and selenium. In addition, the calcium to magnesium ratio is very low. These parameters or ratios are used as indicators for process water impacts outside of the ponds.

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
			7/18/2012
UNITS 3&4 EFFLUENT HOLDING POND - CELL C	PH	7	**7.8**
	SC (UMHOS/CM AT 25 C)	23280	**30900**
	TDS (MEASURED AT 180 C)	34680	**50100**
	TOTAL HARDNESS AS CACO3	31500	**31500**
	CALCIUM (CA) DIS	535	**555**
	MAGNESIUM (MG) DIS	4820	**7320**
	SODIUM (NA) DIS	1900	**2890**
	POTASSIUM (K) DIS	105	**143**
	TOTAL ALKALINITY AS CACO3	90.4	**293**
	BICARBONATE (HCO3)	110	**358**
	CARBONATE AS CO3	<2.6	**<4**
	SULFATE (SO4)	23940	**37400**
	CHLORIDE (CL)	711	**1150**
	FLUORIDE (F)	25	**25**
	BROMIDE (BR)	251	**596**
	NITRATE + NITRITE AS N	1.21	**2.13**
	NITRITE (NO2-N)	0.24	**0.24**
	ORTHOPHOSPHATE (PO4-P)	<0.005	**<0.005**
	PHOSPHORUS (P) TOT	0.2	**0.2**
	ALUMINUM (AL) TOT	2.11	**2.11**
	ANTIMONY (SB) TOT	0.051	**0.051**
	ARSENIC (AS) TOT	0.011	**0.011**
	BARIUM (BA) TOT	0.15	**0.15**
	BERYLLIUM (BE) TOT	<0.001	**<0.001**
	BORON (B) DIS	168	**NA**
	BORON (B) TOT	247	**247**
	CADMIUM (CD) TOT	0.015	**0.015**
	CHLORINE (CL) TOT	<0.1	**<0.1**
	CHROMIUM (CR+6) DIS	<0.01	**<0.01**
	CHROMIUM (CR+3) DIS	<0.01	**<0.01**
	CHROMIUM (CR) TOT	<0.005	**<0.005**
	COBALT (CO) TOT	0.119	**0.119**
	COPPER (CU) TOT	0.091	**0.091**

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
UNITS 3&4 EFFLUENT HOLDING POND - CELL C	IRON (FE) TOT	<0.2	**<0.2**
(continued)	MANGANESE (MN) TOT	39	**39**
	MERCURY (HG) DIS	<0.001	**NA**
	MERCURY (HG) TOT	<0.0001	**<0.0001**
	MOLYBDENUM (MO) TOT	2.22	**2.22**
	NICKEL (NI) TOT	0.734	**0.734**
	SELENIUM (SE) DIS	0.415	**NA**
	SELENIUM (SE) TOT	0.583	**0.583**
	SILVER (AG) TOT	<0.001	**<0.001**
	THALLIUM (TL) TOT	<0.0005	**<0.0005**
	VANADIUM (V) TOT	0.06	**0.06**
	ZINC (ZN) TOT	0.12	**0.12**
	BENZENE VPH	<0.0005	**<0.0005**
	ETHYLENE GLYCOL	<250	**<250**
	ETHYLBENZENE VPH	<0.0005	**<0.0005**
	TOTAL XYLENE VPH	<0.005	**<0.005**
	M-P XYLENE VPH	<0.0005	**<0.0005**
	O-XYLENE VPH	<0.0005	**<0.0005**
	METHYL ETHYL KETONE VOC	<0.02	**<0.02**
	METHYL TERT-BUTYL ETHER VPH	<0.001	**<0.001**
	NAPHTHALENE (VOL)	<0.001	**<0.001**
	TOLUENE VPH	<0.0005	**<0.0005**
	HEXACHLOROBENZENE	<0.01	**<0.01**
	EXTRACTABLE HYDROCARBONS	0.51	**0.51**
	DIESEL RANGE ORGANICS	0.33	**0.33**
	C9-C10 AROMATICS	<0.02	**<0.02**
	C9 TO C12 ALIPHATICS	<0.02	**<0.02**
	OIL & GREASE	<1	**<1**
	PURGEABLE HYDROCARBONS TOT	<0.02	**<0.02**
	TOT EXTRACTABLE HYDROCARBON(EPH)	0.51	**0.51**
	TOT EXTRACTABLE HYDROCARBON(EPHscr)	<303	**<303**
	CYANIDE (CN) TOT	0.72	**0.72**
	C5-C8 ALIPHATICS	<0.02	**<0.02**
			5/18/1999

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
3&4 EHP CELL E	PH	6	6
	SC (UMHOS/CM AT 25 C)	16600	16600
	TDS (MEASURED AT 180 C)	23200	23200
	CALCIUM (CA) DIS	612	612
	MAGNESIUM (MG) DIS	3280	3280
	SODIUM (NA) DIS	1210	1210
	SULFATE (SO4)	14600	14600
	CHLORIDE (CL)	364	364
	BORON (B) DIS	125	125
	SELENIUM (SE) DIS	0.443	0.443
			9/16/2009
3&4 EHP CELL F	PH	7.35	7.3
	SC (UMHOS/CM AT 25 C)	31100	25700
	TDS (MEASURED AT 180 C)	49750	36900
	TOTAL HARDNESS AS CACO3	39200	NA
	CALCIUM (CA) DIS	518	489
	MAGNESIUM (MG) DIS	7105	5010
	SODIUM (NA) DIS	2680	1980
	POTASSIUM (K) DIS	134	106
	TOTAL ALKALINITY AS CACO3	112.5	83
	BICARBONATE (HCO3)	137	101
	CARBONATE AS CO3	4	4
	SULFATE (SO4)	36500	25600
	CHLORIDE (CL)	1024.5	719
	FLUORIDE (F)	38	NA
	ALUMINUM (AL) TOT	0.32	NA
	ANTIMONY (SB) TOT	0.079	NA
	ARSENIC (AS) TOT	0.015	NA
	BARIUM (BA) TOT	0.09	NA
	BERYLLIUM (BE) TOT	0.001	NA
	BORON (B) DIS	183	183
	BORON (B) TOT	303	NA

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
3&4 EHP CELL F	BROMIDE (BR)	338.67	50
(continued)	C5-C8 ALIPHATICS	0.02	NA
	C9 TO C12 ALIPHATICS	0.02	NA
	C9-C10 AROMATICS	0.02	NA
	CADMIUM (CD) TOT	0.018	NA
	NITRATE + NITRITE AS N	1.58	NA
	NITRITE (NO2-N)	0.06	NA
	ORTHOPHOSPHATE (PO4-P)	0.005	NA
	PHOSPHORUS (P) TOT	0.2	NA
	CHLORINE (CL) TOT	0.1	NA
	CHROMIUM (CR) TOT	0.005	NA
	CHROMIUM (CR+3) DIS	0.01	NA
	CHROMIUM (CR+6) DIS	0.01	NA
	COBALT (CO) TOT	0.169	NA
	COPPER (CU) TOT	0.111	NA
	CYANIDE (CN) TOT	0.005	NA
	IRON (FE) TOT	0.2	NA
	MANGANESE (MN) TOT	59.8	NA
	MERCURY (HG) DIS	0.001	0.001
	MERCURY (HG) TOT	0.0001	NA
	NICKEL (NI) TOT	1.02	NA
	SELENIUM (SE) DIS	0.235	0.235
	SELENIUM (SE) TOT	0.625	NA
	SILVER (AG) TOT	0.001	NA
	THALLIUM (TL) TOT	0.0018	NA
	VANADIUM (V) TOT	0.07	NA
	ZINC (ZN) TOT	0.17	NA
	BENZENE VPH	0.0005	NA
	DIESEL RANGE ORGANICS	0.41	NA
	ETHYLBENZENE VPH	0.0005	NA
	ETHYLENE GLYCOL	250	NA
	HEXACHLOROBENZENE	0.01	NA
	METHYL ETHYL KETONE VOC	0.02	NA
	METHYL TERT-BUTYL ETHER VPH	0.001	NA

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
3&4 EHP CELL F	MOLYBDENUM (MO) TOT	2.88	NA
(continued)	M-P XYLENE VPH	0.0005	NA
	NAPHTHALENE (VOL)	0.001	NA
	O-XYLENE VPH	0.0005	NA
	OIL & GREASE	1	NA
	PURGEABLE HYDROCARBONS TOT	0.02	NA
	TOLUENE VPH	0.0005	NA
	TOT EXTRACTABLE HYDROCARBON(EPH)	0.59	NA
	TOT EXTRACTABLE HYDROCARBON(EPHscr)	0.303	NA
	TOTAL XYLENE VPH	0.0005	NA
			9/16/2009
3&4 EHP CELL G	PH	7.2	8.5
	SC (UMHOS/CM AT 25 C)	20200	22400
	TDS (MEASURED AT 180 C)	29750	30000
	CALCIUM (CA) DIS	481	484
	MAGNESIUM (MG) DIS	3940	3910
	SODIUM (NA) DIS	1680	1880
	POTASSIUM (K) DIS	109	109
	TOTAL ALKALINITY AS CACO3	403	403
	BICARBONATE (HCO3)	399	399
	CARBONATE AS CO3	46	46
	SULFATE (SO4)	20150	20800
	CHLORIDE (CL)	584.5	746
	BORON (B) DIS	141	159
	BROMIDE (BR)	23	28
	MERCURY (HG) DIS	0.001	0.001
	SELENIUM (SE) DIS	0.3295	0.077

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
			5/26/1994
3&4 EHP CELL H (OLD Cell H)	PH	6.2	6.1
	SC (UMHOS/CM AT 25 C)	19850	21000
	TDS (MEASURED AT 180 C)	27400	26300
	TOTAL HARDNESS AS CACO3	18100	19000
	CALCIUM (CA) DIS	552	568
	MAGNESIUM (MG) DIS	4060	4270
	SODIUM (NA) DIS	1425	1550
	POTASSIUM (K) DIS	87.5	91
	TOTAL ALKALINITY AS CACO3	39	23
	TOTAL ACIDITY AS CACO3	1	1
	BICARBONATE (HCO3)	48	29
	FLUORIDE (F)	18.1	16
	SULFATE (SO4)	19450	20400
	CHLORIDE (CL)	386	408
	ALUMINUM (AL) DIS	1.5	2.2
	BORON (B) DIS	133	131
	CADMIUM (CD) DIS	0.022	0.008
	COPPER (CU) DIS	0.04	0.04
	IRON (FE) DIS	0.08	0.13
	LEAD (PB) DIS	0.01	0.01
	MANGANESE (MN) DIS	22	25.4
	MERCURY (HG) DIS	0.001	0.001
	NICKEL (NI) DIS	0.32	0.27
	SELENIUM (SE) DIS	0.4955	0.514
	VANADIUM (V) DIS	0.17	0.16
	ZINC (ZN) DIS	0.01	0.01
	NITRATE + NITRITE AS N	11.7	13.3
	ORTHOPHOSPHATE (PO4-P)	0.085	0.02

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
			7/19/2012
3&4 EFFLUENT HOLDING POND	PH	8.22	**10.9**
CLEARWELL (OLD)	SODIUM ADSORPTION RATIO	3.28	**NA**
	SC (UMHOS/CM AT 25 C)	14244	**3510**
	TDS (MEASURED AT 180 C)	20230	**2650**
	TOTAL HARDNESS AS CACO3	13143	**1200**
	CALCIUM (CA) DIS	514	**480**
	MAGNESIUM (MG) DIS	2714	**2**
	SODIUM (NA) DIS	963	**363**
	POTASSIUM (K) DIS	58.3	**17**
	HYDRAZINE	<0.005	**NA**
	TOTAL ALKALINITY AS CACO3	141	**62**
	TOTAL ACIDITY AS CACO3	<1	**NA**
	BICARBONATE (HCO3)	142	**<4**
	CARBONATE AS CO3	15.5	**31**
	SULFATE (SO4)	13976	**1860**
	CHLORIDE (CL)	318	**72**
	FLUORIDE (F)	6.36	**0.7**
	BROMIDE (BR)	24.3	**9**
	NITRATE + NITRITE AS N	4.55	**0.64**
	NITRITE (NO2-N)	0.22	**0.31**
	ORTHOPHOSPHATE (PO4-P)	0.048	**0.008**
	PHOSPHORUS (P) TOT	0.16	**0.06**
	SIGMA	1.87	**NA**
	ALUMINUM (AL) DIS	0.725	**NA**
	ALUMINUM (AL) TOT	0.833	**1.95**
	ANTIMONY (SB) TOT	0.027	**0.004**
	ARSENIC (AS) TOT	0.007	**0.002**
	BARIUM (BA) TOT	0.145	**0.12**
	BERYLLIUM (BE) TOT	<0.001	**<0.001**
	BORON (B) DIS	92.6	**NA**
	BORON (B) TOT	63.8	**2.98**
	CADMIUM (CD) DIS	0.022	**NA**
	CADMIUM (CD) TOT	0.002	**<0.001**

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
3&4 EFFLUENT HOLDING POND	CHLORINE (CL) TOT	0.1	**<0.1**
CLEARWELL (OLD)	CHROMIUM (CR+6) DIS	<0.01	**<0.01**
(continued)	CHROMIUM (CR+3) DIS	<0.01	**<0.01**
	CHROMIUM (CR) TOT	0.01	**<0.005**
	COBALT (CO) TOT	0.019	**<0.005**
	COPPER (CU) DIS	0.04	**NA**
	COPPER (CU) TOT	0.02	**<0.005**
	IRON (FE) DIS	0.243	**NA**
	IRON (FE) TOT	0.123	**0.06**
	LEAD (PB) DIS	0.015	**NA**
	MANGANESE (MN) DIS	13.1	**NA**
	MANGANESE (MN) TOT	2.94	**0.006**
	MERCURY (HG) DIS	0.001	**NA**
	MERCURY (HG) TOT	<0.0001	**<0.0001**
	MOLYBDENUM (MO) TOT	0.876	**0.194**
	NICKEL (NI) DIS	0.085	**NA**
	NICKEL (NI) TOT	0.164	**<0.005**
	SELENIUM (SE) DIS	0.197	**NA**
	SELENIUM (SE) TOT	0.051	**0.005**
	SILVER (AG) TOT	<0.003	**<0.001**
	STRONTIUM (SR) DIS	14.2	**NA**
	THALLIUM (TL) TOT	<0.0503	**<0.0005**
	VANADIUM (V) DIS	0.179	**NA**
	VANADIUM (V) TOT	0.063	**0.04**
	ZINC (ZN) DIS	0.045	**NA**
	ZINC (ZN) TOT	0.04	**<0.01**
	BENZENE VOC	<0.001	**NA**
	BENZENE VPH	<0.0005	**<0.0005**
	ETHYLENE GLYCOL	<130	**<250**
	ETHYLBENZENE VOC	<0.001	**NA**
	ETHYLBENZENE VPH	<0.0005	**<0.0005**
	TOTAL XYLENE VOC	<0.001	**NA**
	TOTAL XYLENE VPH	<0.0013	**<0.0005**
	M-P XYLENE VOC	<0.001	**NA**

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
3&4 EFFLUENT HOLDING POND	M-P XYLENE VPH	<0.0005	**<0.0005**
CLEARWELL (OLD)	O-XYLENE VOC	<0.001	**NA**
(continued)	O-XYLENE VPH	<0.0005	**<0.0005**
	METHYL ETHYL KETONE VOC	<0.02	**<0.02**
	METHYL TERT-BUTYL ETHER VPH	0.168	**<1**
	NAPHTHALENE (VOL)	<0.001	**<0.001**
	TOLUENE VOC	<0.001	**NA**
	TOLUENE VPH	<0.0005	**<0.0005**
	2-METHYLNAPHTHALENE	<0.011	**NA**
	ACENAPHTHENE	<0.011	**NA**
	ACENAPHTHYLENE	<0.011	**NA**
	ANTHRACENE	<0.011	**NA**
	BENZO (A) ANTHRACENE	<0.011	**NA**
	BENZO (A) PYRENE	<0.011	**NA**
	BENZO (B) FLUORANTHENE	<0.011	**NA**
	BENZO (GHI) PERYLENE	<0.011	**NA**
	BENZO (K) FLUORANTHENE	<0.011	**NA**
	CHRYSENE	<0.011	**NA**
	DIBENZ (A,H) ANTHRACENE	<0.011	**NA**
	FLUORANTHENE	<0.011	**NA**
	FLUORENE	<0.011	**NA**
	HEXACHLOROBENZENE	<0.01	**<0.01**
	INDENO (1,2,3-CD) PYRENE	<0.011	**NA**
	NAPHTHALENE (SEMI-VOL)	<0.011	**NA**
	NAPHTHALENE (VPH)	<0.001	**NA**
	PHENANTHRENE	<0.011	**NA**
	PYRENE	<0.011	**NA**
	DIESEL RANGE ORGANICS AS DIESEL	0.325	**NA**
	DIESEL RANGE ORGANICS	0.343	**0.31**
	C9-C10 AROMATICS	<0.02	**<0.02**
	C9 TO C12 ALIPHATICS	<0.02	**<0.02**
	OIL & GREASE	8.25	**<1**
	OIL & GREASE TRC	0.1	**NA**
	PURGEABLE HYDROCARBONS TOT	<0.02	**<0.02**

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
3&4 EFFLUENT HOLDING POND	TOTAL EXTRACTABLE HYDROCARBONS	0.28	**NA**
CLEARWELL (OLD)	TOTAL EXTRACTABLE HYDROCARBONS VPH	<0.33	**NA**
(continued)	TOT EXTRACTABLE HYDROCARBON(EPH)	1.4	**0.78**
	TOT EXTRACTABLE HYDROCARBON(EPHscr)	1.22	**0.588**
	CYANIDE (CN) TOT	0.024	**<0.005**
	C5-C8 ALIPHATICS	<0.02	**<0.02**
	C11-C22 AROMATICS	0.263	**NA**
	C19-C36 ALIPHATICS	3.55	**NA**
	C9-C18 ALIPHATICS	0.325	**NA**
			7/18/2012
UNITS 3&4 EFFLUENT HOLDING POND	PH	6.67	**7.2**
CLEARWELL (NEW) CELL B	SC (UMHOS/CM AT 25 C)	31967	**33200**
	TDS (MEASURED AT 180 C)	49767	**54000**
	TOTAL HARDNESS AS CACO3	30700	**30700**
	CALCIUM (CA) DIS	523	**476**
	MAGNESIUM (MG) DIS	7283	**7160**
	SODIUM (NA) DIS	2670	**2540**
	POTASSIUM (K) DIS	135	**114**
	TOTAL ALKALINITY AS CACO3	67	**157**
	BICARBONATE (HCO3)	82	**192**
	CARBONATE AS CO3	<4	**<4**
	SULFATE (SO4)	37167	**41200**
	CHLORIDE (CL)	1040	**1180**
	FLUORIDE (F)	28	**28**
	BROMIDE (BR)	517	**849**
	NITRATE + NITRITE AS N	10.6	**10.6**
	NITRITE (NO2-N)	0.19	**0.19**
	ORTHOPHOSPHATE (PO4-P)	0.141	**0.141**
	PHOSPHORUS (P) TOT	0.2	**0.2**
	ALUMINUM (AL) TOT	0.82	**0.82**
	ANTIMONY (SB) TOT	0.087	**0.087**
	ARSENIC (AS) TOT	0.021	**0.021**
	BARIUM (BA) TOT	0.15	**0.15**

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
UNITS 3&4 EFFLUENT HOLDING POND	BERYLLIUM (BE) TOT	<0.001	**<0.001**
CLEARWELL (NEW) CELL B	BORON (B) DIS	260	**NA**
(continued)	BORON (B) TOT	296	**296**
	CADMIUM (CD) TOT	0.028	**0.028**
	CHLORINE (CL) TOT	<0.1	**<0.1**
	CHROMIUM (CR+6) DIS	0.02	**0.02**
	CHROMIUM (CR+3) DIS	<0.01	**<0.01**
	CHROMIUM (CR) DIS	0.026	**0.026**
	COBALT (CO) TOT	0.236	**0.236**
	COPPER (CU) TOT	0.164	**0.164**
	IRON (FE) TOT	0.4	**0.4**
	MANGANESE (MN) TOT	64.3	**64.3**
	MERCURY (HG) DIS	<0.001	**NA**
	MERCURY (HG) TOT	0.0003	**0.0003**
	MOLYBDENUM (MO) TOT	2.15	**2.15**
	NICKEL (NI) TOT	1.13	**1.13**
	SELENIUM (SE) DIS	1.13	**NA**
	SELENIUM (SE) TOT	1.4	**1.4**
	SILVER (AG) TOT	<0.001	**<0.001**
	THALLIUM (TL) TOT	0.0048	**0.0048**
	VANADIUM (V) TOT	0.12	**0.12**
	ZINC (ZN) TOT	0.13	**0.13**
	BENZENE VPH	<0.0005	**<0.0005**
	ETHYLENE GLYCOL	<250	**<250**
	ETHYLBENZENE VPH	<0.0005	**<0.0005**
	TOTAL XYLENE VPH	<0.005	**<0.005**
	M-P XYLENE VPH	<0.0005	**<0.0005**
	O-XYLENE VPH	<0.0005	**<0.0005**
	METHYL ETHYL KETONE VOC	<0.02	**<0.02**
	METHYL TERT-BUTYL ETHER VPH	<0.001	**<0.001**
	NAPHTHALENE (VOL)	<0.001	**<0.001**
	TOLUENE VPH	<0.0005	**<0.0005**
	HEXACHLOROBENZENE	<0.01	**<0.01**
	DIESEL RANGE ORGANICS	0.31	**0.31**

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
UNITS 3&4 EFFLUENT HOLDING POND	C9-C10 AROMATICS	<0.02	**<0.02**
CLEARWELL (NEW) CELL B	C9 TO C12 ALIPHATICS	<0.02	**<0.02**
(continued)	OIL & GREASE	<1	**<1**
	PURGEABLE HYDROCARBONS TOT	<0.02	**<0.02**
	TOT EXTRACTABLE HYDROCARBON(EPH)	0.62	**0.62**
	TOT EXTRACTABLE HYDROCARBON(EPHscr)	0.5	**0.5**
	CYANIDE (CN) TOT	0.065	**0.065**
	C5-C8 ALIPHATICS	<0.02	**<0.02**
			7/18/2012
UNITS 3&4 EFFLUENT HOLDING POND	PH	7.58	**7.5**
MAIN DAM SUMP (3&4 MDS)	SODIUM ADSORPTION RATIO	3.09	**NA**
	SC (UMHOS/CM AT 25 C)	13064	**1350**
	TDS (MEASURED AT 180 C)	17295	**16600**
	TOTAL HARDNESS AS CACO3	11375	**NA**
	CALCIUM (CA) DIS	472	**461**
	MAGNESIUM (MG) DIS	2345	**2120**
	SODIUM (NA) DIS	884	**1080**
	POTASSIUM (K) DIS	41.2	**54**
	TOTAL ALKALINITY AS CACO3	412	**365**
	TOTAL ACIDITY AS CACO3	0.5	**NA**
	BICARBONATE (HCO3)	503	**445**
	CARBONATE AS CO3	1.91	**<4**
	SULFATE (SO4)	11493	**11600**
	CHLORIDE (CL)	258	**412**
	FLUORIDE (F)	0.803	**NA**
	BROMIDE (BR)	28.1	**19**
	NITRATE + NITRITE AS N	19.6	**NA**
	ORTHOPHOSPHATE (PO4-P)	0.02	**NA**
	ALUMINUM (AL) DIS	<0.15	**NA**
	BORON (B) DIS	63	**74.3**
	CADMIUM (CD) DIS	0.006	**NA**
	COPPER (CU) DIS	0.02	**NA**
	IRON (FE) DIS	<0.128	**NA**

TABLE 2-2
CHEMICAL PROFILES (DATA USED VALIDATED DATA THROUGH 2012)
*** ALL UNITS mg/L UNLESS OTHERWISE SPECIFIED**
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

SITE	PARAMETER	MEAN	DATE AND ANALYSES OF MOST RECENT SAMPLE
UNITS 3&4 EFFLUENT HOLDING POND	LEAD (PB) DIS	<0.015	**NA**
MAIN DAM SUMP (3&4 MDS)	MANGANESE (MN) DIS	0.045	**NA**
(continued)	MERCURY (HG) DIS	<0.001	**NA**
	NICKEL (NI) DIS	0.025	**NA**
	SELENIUM (SE) DIS	0.02	**<0.005**
	VANADIUM (V) DIS	<0.1	**NA**
	ZINC (ZN) DIS	<0.043	**NA**
			7/6/2012
UNITS 3&4 EFFLUENT HOLDING POND	PH	7.66	7.6
SADDLE DAM SUMP (3&4 SDS)	SC (UMHOS/CM AT 25 C)	5788	4820
	TDS (MEASURED AT 180 C)	6091	4490
	CALCIUM (CA) DIS	391	285
	MAGNESIUM (MG) DIS	674	447
	SODIUM (NA) DIS	355	371
	POTASSIUM (K) DIS	25.2	17
	TOTAL ALKALINITY AS CACO3	416	453
	BICARBONATE (HCO3)	508	552
	CARBONATE AS CO3	2.33	<4
	SULFATE (SO4)	3935	2830
	CHLORIDE (CL)	73.8	34
	BROMIDE (BR)	6	<1
	BORON (B) DIS	9.44	4
	MERCURY (HG) DIS	<0.001	NA
	SELENIUM (SE) DIS	0.017	<0.005

2.2 POND SEEPAGE ESTIMATES

An estimate of seepage to groundwater beneath each pond in the 3&4 EHP is required in this Site Report in accordance with Section VI.A.1(f) of the AOC. Seepage estimates were developed using the following process and are included herein.

1. A review of pond design and construction, including design seepage estimates, was conducted.
2. Lithology and hydrogeologic characteristics for sediments beneath the 3&4 EHP were examined.
3. Methods for calculating seepage were chosen and parameterized for each pond based on specific construction details and hydrogeologic setting.
4. Seepage calculations were completed and validated by field observations and/or compared to previous seepage estimates.

The 3&4 EHP was originally designed without geo-synthetic liners; instead, the first ponds were lined with native soils amended with bentonite below an elevation of 3,200 feet (Bechtel, 1985a). A bentonite amended concrete cutoff wall into bedrock was also constructed to limit seepage through baked shale (clinker) that is present in the pond area. PPLM has begun the process of adding geo-synthetic liners to the 3&4 EHP. PPLM's process will include dewatering cells, grading the pond bottom and covering with low permeability paste, and installing liners with an underdrain and leak detection system. Currently, the 3&4 EHP includes three lined cells (Cells B, F, and H) and three unlined cells (Cells G, C, and the Old Clearwell). The dewatering and paste application phases have begun at Cells G, C, and the Old Clearwell. A description of each cell is included in Table 2-1.

Calculations of seepage for all cells, lined or unlined, are dependent on pond size (area), pool level (head), and underlying permeability. Additional parameters related to liner installation and quality are used for lined cells. A description of basic hydraulic parameters, followed by a narrative of the seepage calculation process for lined and unlined ponds is contained in the following sections.

2.2.1 Pond Area and Water Levels

The area of each 3&4 EHP cell assigned to the seepage calculations was obtained from construction design specifications and/or by delineating the ponds as they appear in recent aerial photographs using AutoCAD Civil 3D. Therefore, the surface area used in the seepage calculation for each pond may not necessarily correspond exactly with the area of each 3&4 EHP cell summarized in Table 2-1. The outer perimeters of lined cells B, F, and H were assumed in the calculations. Conversely, the area for partially dewatered cells C, G, and the Old Clearwell was calculated by delineating the wetted area within the cell during routine operating conditions prior to cell dewatering (circa. 2005). Areas estimated based on past operating conditions are meant to provide a conservative seepage result.

Seepage from ponds, whether they are lined or unlined, is dependent on head. Pond water levels are monitored by PPLM on a weekly basis. Head on the pond liners in each of cells B and F is assumed to be 20 feet, based on recent routine water level surveys. Cell H has only been in operation for a period of a few months; so a depth of 10 feet was used in the seepage calculation for this cell. Typical water level elevations during operation of unlined Cells C, G, and the Old Clearwell were approximately 3,270 feet, 3,235 feet, and 3,235 feet, respectively. Cell bottom elevations, however, were variable with time, depending on the amount of fly ash deposition.

2.2.2 Lithology and Hydraulic Conductivity

Design seepage estimates were made by Bechtel (1982) based on data gathered from geologic mapping and permeability testing at a series of exploration boreholes and monitoring wells drilled within the perimeter of the then proposed unlined ponds. Results of the evaluation indicated that lithology and permeability beneath the 3&4 EHP construction site is variable and is a significant factor for estimating flux beneath the ponds. A simplified sequence of baked shale or clinker, interbedded siltstone, sandstone, claystone, and McKay Coal underlain by more interbedded siltstone, sandstone, and claystone was presented in the report. Permeabilities of thermally unaltered bedrock (i.e. sandstone, siltstone, claystone, and coal) ranged from less than 1 ft/year to 1823 ft/year (Bechtel Power Corporation, 1982).

Permeability of the clinker was inestimable by the test methods presented in the report; however, a review of aquifer testing results from clinker aquifers (Heffern & Coates, 1999) suggests a range of clinker transmissivity in the Powder River Basin from 35,400 ft^2/day to 1,482,400 ft^2/day. Based on testing on well 1002R and evaluation of initial startup pumping data, the hydraulic conductivity (ability of media to transmit water) was calculated to be 2500 feet per day with a transmissivity of about 64,000 ft^2/day. A bentonite amended concrete cutoff wall was constructed around the perimeter of the pond to restrict horizontal flow through the clinker.

The lithology presented in cross sections of the 3&4 EHP Design Report (Bechtel Power Corporation, 1982) is similar to the current understanding of subsurface lithology in the 3&4 EHP area. A discussion of 3&4 EHP area lithology and current geologic cross sections are included in Section 3 of this report. In general, clinker from the Rosebud burn is at the surface, followed by Rosebud/McKay interburden consisting of interbedded siltstone, sandstone, and shale. The McKay Coal is present west and south of the 3&4 EHP. A whole section of the McKay Coal formation is approximately 10 feet thick. Locally, it may be thinner depending on erosion or burn. More Fort Union Formation bedrock is present beneath the McKay. Cross sections (introduced as Figures 3-1 through 3-3 in Section 3 of this report) illustrate the depositional environment beneath the ponds and extending from the ponds in each direction.

2.2.3 Seepage Estimates for Lined Ponds

Geo-synthetic liner materials are inherently of negligible permeability; so seepage through the liner is contingent on the quality of liner installation and the occurrence of liner defects. Equations developed by Giroud (1992, 1997) for estimating seepage through composite landfill liner defects were adapted to estimate seepage through lined cells of the 3&4 EHP. The estimates are parameterized by the frequency and size of liner defects, head above the liner, pond acreage, and thickness and permeability of soil beneath the liner. Equations, variable assignments, calculations, and results of the seepage estimates for lined ponds (B, F, and H) in the 3&4 EHP are included in Table 2-3. The cumulative estimate of current

TABLE 2-3
SEEPAGE ESTIMATES FOR LINED CELLS B, F, AND H
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3&4 EFFLUENT HOLDING POND

Cell	Area (acres)[1]	Head (ft)	Head (m)	I_{avg} [2]	Q_d (m^3/sec)	Q_{cell} (m^3/sec)	Q_{cell} [3] (gpm)
EHP Cell B (New Clearwell)	33.3	20	6.10	1.20	6.53E-07	2.17E-05	0.3
EHP Cell F	67.5	20	6.10	1.20	6.53E-07	4.41E-05	0.7
EHP Cell H	42.0	10	3.05	1.10	6.01E-07	2.52E-05	0.4
						Q_{Total}	***1.4***

Notes:

[1] Area is assumed to be all area within impoundment berm.
[2]Calculated using equation of Giroud (1997).
Assumes one 0.15 in^2 defect per acre.
Assumes 10 feet of dry paste beneath each geosynthetic pond liner.
Assumes quality of liner contact is good. Factor C_q = 0.21
Hydraulic conductivity of 1 ft/day is conservative estimate based on Bechtel (1982) and aquifer test results of wells completed in 3&4 EHP Area.

Equations:

$$i_{avg} = 1 + 0.1\left(\frac{h}{t_s}\right)^{0.95}$$ *analytical expression for average hydraulic gradient*

$$Q_d = C_q{*}i_{avg} * a^{0.1} * h^{0.9} * k^{0.74}$$ *volumetric leakage rate per defect, m^3/sec.*

$$Q_{cell} = Q_d * n * A$$ *volumetric leakage rate per cell*

where:

iavg = average hydraulic gradient (unitless)
h = head above liner (m)
ts = thickness of low permeability soil beneath liner (m)
a = area of defect (m^2)
k = hydraulic conductivity of low-permeability soil beneath liner
Qd = leakage rate per defect
n = number of defects per cell
A = area of cell (acres)
Qcell = leakage rate per cell

Example (for cell F):

A = 67.5 Acres *h = 9.15 m* *n=1* *a = 5.06E-6 m^2 (one-inch circular defect)*
K = 0.028 ft/day (9.88E-8 m/sec) *ts = 3 m* *Cq = 0.21*

$$i_{avg} = 1 + 0.1\left(\frac{h}{t_s}\right)^{0.95} = 1 + 0.1\left(\frac{6.1}{3}\right)^{0.95} = 1.20$$

$$Q_d = C_q{*}i_{avg} * a^{0.1} * h^{0.9} * k^{0.74}$$

$$Q_d = 0.21 * 1.20 * (9.68E^{-5})^{0.1} m^2 * 6.1^{0.9} m{*}9.88E^{-8}\ m/\sec = 6.57E^{-7}\ \frac{m^3}{sec}$$

$$Q_{cell} = Q_d * n * A = 6.57E^{-7}\ \frac{m^3}{sec}{*}1\frac{defect}{acre}{*}67.5\ acres = 4.41E^{-5}\ \frac{m^3}{sec}$$

(convert Q_{cell} to gpm);

$$4.41E^{-5}\ \frac{m^3}{sec}{*}\frac{60\ sec}{1\ min}{*}\frac{264.17 gallon}{1 m^3} = 0.7 \text{ gpm}$$

Sum of Q_{cell} for all lined ponds

$$Q_{total} = \sum Q_{cell} = 0.7 + 0.4 + 0.3 = \mathbf{1.4gpm}$$

seepage from all lined cells is approximately 1.4 gpm. A discussion of model input, results, and sensitivity of parameters is as follows.

To date, cells B, F, and H are lined; but PPLM plans on lining each cell in the 3&4 EHP. Design seepage estimates, assuming all cells are lined, range from 3 gpm to 17 gpm. However, these design calculations are conservative estimates for a single composite liner and do not account for the double-lining strategy that PPLM intends to use. Cells with double synthetic liners will result in lower seepage rates. Cell H was recently constructed as a double-lined pond consisting of an upper 45 mil RFP liner, between liner collection, 37 mil RFP underliner, and underliner collection. Similar construction is planned for future lined cells and will effectively result in near zero seepage under typical operating conditions.

2.2.3.1 Parameterization of Liner Defects

Typical for a liner performance evaluation, one defect per acre is considered with a defect area of 1.5×10^{-2} in^2; for a conservative seepage estimate, a defect area of 0.15 in^2 can be considered (Giroud et al., 1994). The more conservative defect area was used in calculations of seepage through lined ponds in the 3&4 EHP; however, ongoing monitoring of between-liner collection systems indicates that little or no water is present beneath the liners (pers. Comm. Mike Holzwarth). Thus, all calculated values of seepage through lined ponds are conservative estimates.

An empirical contact factor (C) is included in the equations of Giroud (1992, 1997) to parameterize the quality of liner installation. A liner in good contact with underlying sediments is assigned a C value of 0.21. Alternatively, a liner in poor contact with the underlying sediments is assigned a C value of 1.15. Results of Giroud's equations are very sensitive to the assignment of this parameter. For example, the cumulative seepage estimate for the 3&4 EHP, assuming equal values of all other parameters, would increase by greater than a factor of five (i.e. 1.4 gpm would increase to greater than 7.9 gpm). The assumption of poor liner contact would result in an amount of seepage that would be easily detectable in the leachate collection system. This amount of seepage is not supported by between-liner

monitoring data. The C value for good contact (0.21) is assumed appropriate for this seepage calculation.

The liners installed in cells B and F are composite liners that consist of a geosynthetic layer over a layer of dry paste with a leachate collection system between the 45 mil geosynthetic liner and the dry paste. The hydraulic conductivity of the paste layer is important to the function of the composite liner. Note that Cell H has double synthetic liners, but was modeled conservatively as a single lined pond over paste. Paste hydraulic conductivity of $1x\ 10^{-5}$ cm/sec (0.028 ft/day) was used in seepage calculations for lined ponds based on results of paste percolation tests conducted by Hydrometrics, Inc. (Hydrometrics, Inc., November 6, 2008).

2.2.4 Seepage Estimates for Unlined Ponds

Design seepage estimates for the 3&4 EHP were made prior to construction by Bechtel (Bechtel Power Corporation, 1982). Seepage rates were estimated using a seven step approach that included both an analytical method and a numerical model. The analytical method, developed first, was simply a summation of flux estimates for various flow paths around the perimeter of the pond. Flux was calculated by Darcy's law (Q = KIA); where K is hydraulic conductivity, I is hydraulic gradient, and A is cross sectional area perpendicular to groundwater flow. K and A were well parameterized with data gathered during exploration and permeability testing in the 3&4 EHP area. The hydraulic gradient was assumed based on a difference between full pool elevation of 3,280 feet and estimated elevations of presumed hydrologic boundaries and features at known differences from the pond. For example, the elevation of Cow Creek and its distance from the 3&4 EHP was commonly used. Several simplifying assumptions were made in the Darcy flux calculations which include the pond is filled with water; no transient effects of pond filling; not accounting for a reduction in hydraulic head by seepage of liquid through accumulated fly ash; steady state conditions; no consideration for unsaturated flow conditions; and only horizontal flow was considered.

A numerical model was developed later by Bechtel and was used to refine seepage estimates by addressing some of the simplifying assumptions initially identified in the analytical method (Bechtel, 1982). The numerical model included a vertical flow component, addressed variable locations of the water pool within the pond, included effects of effluent material (fly ash) on seepage rates, represented variations of permeability of various rock types, and accounted for transient effects. Calibration factors, calculated as the ratio of numerical model results to Darcy flux calculation results, were applied to yield final seepage estimates.

Bechtel (1982) calculated an initial seepage estimate (analytical method) of 275 gpm at the cutoff wall by applying the Darcy flux analytical method to a scenario where the entire 3&4 EHP was filled to an elevation of 3,280 feet. This initial seepage estimate was refined using the numerical model to produce a final seepage estimate of 90 gpm. Note that the accuracy of the numerical seepage model was limited by the data used as input. Limitations include representativeness of permeabilities determined by percolation tests and the lack of available data to validate transient model predictions.

Hydrometrics adapted the Darcy flux method used by Bechtel in design calculations to estimate a conservative groundwater flux at the bentonite amended concrete cutoff wall under operating conditions of the unlined ponds (Cells G, C, and the Old Clearwell) in the 3&4 EHP. However, the lithology assigned to the calculations was based on an additional 30 years of observations, the hydraulic gradient used in the calculations was based on actual water level measurements made from within the ponds and at monitoring wells both inside and outside of the 3&4 EHP boundary, and no calibration factors were applied to the results that would potentially reduce flux estimates.

Flux was calculated for four different flow paths, each originating at the 3&4 EHP and extending to the north, south, east, and west. These flow paths are consistent with flow perpendicular to the cross sections that Bechtel identified as AC, CE, IE, and IK in both the 3&4 EHP design report (Bechtel 1982) and the as-built report (Bechtel 1985). The present

flux calculations are presented in Table 2-4. A description of each of the four flow paths and the resulting cumulative flux estimate at the bentonite amended concrete cutoff wall is as follows:

- North – This flow path is assumed to the north from the 3&4 EHP towards Cow Creek. It is analogous to flow through Cross Section AC (Bechtel Power Corporation, 1982). The lithology used to parameterize the estimate of flux for the north flow path is exemplified in Cross Section C-C', (Figure 3-3, Section 3 of this report), which was created approximately parallel to the direction of groundwater flow. Groundwater flux for the north flow path was considered as the sum of flow through the bentonite amended concrete cutoff wall and through a sequence of interbedded siltstone, claystone, and sandstone. The McKay Coal is generally absent along the north flowpath. When encountered, the coal is generally burned and a complete flow path through the unit does not appear to exist. Twenty-five feet of head was assigned to the cutoff wall, based on October 2013 water level of 3,235 in the Old Clearwell and a cutoff wall elevation of 3,210 feet. For all flow paths, a cutoff wall thickness of 2 feet and hydraulic conductivity (K) of 0.1 ft/year were assumed. These are listed as minimum specifications in the slurry cutoff wall final construction report (Bechtel, 1985). The first layer of interbedded siltstone was assigned a thickness of 60 feet based on lithology observations made at wells drilled just outside of the bentonite amended concrete cutoff wall (e.g. 1115D and 1080D). Hydraulic conductivity of the upper interbedded interval is assumed to be very low, as no saturated conditions have been observed in this interval during monitoring well drilling. A K value of 20 ft/yr (0.05 ft/day) was applied to this interval based on permeability tests by Bechtel (1982).

  An average K of 365 ft/yr (1 ft/day) was applied to sandstone north of the 3&4 EHP based on testing results at wells 1080D, 1081D, and 1082D that were 4 ft/day, 1.2 ft/day, and 0.04 ft/day, respectively. Total flux estimated at the north 3&4 EHP was 165 gpm. This estimate includes 1.7 gpm through the cutoff wall; but the majority of flow along this pathway is attributed to sandstone bedrock units.

TABLE 2-4
FLUX ESTIMATES FROM UNLINED PONDS
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

	North	
Kw	0.1	$1x10^{-7}$ cm/sec and minimum thickness of 2 feet (Bechtel, 1985).
Hw	25	ft, based on Old Clearwell effluent elevation 3235 and slurry wall bottom elevation of 3210 ft
Lw	2	ft, flow length (thickness of wall)
Tw	25	ft, thickness (depth)
W	3840	feet, from cross section A-C (Bechtel, 1982)
Q	120,000	cf/year
Qgpm	**1.7**	**gpm, Q*f**
Kin	20	ft/yr, from Plate 10 (used lower interburden value based on field observations)
Hin	55	ft, 3235 - 3180 (head in old clear well - basal elevation of interbeds)
Lin	300	ft, distance from north edge of Old Clear Well to opposite side of slurry wall
Tin	55	based on head in clearwell - basal elevation
W	3840	feet, from cross section A-C (Bechtel, 1982)
Q	774,400	cf/year
Qgpm	**11.0**	**gpm, Q*f**
Ks	365	ft/yr, from Plate 10
Hs	55	ft, 3235 - 3180 (head in old clear well - head in sandstone outside of slurry wall)
Ls	300	ft, distance from north edge of Old Clear Well to opposite side of slurry wall
Ts	40	ft, thickness of sandstone bed (from wells 1080D and 1115D)
W	3840	feet, from cross section A-C (Bechtel, 1982)
Q	10,278,400	cf/year
Qgpm	**146**	**gpm, Q*f**
Kin	20	ft/yr, from Plate 10 (used lower interburden value based on field observations)
Hin	40	ft, 3140 - 3100 (assume thickness of unit)
Lin	300	ft, distance from north edge of Old Clear Well to opposite side of slurry wall
Tin	40	ft, thickness of bed from well 581-D2
W	3840	feet, from cross section A-C (Bechtel, 1982)
Q	409,600	cf/year
Qgpm	**6**	**gpm, Q*f**
$Q_{flowpath}$	11,582,400	cf/year
$Q_{flowpath}$	**165**	**gpm, Q*f**

	West	
Kw	0.1	$1x10^{-7}$ cm/sec and minimum thickness of 2 feet (Bechtel, 1985).
Hw	30	Based on 1085R water level (3255 feet) as compared to slurry wall bottom elevation of 3225 ft
Lw	2	ft, flow length (thickness of wall)
Tw	30	ft, thickness (depth)
W	3600	feet, measured cross section I-K (Bechtel, 1982)
Q	162,000	cf/year
Qgpm	**2.3**	**gpm, Q*f**
Kc	200	ft/yr, from Plate 10
Hc	24	Head at well 1085R (3255 feet) minus head at well WM-126 (3231 feet)
Lc	200	Distance between edge of slurry wall and well WM-126
Tc	5	ft, thickness of coal section in tact beneath slurry wall
W	3600	feet, measured cross section I-K (Bechtel, 1982)
Q	432,000	cf/year
Qgpm	**6**	**gpm, Q*f**
Kin	20	ft/yr, from Plate 10
Hin	10	ft, thickness of interbed unit
Lin	200	ft, distance to opposite side of slurry wall
Tin	10	ft, thickness of interbed unit
W	3600	feet, measured cross section I-K (Bechtel, 1982)
Q	36,000	cf/year
Qgpm	**0.5**	**gpm, Q*f**
Ks	100	ft/yr, from Plate 10
Hs	63	ft, water level at 1085R (3255 feet) - head at well 659D (~3192 feet)
Ls	200	ft, distance to well 659D from edge of slurry wall
Ts	20	ft, unit thickness of sandstone
W	3600	feet, measured cross section I-K (Bechtel, 1982)
Q	2,268,000	cf/year
Qgpm	**32**	**gpm, Q*f**
Kin	20	ft/yr, from Plate 10
Hin	13	ft, difference in head between 572D (3203 feet) and 659D (3190 feet)
Lin	2775	ft, distance from 572D (inside slurry wall) to 659D (outside slurry wall)
Tin	15	ft, thickness of unit
W	3600	feet, measured cross section I-K (Bechtel, 1982)
Q	5,059	cf/year
Qgpm	**0.1**	**gpm, Q*f**
Ks	365	ft/yr, from Plate 10
Hs	13	ft, difference in head between 572D (3203 feet) and 659D (3190 feet)
Ls	2775	ft, distance from 572D (inside slurry wall) to 659D (outside slurry wall)
Ts	25	ft
W	3600	feet, measured cross section I-K (Bechtel, 1982)
Q	153,892	cf/year
Qgpm	**2.2**	**gpm, Q*f**
$Q_{flowpath}$	2,898,000	cf/year
$Q_{flowpath}$	**44**	**gpm, Q*f**

Q = KIA, where I = H/L and A = T*W

Q Flux (cubic feet per year)
K Average Hydraulic Conductivity
L Average flow length
W Section Width
T Average Thickness

w slurry wall
in interbedded silstone, sandstone, and shale
c Coal (McKay)
s sandstone

Qgpm Flux (gallons per minute)
f conversion factor:
ft^3/year * 7.48gal/ft^3 / 525,600 min/year

TABLE 2-4
FLUX ESTIMATES FROM UNLINED PONDS
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFFLUENT HOLDING POND

	East	
Kw	0.1	$1x10^{-7}$ cm/sec and minimum thickness of 2 feet (Bechtel, 1985).
Hw	40	ft, based on G Cell effluent elevation of 3235 feet and slurry wall bottom elevation of 3195 feet
Lw	2	ft, flow length (thickness of wall)
Tw	40	ft, thickness (depth)
W	3240	feet, measured cross section C-E (Bechtel, 1982)
Q	259,200	cf/year
Qgpm	**3.7**	**gpm, Q*f**
Kin	20	ft/yr, from Plate 10
Hin	54	ft, based on cell G effluent elevation of 3235 and well 1107D water level elevation of ~ 3181 feet
Lin	400	ft, distance from edge of cell G to representative well 1107D
Tin	30	ft, thickness of interbeds (Cross Section A-A', Figure 3-1).
W	3240	feet, measured cross section C-E (Bechtel, 1982)
Q	262,440	cf/year
Qgpm	**4**	**gpm, Q*f**
Ks	365	ft/yr, from Plate 10
Hs	54	ft, based on cell G effluent elevation of 3235 and well 1107D water level elevation of ~ 3181 feet
Ls	400	ft, distance from edge of cell G to representative well 1107D
Ts	15	ft,thickness of sandstone
W	3240	feet, measured cross section C-E (Bechtel, 1982)
Q	2,394,765	cf/year
Qgpm	**34**	**gpm, Q*f**
Kin	20	ft/yr, from Plate 10
Hin	75	ft, thickness of unit
Lin	400	ft, distance from edge of cell G to representative well 1107D
Tin	75	ft, thickness of unit
W	3240	feet, measured cross section C-E (Bechtel, 1982)
Q	911,250	cf/year
Qgpm	**13**	**gpm, Q*f**
$Q_{flowpath}$	3,827,655	cf/year
$Q_{flowpath}$	**54**	**gpm, Q*f**

	South	
Kw	0.1	$1x10^{-7}$ cm/sec and minimum thickness of 2 feet (Bechtel, 1985).
Hw	40	Based on head in 674R as compared to slurry wall bottom elevation of 3220
Lw	2	ft, flow length (thickness of wall)
Tw	40	ft, thickness (depth)
W	5280	feet, measured cross section E-I (Bechtel, 1982)
Q	422400	cf/year
Qgpm	**6.0**	**gpm, Q*f**
Kin	20	ft/yr, from Plate 10
Hin	45	ft,difference in head between 674R and 675R (~ 3260 feet - 3244 feet)
Lin	600	ft, distance to opposite side of slurry wall
Tin	10	ft, plate 10
W	5280	feet, measured cross section E-I (Bechtel, 1982)
	79200	cf/year
	1.1	**gpm, Q*f**
Kc	200	ft/yr, from Plate 10
Hc	72	ft,difference in head between 674R and 1037M
Lc	2400	ft, distance to 1037M from slurry wall
Tc	10	ft, unit thickness
W	5280	feet, measured cross section E-I (Bechtel, 1982)
Q	316800	cf/year
Qgpm	**4.5**	**gpm, Q*f**
Kin	20	ft/yr, from Plate 10
Hin	45	ft, 3220 - 3180
Lin	600	ft, distance to opposite side of slurry wall
Tin	40	ft, plate 10
W	5280	feet, measured cross section E-I (Bechtel, 1982)
Q	316800	cf/year
Qgpm	**4.5**	**gpm, Q*f**
Ks	365	ft/yr, from Plate 10
Hs	2	ft, difference in head between 572D (3203 feet) and 589D (3201 feet)
Ls	1000	ft, distance from 572D (inside slurry wall) to 589D (outside slurry wall)
Ts	50	ft
W	5280	feet, measured cross section E-I (Bechtel, 1982)
Q	192720	cf/year
Qgpm	**2.7**	**gpm, Q*f**
$Q_{flowpath}$	1011120	cf/year
$Q_{flowpath}$	**14**	**gpm, Q*f**

$$Q_{flowpath} = \sum KIA = \sum \left(Kw * \frac{Hw}{Lw} * Tw * W\right) + \left(Ki * \frac{Hi}{Li} * Ti * W\right) + \left(Kc * \frac{Hc}{Lc} * Tc * W\right) + \left(Ks * \frac{Hs}{Ls} * Ts * W\right)$$

$$\text{Qtotal} = \sum Q_{flowpath}$$

Slurry Wall Flux	**14 gpm**
Sum of all flow paths	**277 gpm**

Q = KIA, where I = H/L and A = T*W

Q Flux (cubic feet per year)
K Average Hydraulic Conductivity
L Average flow length
W Section Width
T Average Thickness

w slurry wall
in interbedded silstone, sandstone, and shale
c Coal (McKay)
s sandstone

Qgpm Flux (gallons per minute)
f conversion factor:
ft^3/year * 7.48gal/ft^3 / 525,600 min/year

- East – The east groundwater flow path is best illustrated in Cross Section A-A', (Figure 3-1, Section 3 of this report) and considers flux through the bentonite amended concrete cutoff wall and underlying strata on the east edge of the 3&4 EHP. Head on the cutoff wall is derived from a typical Cell G effluent elevation of 3,235 feet. Based on the cutoff wall as-built report, the bottom elevation of the cutoff wall ranges from approximately 3,185 to 3,200 feet (Bechtel Power Corporation, February 1985a). An average bottom elevation of 3,195 feet was assigned to the cutoff wall in the flux calculation. Hydraulic conductivities assigned to the interburden and sandstone at the east cutoff wall boundary were consistent with those used for the north flux estimate (K = 365 ft/yr for sandstone and K = 20 ft/yr for siltstone/claystone interburden). The hydraulic gradient was conservatively estimated for each unit as the difference in the water level elevation in cell G (3,235 feet) and the elevation of the hydrostratigraphic interval of interest at an assumed location 400 feet from the pond edge. Four hundred feet is the approximate distance from the edge of Cell G to well 1107D. Well 1107D is completed in the upper sandstone interval and has a water level elevation of approximately 3181 feet. The same water level elevation was assumed for the upper interbedded siltstone/claystone interval. Head for the deeper interbeds was assumed to be equal to the bed thickness of 75 feet. A total flux estimate of 54 gpm was calculated through the east boundary of the 3&4 EHP. This included 3.7 gpm through the bentonite amended concrete cutoff wall.
- West – Groundwater flux through strata beneath the west boundary of the 3&4 EHP was calculated as the summation of flow through the cutoff wall and a sequence of five bedrock intervals: 1) McKay Coal (~10 ft thick); 2) siltstone/claystone interbeds (~10 ft thick); 3) an upper sandstone unit (~ 20 ft thick); 4) a second interbedded unit (~ 15 ft thick); and 5) a deeper sandstone interval (~25 ft thick). Cross section B-B', presented in Figure 3-2 in Section 3 of this report, depicts the lithology parallel to this flowpath. The estimate of flow through the bentonite amended concrete cutoff wall was parameterized by the water level elevation in well 1085R (~3,255 feet) and an average base cutoff wall elevation of 3,225 feet. Flow through the cutoff wall was estimated at 2.3 gpm for the 3,600-foot long west boundary. The cumulative flow estimate through the other five units was 41.7 gpm, resulting in a total estimate of

approximately 44 gpm. Hydraulic gradients for the respective units were established by comparing water level elevations of wells inside the cutoff wall to water level elevations of wells outside of the cutoff wall. Not all of the strata considered in the calculation had paired wells on opposite sides of the cutoff wall. In this case, conservative estimates of head, based on best available data, were made. Water levels inside the cutoff wall were represented by well 1085R (for shallow units) and well 672D (for deeper units).

- South – Lithology used to conceptualize the groundwater flow path to the south of the 3&4 EHP is represented in the southern portion of Cross Section C-C' , (Figure 3-3, Section 3 of this report). This cross section is approximately parallel the direction of groundwater flow to the south of the 3&4 EHP. The average elevation of the bottom of bentonite amended concrete cutoff wall is 3,220 feet. Well 674R is located just inside the cutoff wall and has a typical groundwater elevation of about 3260 feet. Head on the cutoff wall (40 feet) was calculated as the difference between the water level elevation in the nearby well (674R) and the wall bottom elevation. An estimated flux of six gpm was estimated through the cutoff wall. The estimated flux is higher along the south boundary than the other three boundaries considered because of the higher head and greater length of the flow boundary. Flux through strata below the bentonite amended concrete cutoff wall included that through an interbedded siltstone/claystone unit (~10 ft thick), the McKay Coal (~10 ft thick), a second interbed unit (~40 ft thick), and finally a sandstone bed (~50 ft thick). Hydraulic conductivities assigned to the respective units were consistent with those used along other flow pathways; and the hydraulic gradient was established using water level elevations and known distances between wells on opposite sides of the bentonite amended concrete cutoff wall. For example, the difference in head between well 572D (inside cutoff wall) and well 589D (outside cutoff wall) is 2 feet. The wells are separated by an approximate distance of 1000 feet; and both are completed in the deeper sandstone unit. Flow through the south 3&4 EHP boundary, including the bentonite amended concrete cutoff wall, was estimated to be 14 gpm.

- Total – The cumulative flux estimate for all flow pathways beneath the cutoff wall perimeter is 277 gpm; of which, flow through the cutoff wall is estimated at 14 gpm.

Flux estimates were made using a pragmatic approach that employed basic groundwater flow dynamics and a dense network of monitoring and capture wells to parameterize subsurface lithology and groundwater potential along four distinct flow paths. Potentiometric surface maps of Rosebud Coal/Clinker, McKay Coal, and sub-McKay bedrock in the 3&4 EHP area are presented in Figures 3-14 through 3-16 and illustrate that, in general, the 3&4 EHP are centered above a zone of high groundwater potential in each of the respective units. The concept of four groundwater flow pathways is largely validated by applying the principle that the direction of groundwater flow is perpendicular to equipotential lines. A discussion of flow direction and other pertinent groundwater observations for each flow path is discussed as follows.

- North – Potentiometric contours on the north boundary indicate a groundwater flow pathway in the shallow interval (Rosebud clinker or equivalent) that is to the north; although, very little groundwater is present in this interval. Note from Figure 3-14 that wells completed in the clinker (e.g. 1060C and MD-12-17sp) are dry. Sufficient control to predict groundwater flow direction is obtained, however, by triangulating between shallow well 602S and downgradient alluvial wells. Dry conditions immediately outside of the bentonite amended concrete cutoff wall support the estimate made above that relatively little seepage flows through the cutoff wall to the north. The seepage estimate of 1.7 gpm through the cutoff wall is the least of all of the four flow paths. As previously mentioned, the McKay Coal is generally absent along the north flowpath. When encountered, the coal is generally burned and a complete flow path through the unit does not appear to exist. The lack of a continuous coal seam is apparent in the potentiometric surface map (Figure 3-15) and in calculations presented above. The direction of groundwater flow in sub-McKay bedrock is perpendicular to the northern 3&4 EHP boundary and is near true north except where influenced by groundwater capture wells. The conservatively estimated rate of flux through the sub-McKay sandstone north of the ponds (146 gpm) was the

highest of all flux estimates for individual units. Note from Cross Section C-C' (Figure 3-3) that this sandstone unit is directly beneath the 3&4 EHP in Cell C and the Old Clearwell. Several groundwater capture wells are present in this interval to mitigate process water impacts. Groundwater capture effectiveness is discussed further in Section 3.6.

- East – Groundwater flow in shallow bedrock, the McKay Coal, and sub-McKay bedrock trends to the east based on potentiometric contours in Figures 3-14 through 3-16. Less than 8 gpm is estimated to flow through the cutoff wall and shallow interbeds combined. This estimate is corroborated by the minimal amount of groundwater that is captured at the Saddle Dam Interception Trench. Note that the Saddle Dam Interception Trench also captures shallow recharge water that enters the system between the pond and the trench. The Saddle Dam Interception Trench is completed to the base of the McKay Coal stratigraphic interval (the coal is burned on the northeast side of the pond in the vicinity of the trench) and is designed to drain groundwater, by gravity, from the coal and overlaying units. The McKay Coal is found sparsely in the area east of the 3&4 EHP Saddle Dam and is typically either burned or partially burned. Flow through sub-McKay bedrock east of the Saddle Dam was estimated at 34 gpm. Historic groundwater monitoring observations made prior to construction of the 3&4 EHP indicate that native groundwater was present in sub-McKay bedrock; thus, much of the flow in the deeper bedrock may not have originated at the EHP. Ongoing groundwater quality observations indicate that process water impacts in groundwater east of the ponds are dilute in comparison to pure pond water. A discussion of water quality and mitigation of process water impacts east of the 3&4 EHP Saddle Dam is included in Section 3.6.
- West – An examination of the groundwater flow direction west of the 3&4 EHP (Figures 3-14 through 3-16) indicates that flow is to the west in shallow intervals (i.e. clinker); but tends to be more northwesterly with depth. As such, the assumption of westerly flow from the 3&4 EHP west boundary may result in a conservative estimate of the length of the cross section perpendicular to flow and an overestimate of total flux in McKay and sub-McKay units. Low flux, in general, at all units west of the

3&4 EHP is consistent with observations made at the monitoring and capture well network in the area.

- South – Groundwater flow in upper strata south of the 3&4 EHP is to the south, which is consistent with the assumption of southerly flow used in the flux estimates presented in Table 2-4. Flow in deeper units, however, tends to flow more toward the southeast. A slight inflection toward the southeast is seen in potentiometric contours of the McKay Coal (Figure 3-15); and flow is nearly due east in sub-McKay bedrock (Figure 3-16). The apparent easterly flow direction would result in an overestimate of the flux contribution from the 3&4 EHP because flow in the calculation is assumed perpendicular to the mile-long southern boundary of the 3&4 EHP. Estimates of flux in sub-McKay intervals south of the 3&4 EHP cannot be solely attributed to seepage from the pond, which explains why very little process water impacts are present in deeper bedrock of the South Fork Cow Creek (SFCC) drainage. Process water impacts and mitigation of said impacts is discussed further in Section 3.6.

It is difficult to estimate seepage from unlined ponds in the 3&4 EHP due to variable head in the ponds and uncertainty of pond bottom hydraulic conductivity that has likely changed with addition of fly ash and/or paste deposition in the cells. All flow through the bentonite amended concrete cutoff wall is assumed to be impacted by process water or to have originated directly at the 3&4 EHP; likewise, flow through lined ponds is considered to be process water. Flow through the entire perimeter of the cutoff wall is estimated to be 14 gpm; and the conservative estimate of flow through lined ponds was 1.4 gpm. The Darcy flux calculations presented herein account for all groundwater flow, which may include seepage from unlined ponds, seepage from lined ponds, and native groundwater. By considering all groundwater flow, the resulting flux of 277 gpm is an estimate of the upper limit of process water seepage. The present estimate is consistent with the design flux calculation made by Bechtel (1982), which resulted in an estimate of 275 gpm.

2.2.5 Seepage Estimated by Groundwater Model

Section 4 of this report presents results of a numerical groundwater flow model commissioned by PPLM for the Units 3&4 EHP area. NewFields Companies, LLC designed the numerical flow model (Newfields, 2013) based on an existing conceptual model (Geomatrix, 2005) of the Units 3&4 EHP hydrogeologic system. The numerical model provides a tool for simulating groundwater flow patterns in the 3&4 EHP area and for assessing the effectiveness of existing groundwater capture systems. The model was parameterized with data collected in 2003 and 2012. The model report (Newfields, 2013) is included in its entirety in Appendix A. The current model (Newfields, 2013) differs from the design numerical model constructed by Bechtel (1982) in that it was populated with hydrogeologic data from numerous additional wells, extensive aquifer testing results, capture system evaluation data, and a better understanding of the conceptual groundwater flow system, in general. Advances in computer code and computing power also make it possible to create a more detailed model than was originally constructed.

The previously discussed flux estimates were compared to pond seepage estimates derived from the calibrated numerical groundwater flow model of Newfields (2013). Like the flux calculations, seepage simulated by the model is dependent on head in the unlined cells and hydrogeologic parameters of the underlying strata. Seepage from lined cells was considered to be zero in the numerical model. Cumulative seepage estimates for all unlined ponds based on 2003 and 2012 operational parameters were 168 gpm and 281 gpm, respectively. The simulated seepage estimates are consistent with design flux estimates made by Bechtel (1982) and flux estimates presented in Section 2.2.4 of this report.

3.0 SUMMARY OF INVESTIGATIONS

3.1 PAST RELEASES

Table 3-1 contains a list of incidents that resulted in confirmed releases, were suspected of causing releases, or potentially resulted in a release but information gathered after the observation did not confirm a release.

3.2 PAST INVESTIGATIONS

Table 3-2 contains a chronological listing of events in the 3&4 EHP area that have been, or are being investigated. The table includes the approximate date of the report, report title, general topic, and a summary of results or findings.

3.3 SYNOPSIS OF PAST SPILLS, INVESTIGATIONS, MITIGATION, STATUS

Numerous investigations have been conducted in the 3&4 EHP relating to process ponds, spills associated with the pipelines, or changes in water quality identified in operational groundwater monitoring. Table 3-2 contains a list of the reports, date of the report, and a short summary of the work conducted and findings of the investigations or studies.

3.4 CURRENT SITE CONDITIONS

Site hydrogeologic descriptions have been presented in numerous previous site reports which are summarized in Table 3-2 with the report listed in the reference section of this report. An overview, with concentrations on current site condition is provided here for convenience.

TABLE 3-1
SUMMARY OF RELEASES OF ACTIONS TAKEN
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFLLUENT HOLDING POND

Date	Area	Estimated Amount Loss Gallons	Action
December 2, 1987	Near Drain Pit#5, upstream of well WA-144, 350 yards west of Drain Pit #5.	~100,000	Repair was made and a localized groundwater monitoring program was initiated to check the integrity of the pit liner. Evaluation of the pit liner concluded that the liner was intact and monitoring was discontinued.
June 2, 1988	350 yards west of pipeline Drain Pit #5: a road grader damaged the Colstrip Units 3 & 4 EHP pipeline creating a 2-inch gash in the wall.	~50,000 gals of scrubber effluent slurry	The pumps were shut down in 5 minutes. All of the slurry was diverted down the road and into pipeline drain pond #5. None of the spill came in contact with vegetation. Since the spill was contained in the drain pond, no additional clean up measures were taken.
July 27, 1988	3.5 miles east of power plant: fatigue-type failure of the Colstrip Units 3 & 4 EHP pipeline attributed to compression of line when draining before vents are opened.	~100,000 gals of scrubber effluent slurry	Approximately 1.5 acres were affected. Automatic vents were installed prior to the spill, but some of the piping still fatigued. Settled solids were collected from ground surface, and the area was re-seeded in the fall. A complete line inspection was conducted. Downstream wells will continue to be monitored. A flow indicating device to alarm any significant flow loss was installed.
November 9, 1988	Near Drain Pit #5	~4,000 gals of scrubber effluent slurry	Not documented
December 3, 1988	Just west of Drain Pit #5 (a pipeline drain pond): The 3 & 4 EHP pipeline separated at a joint. The separation was caused by a pump train swap.	~60,000 gals of scrubber effluent slurry	Inspection procedures (including inspection of pipeline immediately after a pump train swap) are in place to allow early detection of pipeline failure. This failure was detected in 8 minutes and pumps shut down in 20 minutes. Half of the slurry spill went into Drain Pit #5 and the other half down drainage at 200 yards. A flow alarm was installed. Straw bales were placed in drainage to minimize transport of solids downstream. Wells downstream were monitored.
September 17, 1989	Near Drain Pit #5: drain line washed/eroded a hole in the containment berm. The slurry water went underground and surfaced about 30 feet away and ran into a natural depression.	~2,000 gals of common effluent slurry	No cleanup was initiated since most of the water was soaked up by the ground.
September 25, 1989	3.5 miles east of power plant: fatigue-type failure of the Colstrip Units 3 & 4 EHP pipeline attributed to compression of line when draining before vents are opened.	~30,000 gals of scrubber effluent slurry	Approximately 1 acre was affected. Automatic vents were installed prior to the spill, but some of the piping still fatigues. A complete line inspection was conducted. No clean up measures were conducted at the time of the spill since the solids were less than 1-inch thick. Downstream wells will continue to be monitored. Installation of a flow indicating device to alarm any significant flow loss was completed.
1989	3&4 EHP Main Dam Sump. Investigation of groundwater indicated degraded water was present in the alluvium downgradient of the 3&4 Main Dam Sump. Water losses may have been through subsurface flow from the pond and/or losses from the 3&4 Main Dam Sump.	Not documented	A groundwater interception trench (3&4 EHP Main Dam Interception Trench) was designed and installed in November and December 1989 to capture groundwater flowing in the alluvium downgradient of the 3&4 Main Dam Sump. The trench became operational on December 20, 1989 and was still operating as of this writing.
December 23, 1990	½ mile west of 3&4 EHP auto vent (inside cutoff wall): Pipeline split while putting 3&4 EHP Pipeline fitting back in service after power outage.	~5,000 gals of	Not documented
August 4, 1992	Power outage at the 3&4 EHP Main Dam Sump due to lightning strike. Power was also out at the Lower Main Dam Interception Trench. Electrical power was out for about 14 hours.	Not documented	Repairs were made as soon as possible and the sump was put back into service.
March 1994	Return pipeline failure - Drain Pit #3.	Not documented	Pipeline repaired and placed back in service. Groundwater monitoring initiated at existing downgradient monitoring wells WD-106, WA-132 & WA-134.
1999	3&4 Main Dam Interception Trench – gasket failure.	Not documented	The gasket was repaired and groundwater capture resumed.
December 1999	3&4 EHP Saddle Dam – process water was discovered issuing to ground surface at two locations east of the dam.	Not documented	Surface water was contained by damming the drainage a short distance downstream of the point of issue. Water was returned to the 3&4 EHP. Water levels in 3&4 EHP Cell G were lowered stopping the flow of water. Investigation was begun immediately with installation, sampling and testing of numerous monitoring wells. The monitoring frequency in the area was increased. Groundwater capture wells were installed near the 3&4 EHP Saddle Dam Main Sump. A gravity drain interception trench was installed in shallow material (generally equivalent to base elevation of McKay Coal) to collect groundwater flowing at the contact of unconsolidated and consolidated deposits. Water from the trench drains to the 3&4 EHP Saddle Dam Valley Drain which flows to the 3&4 EHP Saddle Dam Main Sump.

TABLE 3-1
SUMMARY OF RELEASES OF ACTIONS TAKEN
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 AND 4 EFLLUENT HOLDING POND

Date	Area	Estimated Amount Loss Gallons	Action
December 11-14, 1999	Clear water return pipeline valve left open causing Drain Pit #3 to overflow. Water flowed down the drainage several hundred yards.	200,000	PPL immediately responded by closing the valve and pumping water from the pond. Water had flowed down the drainage between 3,000 and 5,000 feet. Water in the drainage downstream was contained and removed. An investigation was conducted resulting in design and installation of an interception trench (Drain Pit#3 Trench), and multiple monitoring wells. The trench includes laterals across the drainage and a drain pipe extending up the drainage. This design was used in an attempt to maximize capture and accelerate cleanup times since the drainage is ephemeral and has flow typically only in response to precipitation runoff.
September 27, 2004	South Fork Cow Creek Seep – south of the 3&4 EHP.	60 gpm when discovered; reduced to seep by June 2005. Dry by fall 2005	PPL immediately began containment activities. A small dam was constructed downstream of the seep (South Fork Diversion) and water was pumped to the 3&4 EHP. Water levels in flooded Cell F and H were lowered. Investigation began immediately. Monitoring wells were installed in South Fork Cow Creek into the alluvium and shallow bedrock to characterize impacts. Capture systems were designed and began pumping to contain downgradient flow of impacted groundwater. Wells were installed south of the 3&4 EHP into the Rosebud interval, McKay coal, and sub-McKay. Certain wells completed in clinker from burning of the Rosebud Coal were converted for groundwater capture and began operating. Wells were installed upstream in SFCC to further evaluate potential flow paths. Impacted wells were converted for groundwater capture. A lift station was constructed to pump impacted groundwater to the 3&4 EHP. Water monitoring was conducted and continues.
November 2004	West Seep – West of the 3&4 EHP.	30 gpm diminished after groundwater collection began and stopped by May 2006	A dam was built across the drainage a short distance downstream of the seep (West Diversion). Water collecting behind the diversion was pumped to the 3&4 EHP. Investigation of the source of the West Seep began immediately. Test pits were excavated at the point of issuance and water was observed flowing from the lower contact of the Rosebud Clinker and underlying interburden. Monitoring wells were installed and several were converted for groundwater capture. Water monitoring was conducted and continues.
November 14, 2008	East of Drain Pit #5. Crack in flyash scrubber slurry pipeline.	Not documented	Pipeline repaired
May 1, 2009	3&4 EHP Saddle Dam Sump. Electrical failure caused main sump pumps to stop operating on April 29, 2009. Water from 3&4 EHP Saddle Dam Chimney Drains the 3&4 EHP Saddle Dam Valley Drain system, and groundwater capture systems. Water was observed spilling on May 1, 2009.	500	Northwestern Energy was immediately contacted by PPL after the spill was discovered. Repairs were made within three hours and the sump was placed back in service. Approximately 500 gallons of water was released. The water was contained about 50 feet downstream of the sump. Water was pumped from the collection area and trucked to the 3&4 EHP.
December 14, 2010	3&4 EHP west of Drain Pit #5 ~100 yards – across drainage ~50 yards. Water and some solids flow about 300 feet downhill from the point of leakage.	5000-10,000	PPLM immediately shut down the pipeline and drained. A containment dike was built in the drainage to control water. Water was pumped from upstream of the containment dike and was hauled to the 3&4 EHP. A shallow monitoring well was installed directly downstream of the containment dike. The area showing the presence of flyash was mapped and soil samples were collected. The flyash was removed and hauled to the 3&4 EHP. Investigation indicated a leaky flange was responsible. Groundwater monitoring was initiated in existing wells and the new wells. Pumps were installed in wells WA-145 and WA-222 located downgradient of Drain Pit #5, after changes in water quality was observed. PPL installed a synthetic liner in Drain Pit #5. Water quality changes were not observed downgradient of the containment dike.
October 11, 2012	SP-15 South (SP-15S) Collection Trench vault. Leakage from a meter and pipe union within the south vault flowed downhill towards a second vault closer to the North SP-15 Interception Trench sump and into the North Vault. This area is hydrologically upgradient of the North SP-15 Interception Trench and the Drain Pit 5 (DP-5) Interception Trench.	300 to 400	Collection wells feeding the pipeline were turned off immediately. Valves on the pipeline were closed to minimize losses during drainage of the pipeline. Water was captured from ground surface and within piping vaults. Repairs were initiated the day after the leakage was discovered. Effected soil in the area was excavated to a depth of 0.5 feet (~ 25 yds^3) and placed in the 3&4 EHP. Capture systems were placed back in service after repairs were completed. The area was reseeded with a native grass mixture.
October 16, 2012	3&4 EHP Saddle Dam Sump. Changes in pipeline configurations may have resulted in an inability for pumps within the sump to overcome hydrologic heads within the pipeline. Collection water exited the sump and flowed approximately 150 yards down the drainage.	3,000 to 4,000	Collection system pumps feeding the sump were immediately turned off and investigation began. Capture system water was re-routed and capture wells were restarted. Approximately 0.5 feet of soil was removed (~10 yds3) and replaced. The area was reseeded with native grass seed. This area is hydrologically upgradient of multiple capture wells.

TABLE 3-2
SUMMARY OF WORK CONDUCTED AND FINDINGS
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 & 4 EFFLUENT HOLDING POND

DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
June 8, 1982	Water Resources of the Cow Creek Drainage near Colstrip, Montana. Hydrometrics, Inc.	Report of investigation of the existing hydrologic system of the Cow Creek watershed including the potential hydrologic impacts of the proposed EHP upon the system.	The 23 square mile Cow Creek drainage is about 9 miles long and is comprised of Cow Creek and its tributary, the South Fork. The drainage slopes gently eastward to its confluence with Rosebud Creek. Nearly flat-lying sediments of the Tongue River member and Lebo Shale member of the Tertiary Fort Union Formation comprise the bedrock in the watershed. The Rosebud Coal seam is present in the uppermost section of the Cow Creek watershed and the McKay coal seam underlies much of the upper 1/3 of the basin and part of the planned EHP. There is about 300 feet of strata between the McKay coal and the top of the Lebo Shale. The Lebo Shale is about 170 feet thick and outcrops in the eastern edge of the watershed. The most significant groundwater-bearing units are the McKay coal, sub-McKay strata and the alluvium present in drainage bottoms. All strata in the drainage except clinker have moderately low to very low permeabilities. Surface water flow in the basin occurs only during part of the year. Surface water is used primarily for stock watering. Groundwater quality in the basin is variable. Most groundwater is a very hard, alkaline, magnesium-sulfate type with low concentrations of nutrients and metals and moderate to high concentrations of boron. Surface water in the upper Cow Creek drainage is very hard, alkaline, magnesium-sulfate type, with TDS concentrations ranging from 2740 to 4490 mg/l, low concentrations of nutrients and metals, and moderate to high concentrations of boron. Water quality in the lower reaches of Cow Creek is similar to that of upper Cow Creek, but TDS concentrations are significantly higher. The proposed 380 acre EHP will be located in the upper reaches of the Cow Creek drainage between Cow Creek and the South Fork. Water in the pond will have an estimated TDS of 32,000 mg/l and will be strongly magnesium-sulfate type water. The lower portion of the pond is in sub-McKay strata. The McKay coal seam outcrops at several places in the pond. Areas of baked shale are present within and peripheral to the upper portions of the pond. Pond seepage impacts will depend on the rate of seepage and may include an increase in salinity of groundwater underlying and peripheral to the pond. Additional investigation of surface water, groundwater and water quality is planned for the upper Cow Creek drainage to better understand these resources.
October 1982	Effluent Holding Pond Design Report, Colstrip Project Montana, Bechtel Power Corporation	Report presenting design and recommendations for the construction of the effluent holding pond for the Colstrip Steam Poser Plant, Units 3 and 4.	This report presents the exploration results, the design criteria, and the recommendations for construction of the EHP Main Dam and Saddle Dam, designed to hold the scrubber effluent and bottom ash from Units 3 & 4 of Colstrip Power Plant. The EHP is to be located in Sections 5 and 6, Township 1 North, Range 42 East, in Rosebud County, Montana. The EHP is scheduled to go into operation starting October 1983.
January 21, 1983	Installation and Testing of Groundwater Monitoring Wells, Upper Cow Creek Drainage, Colstrip, Montana. Hydrometrics, Inc.	A report describing monitor well installation and testing. This report also presents a compilation of groundwater data from the drainage and includes a discussion of the use of basin hydrogeological information as it relates to control of seepage water from the holding pond.	Presently, there are about 85 groundwater observation wells in and near the Upper Cow Creek drainage. Of these, 24 monitoring wells were installed as part of this investigation to provide a comprehensive groundwater monitoring network. Geological units of importance to groundwater resources in the upper Cow Creek drainage are unconsolidated alluvial deposits and several units in the Tongue River Member of the Fort Union Formation including the Rosebud coal, Rosebud/McKay interburden, McKay coal and Sub-McKay strata. Aquifer tests and water quality samples were obtained from all new monitoring wells that contained sufficient water. Results of bailer recovery tests of two McKay coal wells (555M and 571M) showed this unit has a transmissivity of less than 10 gpd/ft. Transmissivity of Sub-McKay sandstone and siltstone strata are widely variable. Transmissivity for ten tests of Sub-McKay strata range from less than 10 to 1600 gpd/ft. Five wells in Cow Creek and South Fork Cow Creek alluvium all have moderately high transmissivity ranging from about 15,000 to >50,000 gpd/ft. Water quality is highly variable.

TABLE 3-2
SUMMARY OF WORK CONDUCTED AND FINDINGS
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 & 4 EFFLUENT HOLDING POND

DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
March 30, 1984	Development of a Groundwater Monitoring System for Colstrip Units 3&4 Process Ponds, Colstrip, Montana. Hydrometrics, Inc.	A comprehensive groundwater monitoring system for the 3&4 Effluent Holding Ponds is developed in this report.	Hydrometrics installed 27 groundwater monitoring wells in the vicinity of the proposed 3&4 EHP during July 1983 using forward rotary drilling. Each well was completed in a single water-bearing zone and was isolated from overlying zones with packers and by backfilling the well annulus with low permeability materials. Wells were constructed of 4.5-inch PVC casing with saw-cut slots. Eight wells were installed in the McKay coal, five in the sub-McKay strata, eight in old mine spoils, and six in shallow McKay coal overburden. Wells were developed and sampled for water quality.
March 1985	Installation and Testing of Groundwater Monitoring Wells near the Units 3 and 4 Effluent Holding Pond, Colstrip, Montana. Hydrometrics, Inc.	Report of drilling, construction and testing of all monitoring wells installed in the vicinity of the EHP by Hydrometrics, Western Energy, and Bechtel.	38 groundwater monitoring wells were installed by Hydrometrics from 1982 to 1983. Aquifer testing was completed at each of these wells to evaluate transmissivity of the water bearing units that include the McKay Coal, the sub-McKay sandstone and siltstone, and the alluvium of Cow Creek and its tributaries. All wells, including the Western Energy and Bechtel wells, were sampled for laboratory analysis of water quality. Bailer recovery tests of two McKay wells indicate a transmissivity of this unit of less than 10 gpd/ft. Transmissivity of 19 tests of sub-McKay strata ranged from less than 10 to 3100 gpd/ft. Five wells in the Cow Creek and South Fork Cow Creek alluvium all have moderately high transmissivities ranging from about 15,000 to greater than 50,000 gpd/ft. Tributary channels in the Upper Cow Creek drainage contain thin, narrow, deposits of alluvium and/or colluvium. The alluvial-colluvial deposits were observed to be dry or to have only thin saturated zones at their base. Strata in the EHP area are nearly horizontal. Generally pond seepage will be vertically downward until it encounters impermeable strata or the groundwater table; then groundwater movement will be predominately lateral. Engineering measures for controlling pond seepage water include construction of a slurry wall, division of the EHP in to discreet cells, and interception of seepage from the dams by use of internal drainage systems and downstream pump-back systems. A comprehensive groundwater monitoring program is being used to monitor performance of the holding pond. Groundwater quality and water levels are monitored in strata peripheral to the pond to determine impacts of seepage on the existing groundwater system.
July 1985	Evaluation of 1984 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana. Hydrometrics, Inc.	Annual Water Resources Report	44 wells are utilized for monitoring groundwater quality near the 3&4 EHP. Four wells show changes in sulfate or SC great than 20 %. Changes could not be related to pond seepage. McKay coal wells 555M and 571M showed significant water level rises during 1984. These rises are likely related to nearby slurry wall construction. Chemical analysis of water from the 3&4 EHP shows a significant increase in dissolved solids concentration from 1983 to 1984.
December 1985	Drilling and Completion of Genie Alternate Stock Wells Rosebud County, Montana	The purpose of this project was to demonstrate an adequate water source on Genie Land Company property for use as replacement stock water.	The project involved drilling and completing three water wells to depths ranging from 100 to 200 feet deep. Base on the driller's yield test all of these wells demonstrate a capacity to yield 10 gallons per minute or more. Specific conductance of the water in each of the wells is less than 3000 µmhos/cm, which is well below the recommended specific conductance (4500 ppm TDS) limit for stock water. These results demonstrate an adequate stock water resource.
June 25, 1986	Evaluation of 1985 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana. Hydrometrics, Inc.	Annual Water Resources Report	Five new wells were installed outside of the slurry wall; these include 588D, 589D, 589M, 590I and 590M. Wells influenced by slurry wall construction activities include 555M, 556D, 571D, 572D, WI-108 and WM-124 as indicated by water level increases and/or water quality changes.
August 1986	Data Report Hydrogeochemical Study of the Cow and Pony Creek Drainages, Rosebud County, MT. Battelle Pacific Northwest Laboratory	Data compilation report that includes hydro-geochemical information collected in the study drainages from October 1984 through December 1985. The objective of the study is to assess existing water quality east of the Colstrip Power Plant to measure potential effects of the ash disposal pond.	Background geochemistry data were obtained by sampling and analyzed surface water, springs, and wells in Cow and Pony Creek drainages. Eight new monitoring wells were constructed in North Cow Creek and South Cow Creek to supplement an existing stock watering well near the junction of the two drainages. Flow measurements or estimates were made at the time of sample collection for all surface water sites.

TABLE 3-2
SUMMARY OF WORK CONDUCTED AND FINDINGS
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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
August 1986 (continued)			Water levels measured in the new wells (GNW designation) were consistently near the land surface, ranging only a few feet between seasons of the year. Recommendations include measurement of water levels in all wells, measurement of the outflow from Cow and Pony Creeks, and further defining subsurface features that divide drainage into three segments.
May 1987	Evaluation of 1986 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana. Hydrometrics, Inc.	Annual Water Resources Report	Wells 581D and 582A showed increases in indicator parameters, possibly by process water from the main dam sump. WA-133, downgradient of both these wells shows a continued improvement since it was installed.
May 1987	DRAFT Hydrogeochemical Study of the Cow and Pony Creek Drainages, Rosebud County, MT. Battelle Pacific Northwest Laboratory (Report was not finalized)	The objective of the study is to assess existing water quality east of the Colstrip Power Plant to measure potential effects of the 3&4 EHP.	This study initially considered the three drainages equivalent. Analyses conducted during the study have shown that significant differences in the water quality exist between waters from Cow Creek and Pony Creek drainages. All sites within the Pony Creek drainage with the exception of GOW 5 are dominant in sulfate, bicarbonate, magnesium, calcium, and sodium, with low concentrations of chloride. There are significant differences in the concentration of the major constituents within South Cow Creek. In general the trend down the drainage changes from a calcium/magnesium sulfate water to a sodium sulfate water. The geochemistry of groundwater from the alluvial aquifer in North Cow Creek is remarkably consistent. The aquifer can be considered to exist in a calcium/magnesium sulfate system.
January 1988	Investigation of Hydrogeological Conditions Downstream of the Main Dam – Effluent Holding Pond – Colstrip Units 3 and 4, Colstrip Montana. Hydrometrics, Inc.	This report describes hydrogeological conditions peripheral to the EHP, discusses changes in water levels and water quality, and assesses the relationship between groundwater quality and effluent stored in the EHP.	The EHP is in a small ephemeral tributary drainage to Cow Creek. The main Cow Creek drainage is about 2500 feet downstream from the EHP Main Dam. Disposal of scrubber slurry into the EHP began in late 1983. During the initial stages of pond usage, the effluent formed a small pool in the clay-lined bottom of the EHP. Construction of the slurry wall began in mid-1983 and was completed by mid-1984. Another feature of the EHP is a toe drain in the Main Dam embankment. This drain connects to a 20-inch diameter plastic pipeline, perforated on the bottom that extends from the drain downstream to the valley drain sump. The objective of the drain is to intercept seepage water in the dam embankment and to intercept any water that enters the valley between the dam and the drain sump. The valley drain line is perforated pipe and, as such, it allows both inflow and outflow of water. The drain sump, located about 650 feet downstream (northeast) of the EHP, receives seepage water from the valley drain pipeline. The sump is equipped with an automatic water level control device that periodically activates a pump that transfers collected effluent back to the EHP. Wells 581D and 582A show a change in groundwater quality since 1985 and 1986. New monitoring well 593A has water quality similar to 581D and 582A. Other monitoring wells in the area such as 552D, 555M, 554D, and WA-133 have not exhibited water quality changes during the period of record. The changes in quality in 581D and 582A are best shown by the increase in specific electrical conductance, sulfate, calcium, magnesium, and boron. These parameters also are elevated in process water contained in the EHP and in water in valley drain sump. The nearness of the EHP, the groundwater gradient direction and parameters involved suggest water quality changes in groundwater are related to the EHP. Possible pathways for process water from the EHP into groundwater are: 1) Leakage from the valley drain line or drain sump, and 2) Seepage through permeable bedrock beneath the impervious slurry wall. Based on site hydrogeological conditions and a review of the Main Dam construction, it appears that loss of water from the perforated valley drain line is a likely pathway leading to the observed water quality changes.
April 21, 1988	Hydrogeological Investigation of the MPC Units 3 and 4 Effluent Holding Pond Colstrip, Montana. Hydrometrics. Inc.	Evaluation of the subsurface component of fluid storage in the geologic strata beneath the EHP.	Total potential subsurface storage of water in the Units 3 and 4 EHP is an estimated 742 million gallons when the EHP is ultimately filled to 3,280 feet elevation MSL. The sandstone unit underlying the McKay coal seam is capable of storing 403 million gallons, the baked rock storage potential is 279 million gallons and all of the other unsaturated units can accept another 60 million gallons. Seepage during the first two years of operation of the EHP saturated the sandstone unit under cells C, G, and the Clearwell at rates that may have reached 150 gpm at times, filling a total volume of 75 million gallons. After initial saturation, seepage outflow has been controlled by sandstone thickness and hydraulic gradient. Current seepage rates from this area are estimated to be less than 50 gpm.

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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
April 21, 1988 (continued)			Seepage from the Area F Pond occurs as a minimal downward seepage (8 gpm) through impervious units and lateral seepage into the baked rock. An estimated 37 million gallons of water saturated the porous baked rock since Area F Pond water levels rose above the baked rock unit base in 1985.
June 1988	Evaluation of 1987 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana. Hydrometrics, Inc.	Annual Water Resources Report	Eight additional monitoring wells were installed in the EHP area in fall of 1987 (593A, 594D, 595D, 596D, 598D, 599D, 600M and 601M). Two wells (591A and 592A) installed in fall of 1986 were also included in the sampling in 1987. Wells 581D and 582A continue to show significant groundwater degradation. Wells 593A and 594D were installed to further monitor groundwater downgradient of 581D and 582A. 593A water quality is similar to the poor quality observed at 582A and 581D. Several monitoring wells, mainly those downgradient near the east and northeast perimeter of the EHP have shown gradual but distinct water level rises beginning in 1984. Hydrographs for these wells display water level changes ranging from 1 to 8 feet during this period. Water levels in these wells are responding to the hydrostatic pressure increases due to the physical loading of the sub-McKay sandstones and siltstones that underlie the EHP.
December 9, 1988	Phase I Inspection of Units 3 and 4 Effluent Pond, Colstrip, MT. Chen Northern, Inc.	Report summarizing results of an inspection of the Pond including both the Main and Saddle Dam.	One of findings was a zone of seepage near the toe of the Main Dam. Recommendations included installation of an observation well to monitor water level.
January 24, 1989	Interception of Degraded Groundwater near the Units 3 and 4 Effluent Holding Pond Colstrip, Montana. Hydrometrics, Inc.	The presence and character of groundwater downstream from the EHP Main Dam collection sump was investigated to evaluate if interception was feasible. Report describes test hole drilling and design and installation of the dewatering system.	Seven test holes were drilled, two were dry and the other five were completed as monitoring wells. None of the five completed wells produced sufficient water to allow dewatering of strata containing degraded groundwater. Results of laboratory analysis of groundwater samples from the test holes showed that there was degraded groundwater extending down the drainage between test holes 602D and 606A. Degraded water was identified as having a specific electrical conductivity of more the 4500 µmhos/com. Based on all geological and groundwater information from this small ephemeral drainage, it was concluded that a very small flow of degraded water is slowly migrating down the drainage in shallow bedrock and alluvium. The low yield of water from test holes, and nearly all monitoring wells except well 581D, indicates a low permeability in both the bedrock and alluvium. Based on the moderate yield (8 to 12 gpm) at well 581D, it was decided this well would be suitable as a dewatering well. A dewatering system consisting of fitting the well with a submersible pump and connecting the well via pipeline to the Main Dam collection sump was developed and implemented.
July 21, 1989	Evaluation of 1988 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana. Hydrometrics, Inc.	Annual Water Resources Report	A total of 58 wells were sampled in the spring and 63 wells were sampled in the fall of 1988. Five additional monitoring wells were installed in the vicinity of the 3&4 EHP in October 1988 (602D, 603D, 604A, 605A, and 606A) The EHP Main Dam Sump, spring SP-14, and water flowing through older NP Railroad spoils were also sampled. Surface water samples were collected from two sites along Cow Creek. Eleven of the 58 monitoring wells showed water quality changes in 1988. Nine wells had poorer quality and two had improved water quality, when current indicator parameter concentrations were compared to the previous four-year averages. • 555M showed an increase in concentrations possibly indicating a return to pre-construction water quality within the McKay burn zone. • 556M continued a trend of declining water quality since 1984; water levels have risen 16 feet in this well since 1984. • 571M continued to show water quality decline. • 582A, 593A and WA-133 located downgradient of the Main Dam show water quality decline. • WI-108 continued to show improvement. • 599D shows water quality improvement. • SP-14 shows seasonal variability.

TABLE 3-2
SUMMARY OF WORK CONDUCTED AND FINDINGS
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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
August 1989	Drilling, Completion and Testing of Genie Alternate Stock Wells – Rosebud County, Montana. Hydrometrics, Inc.	Installation of additional wells for alternate source of livestock water on Genie Land Company Property.	Four wells were drilled, completed and tested for yield and water quality on Genie Land Company property. Transmissivities calculated from pump testing the wells ranged from 15 gpd/ft. to 290 gpd/ft. The Genie Alternate Stock wells were completed in the Lebo Member of the Fort Union Formation. Water quality samples indicate a sodium-bicarbonate type water with low hardness and low dissolved solids content, characteristic of the Lebo Member.
1990	Evaluation of 1989 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana. Hydrometrics, Inc.	Annual Water Resources Report	Of the 65 wells monitored in the EHP area in 1989, 15 showed water quality changes, with 12 wells having poorer water quality and 3 having improved water quality. • Water quality declined in 1989 at 552D, this well is completed in sandstone downgradient of the west abutment of the EHP Main Dam. Water levels have risen steadily since 1984 but water quality remained unchanged through 1988. • Water quality at 555M declined in fall 1988 and remained similar in 1989. This well is located northeast of the EHP Saddle Dam. • 555M showed significant increases in concentrations of calcium, magnesium, bicarbonate and sulfate in 1988 and 1989. Boron remains low. • Wells located downgradient of the EHP Main Dam continue to indicate the influence of poor quality groundwater in this area. These include 581D, 582A, 593A, 594D, 604A, 605A, 606A and WA-133. Degraded water is restricted to the shallow, unconsolidated silt and sand alluvial/colluvial deposits in the drainage bottom and shallow bedrock zones immediately underlying these deposits. In November and December 1989, a groundwater interception trench was constructed across the ephemeral channel located about 600 feet downgradient of the EHP Main Dam. This trench was designed to intercept groundwater flow in the alluvium and shallow bedrock strata. The intercepted water is pumped back to the main valley drain sump.
March 1990	Site Investigation, Design, Construction and Performance of the Groundwater Interception System Downgradient of the Colstrip Units 3 and 4 Effluent Holding Pond Colstrip, Montana. Hydrometrics, Inc.	Report describing site investigation and site geology to support the design and construction of an interception trench across the ephemeral drainage about 600 feet below the Main Dam sump. The performance of the interception trench and discharge system is also summarized.	Based on test pits and monitoring well logs, it was concluded that poor quality groundwater was moving laterally within alluvial gravels and possibly in the shallow bedrock. An interception drain was designed to collect groundwater in the shallow alluvium and bedrock layers and divert it to the main sump. The interceptor trench was constructed during November and December 1989 and consisted of an east-west trending trench keyed into bedrock. Drain pipes located in the bottom of the trench slope toward a 24-inch diameter sump in the deepest portion of the valley fill. The trench was backfilled to above the lower water bearing gravel with graded filter material. A submersible pump placed in the sump discharges water through a one-inch discharge line to the main drain sump. Pumping commenced on December 20, 1989. During the initial pumping period, MPC personnel measured water level and down-hole specific conductivity twice weekly in the monitoring wells located within the drainage. Data collected during the first seven weeks of operation indicated that poorer quality water migrating through the unconsolidated alluvial deposits downgradient of the Main Dam was successfully collected by the newly installed trench system. Monitoring wells downgradient of the trench showed declining water levels and stabilizing water quality.
April 1990	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana CY 1989, Battelle Pacific Northwest Laboratories	Continuing assessment of the existing water quality east of the Colstrip Power Plant to measure potential future effects of the 3&4 EHP. Study was initiated in 1984, was suspended from May through August 1989, and was reconvened in September 1989. During the reconvened study, water samples were collected in September 1989 from sites owned by Genie Land Co.	Water level measurements were made in conjunction with geochemical sampling in stock wells, monitoring wells, and stream and spring discharges. Results are tabulated in the report. Quality assurance data indicated problems with silicon, conductivity, chloride, and sulfate values reported. Additional attempts to verify data resulted in further data discrepancies. Water level measurements are consistent with previous measurements.

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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
May 21, 1990	Ash Disposal Pond Reclamation, Reclamation Research Unit.	Report on Potential Ash Disposal Pond Reclamation Treatments.	Strategies for permanent reclamation of flyash disposal ponds are discussed, including: topsoil requirements, capillary barrier implementation, and plant species. This report outlines a proposal and budget for field study of various soil cover treatments.
May 1991	Evaluation of 1990 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana. Hydrometrics, Inc.	Annual Water Resources Report	Of the 65 water quality monitoring sites, 11 wells showed poorer quality and 2 had improved quality. • 552D continued to exhibit increases in most chemical parameter concentrations since 1989. Water levels have risen steadily since 1984. • 602D, also completed in the sub-McKay zone downgradient of the EHP, showed a decline in water quality. • 571M continued to show water quality degradation; this well is located within the slurry wall perimeter. • 581D, 582A, 604A, and 605A continue to show poor water quality. • WA-135 shows a gradual increasing trend in chemical concentrations. This well is completed in shallow alluvium approximately 2500 feet downgradient from a reported process water spill associated with EHP pipeline breaks. A groundwater interception trench was constructed in 1989 across the ephemeral channel located about 600 feet downgradient of the EHP Main Dam. This trench was designed to intercept groundwater flow in the alluvium and shallow bedrock. The intercepted water is pumped back to the main valley drain sump. Groundwater quality at monitoring wells located downgradient of this trench (593A, 594D, and 606A) was unchanged or improved in 1990, when compared to 1989 results. Well WA-133, also downgradient, showed a water level drop and was essentially dry in 1990. Improvements to the Main Dam pumping system were made in 1990 reducing chances of releases of poor quality process water from the sump.
May 1991	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1990, Battelle Pacific Northwest Laboratories	Continuing assessment of the existing water quality east of the Colstrip Power Plant to measure potential future effects of the 3&4 EHP.	Water level measurements indicate groundwater is generally moving to the east in the alluvial and sub-McKay aquifers. Movement of contaminants through the creek valleys may be substantially enhanced if all or part of the flow path occurs as stream flow. However, further work is needed to understand interactions between groundwater and surface water in the alluvium and sub-McKay stratigraphic units in the Pony Creek, Cow Creek, and South Fork Cow Creek drainages. Based on the 1990 chemical data, there are significant differences in groundwater quality between Cow Creek, South Fork Cow creek, and Pony Creek. Groundwater in the Cow Creek alluvium has the highest concentrations of boron and sulfate and the highest conductivity values, followed by South Fork Cow Creek and then Pony Creek. There was also a significant decrease in drainage mean conductivity values for Cow and South Fork Cow Creeks between 1985-86 and 1990. No change was observed in water quality in Pony Creek between 1986 and 1990. Elevated cation and anion concentrations were measured at GSW 1 during the May sampling episode. The elevated concentrations may be attributed to the remobilization of flue gas desulfurization slurry solution into the surface water by a runoff event or mine-water discharge. The fact that water from GSW 1 has significantly higher concentrations of cations and anions than either GSP 1 or GNW 1 suggests that a surface runoff event transported materials to that surface water site. The following statement was made in the summary of this report. *"Based on 1990 data further refinement of the conclusions presented in the 1987 draft report are needed."* Water-level measurements we consistent with previous measurements. Consequently, the rates and directions of groundwater movement are approximately the same as those calculated in 1990.

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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
April 1992	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1991, Battelle Pacific Northwest Laboratories	Objective of study is to continue to assess the existing water quality east of Colstrip, MT, so any future effects of the 3&4 EHP can be measured. Report includes the 1985, 1986, 1987, 1990 and 1991 data collected to fulfill the requirements under stipulation 12(d). The fall 1989 data are excluded because of concern about their precision and accuracy.	Two new monitoring wells are recommended for the Pony Creek drainage to ensure proper monitoring of the uppermost alluvial aquifer. There continues to be significant differences in groundwater quality between Cow Creek, South Fork Cow Creek, and Pony Creek. Cow Creek drainage alluvial water has the highest concentrations of boron, sulfate, and conductivity values, followed by South Fork Cow Creek and Pony Creek. The differences in boron concentrations between Cow Creek and South Fork Cow Creek were not significant. Comparing the 1985-1986 baseline data to 1991 data, no significant changes in drainage mean values were observed for boron and sulfate concentrations or conductivity values. No time-dependent trends for the drainage mean values for the three aforementioned parameters were observed in the data collected under stipulation 12(d) (excluding 1989). Numerous site-specific changes in groundwater quality occurred between the 1985-1986 and 1991 data at GOW11, GNW 4, GNW 5, and GSP 8. Significant decreases in conductivity values at GOW 11, GNW 4, and GNW 5 and significant decreases in sulfate concentrations at GNW 4 and GNW 5 were observed. These decreases could be attributed to the increase in precipitation during 1991 to normal levels. Water-level measurements we consistent with previous measurements. The rates and directions of groundwater movement are approximately the same as those calculated in 1990 for the Cow Creek and South Fork Cow Creek drainages.
April 30, 1992	Evaluation of 1991 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana Hydrometrics, Inc.	Annual Water Resources Report	Three new monitoring wells were drilled in the EHP area in 1991. They include 598D-2, 607A, and 608D. Of the 62 water quality monitoring wells sampled, 8 showed poor water quality and 4 showed improved water quality in 1991. • 552D continued to show water quality decline and water levels continue to rise. • 602D showed water quality decline, this well is located on the east abutment of the Main Dam. • 571M continued to show significant degradation and is located within the slurry wall. • 582A, 604A and 605A, located in the vicinity of the Main Dam Sump, continue to indicate the influence of poor quality groundwater in this area in 1991. • 593A showed declining water quality in 1991. This well is downgradient of an interception trench installed in 1989.
April 1993	Evaluation of 1992 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana, CPD/EED	Annual Water Resources Report	The interceptor trench below the EHP Main Dam collected approximately 3 million gallons of groundwater from alluvium and shallow bedrock. Wells upstream of the trench, 581D, 602D, 603D, 604A, and 605A, have shown a decline in water quality during 1992. Water quality declined at well 552D; this well is located in sandstone just downgradient of the west abutment of the Main Dam. No water was collected in 1992 by the Saddle Dam Sump. In late 1989, a pipeline failure caused erosion damage to Drain Pit #5. Drain Pit #5 is a clay-lined pit used only to impound EHP pipeline drainage when pipeline repairs are needed. Repairs were made to the pit and a localized monitoring program was initiated to check the integrity of the pit. Quarterly field conductivity and SWL data indicate that SC has either improved or stabilized and SWL's decreased by 1to 2 feet since the liner was repaired. These observations suggest that the liner is intact.
April 1993	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1992, Battelle Pacific Northwest Laboratories	Objective of study is to continue to assess the existing water quality east of Colstrip, MT, so any future effects of the 3&4 EHP can be measured. Report includes the 1985, 1986, 1987, 1990, 1991 and 1992 data collected to fulfill the requirements under stipulation 12(d). The	Two new monitoring wells are recommended for the Pony Creek drainage to ensure proper monitoring of the uppermost alluvial aquifer.

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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
April 1993 (continued)		fall 1989 data are excluded because of concern about their precision and accuracy.	There continues to be significant differences in groundwater quality between Cow Creek, South Fork Cow Creek, and Pony Creek. Cow Creek drainage alluvial water has the highest concentrations of boron and sulfate and conductivity values, followed by South Fork Cow Creek and Pony Creek. There was significant decrease in conductivity values in the Cow Creek drainage during 1992. Numerous site-specific trends in groundwater quality were observed when comparing the 1985-1987 and 1990-1992 data. Significant decreases in SC and/or sulfate values were observed at seven wells. A significant increase in sulfate was observed at one well. Water-level measurements are consistent with previous measurements. The rates and directions of groundwater movement are approximately the same as those calculated in 1990 for the Cow Creek and South Fork Cow Creek drainages. The groundwater monitoring for 1993 indicate little change in overall flow rates and direction from 1990.
April 1994	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1993, Battelle Pacific Northwest Laboratories	Objective of study is to continue to assess the existing water quality east of Colstrip, MT, so any future effects of the 3&4 EHP can be measured. Report includes the 1985, 1986, 1987, 1990, 1991, 1992 and 1993 data collected to fulfill the requirements under stipulation 12(d). The fall 1989 data are excluded because of concern about their precision and accuracy.	The mean boron concentration in the Cow Creek drainage was the highest observed since the inception of the 12(d) study. Cow Creek drainage alluvial water has the highest concentrations of boron and sulfate and conductivity values, followed by South Fork Cow Creek and Pony Creek. These groundwater monitoring data for 1993 indicate little change in overall flow rates and direction from 1990. . Based on all data collected from 1985 through 1993 (excluding 1989), there were no significant decrease in conductivity values and an increase in boron observed in groundwater within any of the study drainages.
May 1994	Evaluation of 1993 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana, CPD/EED	Annual Water Resources Report	Higher than normal precipitation was reported for 1993, which may be reflected in improved water quality at surface water sites that included the NP Cut, SP-14, and CC4. 4.4 million gallons or groundwater was pumped from the interception trench below the Main Dam sump in 1993. All monitoring wells downstream of the trench continue to show lower static water levels than the levels prior to construction and operation of the trench. The Main Dam Sump captured 9.1 million gallons of groundwater. Wells in this area with increasing levels of dissolved constituents include 552D, 581D, 582A, 603D, 604A, and 605A. Wells 606A and 607A, downstream of the trench, have shown water quality improvement since trench operation was initiated. Well 552D, just downgradient of the west abutment of the Main Dam, continues to show a decline of water quality related to seepage from the EHP through the sandstone. Additional water level monitoring in the area shows water levels rising in EAP-514, 552D, and EAP-502 since 1992. No effects of pond water are seen at 551D. No water was pumped by the Saddle Dam Sump. Well 556D in this area showed water quality decline. Well WM-138 showed increase of dissolved constituents in 1993, possibility related to mine spoils in this area. Well WA-142, downstream of Drain Pit #5, showed increase in dissolved boron but a decrease in other constituents.
May 1995	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1994, Battelle Pacific Northwest Laboratories	Objective of study is to continue to assess the existing water quality east of Colstrip, MT, so any future effects of the 3&4 EHP can be measured. Report includes the 1985, 1986, 1987, 1990, 1991, 1992, 1993 and 1994 data collected to fulfill the requirements under	Average precipitation (15.02 in.) was recorded during 1994. Cow Creek drainage alluvial water has the highest concentrations of boron and sulfate and conductivity values, followed by South Fork Cow Creek and Pony Creek.

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May 1995 (continued)		stipulation 12(d). The fall 1989 data are excluded because of concern about their precision and accuracy.	These groundwater monitoring data for 1994 indicate little change in overall flow rates and directions over the past five years. Based on all data collected from 1985 through 1994 (excluding 1989), there were no significant changes in conductivity values or sulfate and boron concentrations in any of the study drainages.
May 24, 1995	Evaluation of 1994 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana, CPD/EED	Annual Water Resources Report	66 monitoring wells were sampled in the spring and fall. Surface water was sampled at CC-4 in Cow Creek, the NP Cut, and SP-14. All other surface water sites were dry. CC-4 showed improved water quality. 5.2 million gallons of groundwater was recovered by the interception trench located downgradient of the Main Dam Sump. Approximately 9.5 million gallons of groundwater was captured by the Main Dam Sump. Water quality observed at wells in this area show a decline at 593A, 604A, 607A and WA-133. Water quality improved downgradient of the trench at 606A. Water quality stabilized at well 552D, after several years of steady decline. Water levels at other wells in the area of the west abutment continue to rise. No water was pumped at the Saddle Dam Sump. Water quality declined at well 556D. Water levels in other wells east of the Saddle Dam have been increasing. A localized monitoring program was initiated in 1994 downgradient of Drain Pit #3 to observe effects of a return pipeline failure that occurred in March 1994. Very little if any impact was observed at wells WD-106, WA-134 and WA-132.
March 20, 1996	Evaluation of 1995 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana, CPD/EED	Annual Water Resources Report	66 monitoring wells were sampled in the spring and fall. Surface water was sampled at CC-4 in Cow Creek, the NP Cut, and SP-14. CC-4 showed improved water quality. 5.2 million gallons of groundwater was recovered by the interception trench located downgradient of the Main Dam Sump. Approximately 14.7 million gallons of groundwater was captured by the Main Dam Sump. Water quality observed at wells in this area show a decline at 552D, 593A, 594D, 603D, 605A, and WA-133. Water quality improved downgradient of the trench at 606A and 607A. Water levels at other wells in the area of the west abutment continue to rise. No water was pumped at the Saddle Dam Sump. Concentrations of dissolved constituents increased at well 590M.
May 1996	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1995, Battelle Pacific Northwest Laboratories	Objective of study is to continue to assess the existing water quality east of Colstrip, MT, so any future effects of the 3&4 EHP can be measured. Report includes data collected from 1985 through 1995 (excluding 1989) to fulfill the requirements under stipulation 12(d). The fall 1989 data are excluded because of concern about their precision and accuracy.	Slightly below average precipitation (14.64 in.) was recorded during 1995. The 1995 analytical results identified nine sites where water quality changed significantly from previously reported values measured during the 1990 to 1995 period. There has been a trend of decreasing conductivity values in South Fork Cow Creek drainage. No significant changes were observed for boron and sulfate concentrations in any of the study drainages. Cow Creek drainage alluvial water has the highest concentrations of boron and sulfate and conductivity values, followed by South Fork Cow Creek and Pony Creek. Although conductivity, sulfate, and boron remain at higher levels in Cow Creek than in Pony Creek, they are declining at several Cow Creek sites; and conductivity is declining at the South Fork Cow Creek drainage. The water level data from groundwater monitoring data in 1995 indicate little change in overall flow rates and directions over the past five years. No significant changes were observed for boron and sulfate concentrations in any of the study drainages.
May 1997	Evaluation of 1996 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana, CPD/EED	Annual Water Resources Report	65 monitoring wells were sampled in the spring and fall. Surface water was sampled at CC-3 and CC-4 in Cow Creek, the NP Cut, and SP-14.

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May 1997 (continued)			4.9 million gallons of groundwater was recovered by the interception trench located downgradient of the Main Dam Sump. Approximately 9.8 million gallons of groundwater was captured by the Main Dam Sump. Water quality observed at wells in this area show a decline at 552D, 582A, 593A, 594D, 603D, 604A, 605A, and WA-133. Water quality improved downgradient of the trench at 606A and 607A. No water was pumped at the Saddle Dam Sump. 556D, 560A and 601M showed declining water quality.
May 1997	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1996, Battelle Pacific Northwest Laboratories	The objective of the 1996 study was to determine whether there were changes in water quality downgradient of the EHP since the 1985-1986 baseline study was completed. A further objective was to establish the current characteristics and conditions of water quality so that the effects of ongoing or future events associated with EHP and related operations could be evaluated. Conductivity, boron, and sulfate concentrations have been monitored since 1985 as indicators of leakage from the EHP.	Nearly average precipitation (15.32 in.) was recorded during 1996. The 1996 analytical results identified eight sites where water quality changed significantly from previously reported values measured during the 1990 to 1996 period. At the drainage level, there has been a trend of decreasing conductivity values and sulfate concentration in South Fork Cow Creek drainage. No significant changes were observed for conductivity values or boron and sulfate concentrations the other drainages. Cow Creek drainage alluvial water has the highest concentrations of boron and sulfate and conductivity values, followed by South Fork Cow Creek and Pony Creek. Although conductivity, sulfate, and boron remain at higher levels in Cow Creek than in Pony Creek, they are declining at several Cow Creek sites; and conductivity is declining at the South Fork Cow Creek drainage. The water level data from groundwater monitoring data in 1996 indicate little change in overall flow rates and directions compared with water levels measured over the past five years.
March 1998	Evaluation of 1997 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana, CPD/EED	Annual Water Resources Report	65 monitoring wells were sampled in the spring and fall. Surface water was sampled at CC-3 and CC-4 in Cow Creek, the NP Cut, and SP-14. Water quality improved at CC-3. Approximately six million gallons of groundwater was recovered by the interception trench located downgradient of the Main Dam Sump. Approximately 17.7 million gallons of groundwater was captured by the Main Dam Sump. Water quality observed at wells in this area show a decline at 552D, 581A, 582A, 594D, 604A, 605A, and WA-133. Water quality improved downgradient of the trench at 606A and 607A. No water was pumped at the Saddle Dam Sump. Well 556D showed declining water quality.
May 1998	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1997, Battelle Pacific Northwest Laboratories	The objective of the 1997 study was to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed. A further objective was to establish the current characteristics and conditions of water quality so that the effects of ongoing or future events associated with EHP and related operations could be evaluated. Conductivity, boron, and sulfate concentrations have been monitored since 1985 as indicators of leakage from the EHP.	A water level rise of up to several feet was measured in the alluvial aquifer in 1997, with water levels recovering to those observed in the early 1990s. . Precipitation of 16.78 in. was recorded during 1997, compared with the long-term average of 15.50 in. During the past year the geochemistry and groundwater quality of GAS 5 has changed. The water quality has degraded from previous years, apparently because alluvial water has traveled down the casing into the lower aquifer. Based on this information, this well should be sealed to prevent downward movement of alluvial water into the lower aquifer. The 1997 analytical results identified seven sites where water quality changed significantly from the values measured during the 1990 through 1997 period. Based on all data collected from 1985 through 1997 (excluding 1989), South Fork Cow Creek had a significant decreasing (recent) trend in the drainage mean value for sulfate and boron concentrations. No significant temporal changes were observed in conductivity values or sulfate and boron concentrations at the drainage level in either Cow Creek or Pony Creek. The water level data from groundwater monitoring in 1997 indicate little change in overall flow rates and directions over the past five years.
September 1998	Groundwater Investigation of the Stage II and 3 & 4 Effluent Holding Pond Areas. Hydrometrics, Inc.	Groundwater investigation in the Units 3 & 4 EHP area focused on three general flow corridors: groundwater in the vicinity of well 556D (northeast of the western abutment of the saddle dam), well 552D (northwest of	Three problems appear to exist in the main dam sump and interception trench area. These are: continued flow of degraded water past the main dam sump, decreasing water quality in alluvial wells downstream of the interception trench, and decreasing water quality in bedrock well 594D downstream of the interception trench. It is not clear if declining water quality in the bedrock system downstream of the interception trench

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September 1998 (continued)		the main dam), and the area downstream of the main dam near the main dam sump and groundwater interception trench.	(WA-133, 593A) is the result of direct flow from the ponds or results from recharge from the overlying alluvium upstream of the trench. Based on existing data, it appears that the latter is the case. Recommendations include: Refine contingency plan to address power outages; cleanout interception trench laterals; cleanout toe drain lines to the main dam sump; evaluate effects of pumping the main dam sump on surrounding groundwater table; check integrity of all wells with packers placed in the alluvium, check plumbing associated with 581D and consider replacing this well and monitor water levels in the interception trench.
January 1999	The Montana Power Company Fall 1998 Groundwater Evaluation 3&4 Evaporation Holding Pond Area, Hydrometrics, Inc.	Report of an evaluation of the Main Dam Interception Trench and Main Dam Sump, review of site construction drawings, installation of three groundwater recovery systems, installation of four monitoring wells and six piezometers, water sampling and analysis, and evaluation of the effectiveness of groundwater capture.	Evaluation of the Main Dam Interception Trench indicates the system is operating as designed and is effectively capturing groundwater from the alluvium. Perched groundwater is not present above the Interception Trench as indicated by an auger hole advanced over the trace of the interception trench. Yield tests, conducted on wells WA-133, 593A, and 594D, indicate less than 1/4 gpm in each well. Groundwater capture in this area using vertical wells would be ineffective because of the low yield and thin saturated thickness. Water levels measured in piezometers near the Main Dam Sump suggest that pumping from the sump may have a small effect on the local groundwater table. Pumping at the sump has little instantaneous effect on water levels very near (4 feet) the sump, suggesting any drawdown associated with the pumping is the results of long term pumping. Review of construction drawings indicates that water from the toe drain system could potentially enter the alluvial groundwater through perforated drainpipes. However, available data suggests that this is not happening. Drawings indicate a sub-drain system was installed in the active cells of the 3&4 EHP. However, the sub-drain was not operating as designed; and pumping was stopped by MPC. Sub-drain piping in Cell G may provide a direct conduit to the remainder of the system. MPC plans to route fly ash into Cell G in early 1999 to cover the floor of the cell. Once the sub-drain pipes are covered with fly ash, slurry will be routed to another cell to allow fly ash in Cell G to dry. Once the fly ash has dried, experiments can be conducted to see if performance approaches that of a true sub-drain system. Groundwater recovery systems were installed using wells 604A, 581D, 552D, 609D, and 610D. The systems were started in October and November, 1998. Data suggests that drawdown associated with pumping at wells 604A, 581D, and 552D is effecting water levels near the wells. Four new wells were installed into the sub-McKay sandstone to investigate groundwater conditions west of well 552D. Potentiometric contours indicate groundwater from the Sub-McKay sandstone may issue into alluvium near the Main Dam Sump. Water samples collected from the new monitoring wells indicate pond seepage is impacting water quality near wells 613D and 616D, located in the drainage near 552D. Water at well 614D, located at the northwest corner of the 3&4 EHP, and 615D is not affected by the ponds.
April 1999	MPC Capture System Installation Summary Report. Hydrometrics, Inc.	Monitoring wells were installed and tested north of the 3&4 EHP Main Dam and in the Drain Pit #5 area. A new groundwater recovery system was installed, started, and monitored; and three recovery systems were expanded. Data from this work were evaluated and included in the report.	A summary of investigation work and conclusions: The interception trench is operating as designed and is successfully capturing and returning 99% of alluvial groundwater downstream of the Main Dam Sump. Additional testing conducted in the alluvium downstream of the trench indicates very low groundwater flow in this area. Well 605A was abandoned to reduce potential downward percolation of groundwater. Well 605A-2 was installed as a replacement for 605A and converted for capture.

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April 1999 (continued)			Flows into the interception trench are expected to be reduced with time as the result of groundwater capture efforts in the Main Dam Sump area. Wells 618D and 619D and piezometers 620D-P and 622D-P were installed to evaluate hydrogeologic conditions in the area. Water quality results indicate that a narrow band of groundwater, potentially affected by pond seepage, is present in the vicinity of well 552D. This band extends between the Main Dam drainage at well 613D westward to the area between 616D and 618D. The band of potentially impacted water appears to be coincident with a small drainage entering the Main Dam Sump drainage from the west. The existing groundwater capture system at well 552D was extended to include wells 613D, 616D, and 619D. The discharge line for the new wells was rerouted from the Main Dam Toe Drain to Cell A of the 3&4 EHP. Initial indications suggest that the capture system is effectively removing groundwater from the affected area. Well 621D was installed between 609D and 610D. Water in this well does not show effects of process pond water. However, the well was instrumented with a recovery pump to increase the effective groundwater capture in the area. Water levels in well 556D area have decreased by about 1.5 ft. since pumping began at wells 609D and 610D. Numerous scrubber slurry spills occurred in the vicinity of Drain Pond #5, with the majority occurring in the 1980's. Water quality in alluvial wells WA-142 and WA-135 has shown a decline in recent years. Well WA-135 was instrumented with a submersible pump to remove groundwater from the alluvium. Water levels currently being monitored at 617A-P appear to show drawdown in response to pumping at WA-135. Results of drilling and water quality sampling at wells 614D and 615D (northwest comer of ponds) indicate water from the 3&4 EHP is not impacting water quality in the drainage downstream of Drain Pond #5.
April 1999	Evaluation of 1998 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana, CPD/EED	Annual Water Resources Report	62 monitoring wells were sampled in the spring and fall. Surface water was sampled at CC-3 and CC-4 in Cow Creek, the NP Cut, and SP-14. Four new monitoring wells, 613D, 614D, 615D, and 616D, and six piezometers, IT-1, IT-2, IT-3, IT4-, MDS-1, and MDS-2 were installed. Approximately 5.8 million gallons of groundwater was recovered by the interception trench located downgradient of the Main Dam Sump. Approximately 20.5 million gallons of groundwater was pumped back to the EHP via the Main Dam Sump. Water quality observed at wells in this area show a decline at 552D, 581A, 594D, 604A, 605A, and 606A. Water quality improved downgradient of the trench at 607A and WA-133. Wells 552D, 581D, 604A were converted to capture the poor quality water in this area. No water was pumped at the Saddle Dam Sump. Well 556D showed declining water quality. Wells 609D and 610D were converted for capture to address poor water quality in this area. WA-135, downgradient of Drain Pit#5, was converted to capture degraded water that has traveled downgradient from the pit.
May 1999	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1998, Battelle Pacific Northwest Laboratories	The objective of the 1998 study was to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed. A	Groundwater monitoring data for 1998 indicated little change in overall flow rates and directions compared with water levels measured in 1997. Precipitation during 1998 totaled 15.33 in. compared to the long-term average of 15.50 in.

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May 1999 (continued)		further objective was to establish the current characteristics and conditions of water quality so that the effects of ongoing or future events associated with EHP and related operations could be evaluated. Conductivity, boron, and sulfate concentrations have been monitored since 1985 as indicators of leakage from the EHP.	The 1998 analytical results identified five sites where water quality parameters changed conclusively from the previously reported values measured during the period from 1990 to 1998. At the drainage level, a statistically significant declining trend was found only for sulfate in South Fork Cow Creek. No other strict trends were observed at the drainage level. Using data from the entire observation period (1985-1987 and 1990-1998) and based on the selected sample sites, Pony Creek drainage is found to be lowest in conductivity, boron, and sulfate. Cow Creek drainage is distinctly highest in conductivity and sulfate, and the South Fork Cow Creek drainage means fall between the values of the other drainages, except for boron, whose mean level does not differ from Cow Creek.
December 17, 1999	**PPLM Closes on assets**		
March 2000	PPL Montana, LLC Fall 1999/Winter 2000 Groundwater Investigation Report Colstrip, MT, Hydrometrics, Inc.	This report includes an evaluation of the Unit 3&4 EHP Area. Work included installation and testing of six wells in the Units 3&4 EHP Area, and re-evaluation of groundwater capture systems.	The hydraulic conductivity of Cow Creek alluvium is much higher than in the 3&4 EHP Interception Trench drainage. Well yields from 625A and 626A are also much higher than those observed in alluvial wells in the tributary drainage. Water sampled from these wells does not show definitive impacts from process water. Water sampled from wells 623D and 624D, located northwest of the 3&4 EHP do not show clear effects of pond water. Hydraulic conductivity in the sandstone near these wells is very low and would limit the flow of groundwater except through fractures. Wells 627D and 628D, located northeast of the Units 3&4 EHP Saddle Dam, showed SC concentrations exceeding 5600 µmhos/cm. Both wells showed calcium/magnesium ratios above 1, sulfate exceeding 3000 mg/L, and boron less than 1 mg/L. Very little water was encountered during drilling, development, and sampling of the wells. In addition, a slug test conducted on 627D indicated very low hydraulic conductivity for the unit. Groundwater capture systems at wells 552D and 604A are effectively capturing groundwater. Wells 609D, 610D, and 621D are effectively removing water from the system. However, the water at well 556D is not being intercepted by the system. Further expansion of this system to include well 556D and installation of one piezometer to monitor water levels was recommended. Well WA-135 is effectively capturing groundwater downgradient of Drain Pit #5; however, the water column is very thin in this area, which limits the effectiveness of groundwater capture and increases the chance that water can flow past the system during seasonally high water or during pump outages. Two additional wells were recommended for this system to increase capture.
March 23, 2000	Evaluation of 1999 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana, CPD/EED	Annual Water Resources Report	New monitoring wells 605A-2,618D, 619D, 621D, 623D, 624D, 625A, 626A, 627D, and 628D were installed. New piezometers added in 1999 were 620D-P and 622D-P. In early 1999 wells 605A-2 (expansion of 604A/581D system), 613D, 616D, 619D (expansion of 552D system), and 621D (expansion of 609D/610D system), were started up as dewatering wells. Wells 614D, 616D, 618D, 606A, 593A, and 581D showed elevated levels of dissolved constituents in the vicinity of the Main Dam. Beginning in June of 1999, MPC began pumping down the Saddle Dam Valley Drain Sump, in response to raising the level of 3&4 EHP G cell. On December 21, 1999 surface seepage was first noted east of the Saddle Dam. Onsite analysis indicated that the most likely source of seepage was the 3&4 EHP. This seepage was contained and controlled by routing it to the valley sump, where it would be returned to the pond. The level of the pond (G cell) was immediately lowered and mitigation measures were initiated.

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April 14, 2000	Drain Pit #3 Investigation Report, Hydrometrics, Inc.	Report of preliminary subsurface investigation of the area downstream of Drain Pit #3 to evaluate impacts to groundwater resulting from a process water release that occurred December 1999.	Based on data collected during this investigation and discussions with PPLM personnel, it is apparent that process water from the Drain Pit #3 release flowed overland for approximately 3,000 to 3,500 feet down a tributary to Cow Creek. Most of the water was contained within the upper l/4 mile. Approximately 50,000 gallons of the process water was recovered and returned to the process water circuit. The remaining water either infiltrated into the soil or evaporated. Monitoring wells and private wells (WD-106, 636R, 639D, and Snider Well) completed in deeper bedrock units have not been impacted by the release. Recommendations include installation of a groundwater interceptor trench and additional monitoring.
May 2000	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1999, Battelle Pacific Northwest Laboratories	The study objectives were to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed and to establish current characteristics and conditions of water quality so that potential effects of ongoing or future EHP related operations could be evaluated. Conductivity, boron, and sulfate concentrations have been monitored since 1985 as indicators of leakage from the EHP.	Hydrologic measurements were taken in June and October 1999. Alluvial wells generally showed less than 1.0 foot of fluctuation. Precipitation during 1999 totaled 13.91 in. compared to the long-term average of 15.50 in. Statistical analysis of the 1999 and pre-1999 analytical results showed declining trends at four sites. At the drainage level, a statistically significant declining trend was found only for sulfate in all three drainages. No other strict trends were observed at the drainage level. These results, reflecting recent trends, suggest there are currently no impacts on water quality from operations at Colstrip Power Plant Units 3and 4 effluent holding pond. Groundwater monitoring data for 1999 indicated little change in overall flow rates and directions compared with water levels measured in 1998.
May 2000	Units 3&4 EHP Saddle Dam – Interim Report. Hydrometrics, Inc.	Preliminary analysis and recommendations for addressing seepage at the 3&4 EHP Saddle Dam were presented in this report. The report also addresses water quality reporting requirements set forth in letters from DEQ to PPLM dated March 22 and April 14, 2000.	Seepage was observed downslope of the Units 3 & 4 EHP Saddle Dam in December 1999 when the water level in Cell G was raised to an elevation of about 3,246 feet. Seepage emerged from the slopes below the dam in two places and was directed to a sump from which it was pumped back to the impoundment. A subsurface investigation was performed using 6 test pits followed by an electromagnetic survey and 28 borings. Standpipe piezometers were installed in 20 borings, all but two on the outboard side of the slurry wall, to allow water level measurements in the embankment. Slope indicator casings were installed in 7 borings to identify and monitor movement. The water level in Cell G behind the Saddle Dam was lowered to an elevation of about 3,235.5 feet to reduce seepage while the subsurface investigation was in progress. Following installation of monitoring equipment, the water level was raised about 5 feet to an elevation of 3,242.3 feet. The increased water level was intended to reconstruct conditions that existed when the leaks were first observed and to detect groundwater mounding in the wells that would assist in defining the seepage paths. Water elevation data indicate potential seepage paths centered in three areas of the Saddle Dam. Although the clay core appeared to be carefully controlled and compacted where encountered in the borings and test pits, water level elevation data and the timing of arrival of water in piezometers suggest that at least the northernmost seepage path may involve piping through the clay core over the top of the slurry wall. Three potential alternatives or combinations of alternatives are being considered to relieve the seepage problem. Grouting of the Rosebud Clinker on the inboard side of the slurry wall would seal defects in the slurry wall. Also, if water has been piping through the core, grouting the clinker on the inboard side would increase the length of flow paths through the core and reduce the risk of piping. A second alternative is to construct an interception trench along the base of the Rosebud Clinker downstream from the embankment to capture fugitive seepage. The third alternative is to construct a berm of bottom ash inboard of the embankment to reduce seepage into the clinker and push the water surface back from the embankment. This alternative would increase the length of flow paths through the clinker and reduce seepage.

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May 2000 (continued)			Water quality samples are being collected monthly from 13 wells and quarterly at two wells east of the 3& 4 EHP. Sampling parameters include: pH, SC, TDS, calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate, chloride, nitrate plus nitrite, dissolved boron, dissolved selenium, temperature, and static water levels. Study is ongoing.
June 2, 2000	Groundwater Quality Data Assessment for Montana Power Company Regarding the Colstrip Project, URS Greiner Woodward Clyde	Groundwater quality assessment report including the Units 3&4 EHP area.	The Units 3 & 4 Effluent Holding Ponds were designed to minimize process water seepage by (1) lining the base of the main pond (C and G Pond and Clearwell) with clay, and (2) constructing a slurry wall around the perimeter of the ponds to prevent seepage through the highly permeable clinker present near the surface in the 3 & 4 EHP area. In general, there is one main plume of affected groundwater beneath and downgradient of the Units 3 & 4 EHP that is flowing radially outward from the ponds. Seepage appears to be greatest in the Main Dam and Saddle Dam areas. There are 34 affected wells in the area surrounding the EHP. Twenty-five of these wells are screened in the shallow groundwater flow system. Eight of these affected wells are Sub-McKay wells screened in the deep groundwater flow system. The groundwater recovery systems appear to be reducing impacted groundwater migration but there are affected wells downgradient of the recovery system capture zones. The other plume that exists in the Units 3&4 EHP Area was caused by leaks related to the slurry pipeline from the Plant Site and Drain Pond #5. This plume is migrating to the northeast in a drainage channel confined to within the shallow alluvium.
July 2000	Units 3&4 EHP Saddle Dam Geotechnical and Groundwater Report. Hydrometrics, Inc.	Report of results of preliminary analysis and recommendations for addressing seepage and cracks at the Unit 3&4 EHP Saddle Dam and associated water quality monitoring and reporting.	Seepage was observed downslope of the Units 3 & 4 EHP Saddle Dam in December 1999 when the water level in Cell G was raised to an elevation of about 3246 feet. Seepage emerged from the slopes below the dam in two places and was directed to a sump from which it was pumped back to the impoundment. The dam, which was built in 1983 and 1984, is a zoned embankment with a clay core and plastic concrete cutoff wall below the core. Also of concern are cracks along the embankment surface that parallel the inboard edge of the cutoff wall. In some cases the cracks are more than one foot wide near the inboard crest. The subsurface investigation included 6 test pits followed by an electromagnetic survey and 28 borings. Standpipe piezometers were installed in 20 borings, all but two on the outboard side of the cutoff wall, to allow water levels to be measured in the clinker embankment foundation. Slope indicator casings were installed in 7 borings to identify and monitor movement. Water level elevation and quality data were collected in the piezometers and monitoring wells downhill of the Saddle Dam. Surface monitoring points were also installed and surveyed, and a detailed topographic map was generated. Water from the impoundment apparently moved through defects in the cutoff wall and or clay core and followed the base of the Rosebud Clinker out to the outcrop, where it emerged in seeps. Water elevation data indicate potential seepage paths centered in three areas in the north half of the Saddle Dam. Although the clay core appeared to be controlled and compacted where encountered in the borings and test pits, water level elevation data and the timing of arrival of water in piezometers suggest that at least the northernmost seepage path may involve piping through the clay core over the top of the cutoff wall. The clay core material is low plastic clay that appears to be erodible and vulnerable to piping. Settlement and stability analyses indicate that the surface cracks were caused by hydroconsolidation of foundation materials on the upstream side of the cutoff wall. Wetting apparently caused the clinker and local deposits of colluvial soil to consolidate, resulting in differential settlement on the order of 1 to 2 feet. There is no evidence that the embankment is unstable. The slope indicator casings have detected very little movement, and stability analyses indicate high factors of safety against embankment failure.

TABLE 3-2
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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
July 2000 (continued)			Seepage analyses indicate that high hydraulic gradients may exist in the clay core trench of the dam, where the clay core is in direct contact with the underlying clinker. Potential seepage paths are very short here because the clinker provides nearly direct contact with the impoundment pool; and seepage paths may follow the interface between the clay core and the top of the cutoff wall. Piping through the clay core may have been exacerbated by cracking caused by differential settlement between the wet and dry sides of the cutoff wall. Moisture content of clay core samples obtained during drilling are quite low, indicating that there was no phreatic surface in the main body of the core at the time of the investigation. Potential alternatives or combinations of alternatives were considered to relieve the seepage problem, including: a new cutoff wall, lining Cell G, treatment of the clinker outcrop in Cell G, grouting the Rosebud Clinker, reconstruction of the Phase 1 embankment, and modification of the Phase 2 design. A discussion of the pros and cons of each option is included in the report.
December 6, 2000	Drain Pit #5 Interceptor Trench Drawings. Hydrometrics, Inc.	Letter including description of site investigation and construction drawings for the Drain Pit #5 Interception Trench.	Installation of the trench was based on an investigation conducted June 14, 2000. Observations of the hydrogeologic conditions in the test pits and the trench excavation indicate groundwater is present in silty gravel, located at the bedrock contact. Rock fragments comprising the gravel are mostly sandstone and clinker. Groundwater was also observed in the first couple of feet in the bedrock. This bedrock interval is highly fractured and hydraulically connected to the alluvium. The alluvial interval likely has good hydraulic conductivity but the saturated thickness is limited. Groundwater captured using an interception trench will be more effective at removing impacted water from the drainage than groundwater capture wells. For this reason, an interception trench was recommended and installed in August and September 2000. Four piezometers were installed to monitor groundwater levels in the vicinity of the trench.
January 2001	PPL Fall 2000 Groundwater Investigation Report. Hydrometrics, Inc.	Work described in this report was conducted between March 2000 and December 2000 that includes installation of an interception trench and conversion of a monitoring well for capture.	Well 556D was converted to a groundwater capture well and is currently removing water from the system. The well exhibits a low yield and may have only a limited capture radius. Monitoring wells 611D and 612D are currently being monitored to detect changes in quality or water levels. A groundwater interception trench was installed downstream of Drain Pit #5 in the vicinity of well WA-135. The trench extends 650 feet from east to west. Groundwater from the alluvium and shallow bedrock is drained through HDPE pipe to a central sump. Water is pumped from the sump through a 2-inch HDPE pipeline into Cell A of the 3&4 EHP. Groundwater capture from the trench began September 15, 2000. Water levels in downstream piezometer 617A-P have dropped indicating effective capture. Four additional piezometers (DP5-PI. DP5-P2. DP5-PJ, DP5-P4) were installed to further monitor groundwater levels in the vicinity of the trench.
January 31, 2001	Seep 3 Interception Trench Drawings. Hydrometrics, Inc.	Letter report of Saddle Dam Seep 3 site investigation, trench construction drawings, cross sections, and photo log of trench installation.	Seep 3 was discovered a few weeks after Seeps 1 and 2 were observed downstream of the 3&4 EHP Saddle Dam Sump in December 1999. Seeps 1 and 2 were both issuing from the base of the clinker that was formed from the natural burning of the Rosebud Coal. Seep 3 was issuing from a point interpreted to be the base of the McKay Coal or clinker formed from its burning. Six test pits were located along the proposed trench location to define geologic conditions prior to installation. Trench installation commenced in November 2000 and was completed in December 2000. A previously undetected alluvial channel, oriented northwest-southeast, was encountered during construction of the main trench. A T-trench was installed to compensate for this channel. Installation of the T-trench was designed to capture water from the alluvium at a higher elevation than the main trench. Water from the T-trench is transported to the main trench through a solid pipe. Flow from the interception trench was estimated during construction to be two to three gpm.
February 2001	Units 3&4 EHP Saddle Dam Remedial Measures Preliminary Design. Hydrometrics, Inc.	Report presents results of engineering analysis and development of remedial measures to address operational issues for the Units 3&4 EHP.	Emphasis of report is on a potential design for repairs to the Saddle Dam and does not focus on other seepage areas north and west of the EHP. The preliminary design includes constructing a Stage 2 Saddle Dam Embankment. The design is considered a partial measure alternative and consist of the following elements:

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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
February 2001 (continued)			• A new Stage 2 Saddle Dam embankment, constructed east of the existing Saddle Dam. • A core trench, excavated in the embankment foundation to remove clinker from below the clay core. • The geometry of the embankment core would increase the core base width in order to provide internal stability of the core. • A chimney drain and seepage collection and filter system would control and collect seepage from the embankment foundation. • New slurry cutoff walls constructed at each abutment and connected to the existing cutoff wall to control seepage.
March 21, 2001	Evaluation of 2000 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana, CPD/EED	Annual Water Resources Report	In 2000 new wells 629D, 630D, 63 ID, 632M, 633M, 634D, and 635A were installed to monitor the effects of seepage below the 3&4 Saddle Dam. Monitoring wells 636R, 637A, 638A, and 639D, and piezometers TP-1, TP-2, and Main Trench Piezometer (MTP) were installed to further evaluate the Drain Pit #3 area. Piezometers DP5-1, DP5-2, DP5-3, and DP5-4 were installed to monitor the Drain Pond 5 interception trench area. In September 2000 seepage was observed from an area between dewatering wells 604A and 605A-2, downgradient of the Main Dam sump. The seepage flowed above ground for approximately 100 feet, then infiltrated and was captured by the main dam interception trench. In late December 2000 a short trench was excavated upgradient of, and near, the main dam sump which intercepted the seepage and diverted it to the sump. Another seep was observed near dewatering well 552D. Study of this area continues. These seeps do not appear to be associated with the main dam. Dissolved parameters increased at wells 593A, 606A and WA133. Installation of a permanent 1,380-foot long interception trench to divert impacted groundwater from a seep east of the saddle dam was completed in December 2000. In late summer of 1999 increased seepage was noted in the area approximately 2000 feet west of the northwest corner of the 3&4 EHP. The seepage was flowing downgradient in a north-northwesterly direction to the Cow Creek tributary associated with Drain Pit 5, entering the tributary immediately down-gradient of well WA- 142 and upgradient of well WA-135. Analysis indicated this to be poor quality water. This water infiltrates in the Cow Creek tributary soon after entering it. Migration of this seepage has been limited by dewatering well WA-135, and then by the Drain Pit #5 interception trench after it was completed. A groundwater interception trench was installed below Drain Pit #3 to collect process pond water that overflowed from the pit in December 1999. Start-up was in June of 2000. Groundwater data from the new and existing wells in this area indicate at this time that impacts from this spill are contained upgradient of the collection trench. Due to the large volume of water subject to capture below Drain Pit #5, a 650-foot long collection trench and sump were constructed immediately upgradient of well WA-135 in September 2000. Use of well WA-135 as a dewatering well was discontinued. Well WA-135 exhibited a significant increase in boron concentration in Fall 2000.
May 2001	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2000, Battelle Pacific Northwest Laboratories	The objectives of the 2000 study were to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed and to establish the current conditions of water quality so that the effects of ongoing or future events associated	Hydrologic measurements for this study were taken in June and October 2000. Water level declines were observed in most wells during the past year, based on comparisons of the October 1999 and October 2000 data. Precipitation in 2000 was 2 inches less than the long-term average, and this appears to have resulted in about a 1-ft water level decline in the alluvium.

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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
May 2001 (continued)		with EHP and related operations could be evaluated. Conductivity, boron, and sulfate concentrations have been monitored since 1985 as indicators of leakage from the EHP.	Statistical analysis of the 2000 and pre-2000 analytical results showed statistically significant trends at six sites where water quality changed significantly from previous years data. At the drainage level, a statistically significant decrease in sulfate concentration and an increase in boron concentration were observed in the Cow Creek drainage. These results, focused on recent trends, suggest there are currently no impacts on water quality from operations at Colstrip Power Plant Units 3and 4 effluent holding pond.
September 2001	Analysis of Water Reuse and Treatment Options at the PPL Montana Colstrip Site – Draft. Hydrometrics, Inc.	An evaluation was conducted to identify methods that could potentially be implemented which would assist with the reduction of water volumes impounded in facility ponds.	Eleven options were considered for water reuse and treatment. Of these, five were considered viable options and were further developed. Two alternatives were considered for four of the options. Options evaluated included improvement of water management practices, water treatment, evaporators, and other treatment/reuse options. PPLM has implemented some of these alternatives and are currently experiencing a reduction in water storage requirements.
December 2001	PPL Montana LLC Fall North EHP and Scoria Seep (SP-15) Investigation Report. Hydrometrics, Inc.	This report describes work conducted in the spring and summer of 2001 near the Units 3 & 4 EHP. Investigational activities addressed in this report include: installation of two new monitoring wells, six new piezometers, two electronic piezometers, drilling and sampling of 10 open boreholes, excavation and groundwater sampling of two test pits, aquifer testing, water quality sampling and analysis, joint orientation evaluation, and installation of an interception drain trench in the North EHP area upstream of the Main Dam Sump.	Results of drilling and testing on the 3&4 Main Dam and in the North EHP area indicate seepage is occurring through bedrock sandstone below the east and west abutments of the dam. This seepage is under the slurry wall. At the east abutment, potentiometric maps indicate the seepage may be flowing from the area near 644D towards the locations of borings B-NEHP-3 and B-NEHP-4. However, the exact flow path could not be identified because groundwater was not encountered in any of the boreholes that were advanced into the sandstone along the valley margins. This suggests that flow in the sandstone through the east abutment is likely fracture controlled. The sandstone was eroded by the ancestral channel downstream of the dam causing groundwater contained within the unit to discharge into the alluvium. Water issuing into the alluvium is being captured by either the MDS Interception Drain Trench or the interception trench downstream of the sump. Water in the sandstone on the west abutment flows toward four capture wells. Results of water quality sampling and drilling conducted west of the EHP suggest impacted water exists in the Rosebud interval outside of the EHP slurry wall in the vicinity of piezometers 640P and 641P. This indicates potential seepage through the slurry wall near these piezometers. In the vicinity of piezometer 643P, the impacted water apparently flows either into unconsolidated sediments where the Rosebud has been removed by erosion, or downward to the McKay interval. Water eventually issues either at SP-15 or into the alluvium in the drainage south of the localized hydrologic divide. An Interception Drain Trench was installed approximately 30 feet upstream of the Main Dam Sump to capture water that was issuing at the North EHP Seep and from filter material below the Valley Drain. Water is no longer issuing from the North EHP Seep.
December 2001	PPLM Montana Fall 2001 Groundwater Investigation and Capture System Installation Report. Hydrometrics, Inc.	This report describes work conducted in EHP area including additional monitoring well installation and repairs and maintenance on the groundwater interception trench below the Main Dam.	Two monitoring wells (646D & 647D) were installed near well 578D in the vicinity of the Units 3&4 Valley Drain Sump. Water quality samples collected from the wells indicated probable impacts from process pond water. The observed water quality may be the result of recharge to the shallow sandstone following seepage below the Saddle Dam that occurred in 1999 and 2000. Water flowing on the surface may have entered filter material below the Valley Drain Pipe and been transported to the Valley Drain Sump where recharge to either the alluvium or bedrock could have occurred. Groundwater was not observed in the alluvium at either drilling location. Recommend groundwater capture in this area and installation of additional wells to delineate extent of impacted water. The west lateral of the Units 3&4 Main Dam Interception Trench was excavated to examine the integrity of the drainpipe. Two jetting heads, tubing, and nylon strapping, lost in the lateral during previous cleanout attempts, were removed. Two damaged sections of pipe and one section of pipe clogged with debris were replaced. The remainder of drainpipe was flushed with water. The left lateral of the trench was extended to the west by approximately 40 feet. A low volume of water with an SC of approximately 4000 µmhos/cm was encountered in the extended portion of the trench. Three small earth mounds, approximately two feet high, were constructed directly downstream of the Units 3&4 Main Dam Interception Trench. The purpose of the mounds is to capture runoff water to enhance local recharge to the alluvium. Construction of the interception trench effectively cuts off flow from the alluvium. Therefore, recharge to the alluvium directly

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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
December 2001 (continued)			below the trench is limited to precipitation that falls directly on the area. Installation of the mounds will potentially enhance recharge to the alluvium. Repairs were made to the annular seal in well 557A, located in lower Cow Creek. The repairs were necessary after a sinkhole developed adjacent to the well.
January 11, 2002	Report of Geotechnical Laboratory Testing Bentonite-modified Paste Fly Ash, Units 3&4 Effluent Holding Pond, Colstrip Steam Electric Station, Colstrip, Montana. Golder Associates, Inc.	Report of geotechnical characterization of neutralized fly ash (NFA) modified by adding controlled amounts of powdered bentonite. The goal of the test was to identify a fly ash/bentonite mix to achieve a target permeability of between 1 x 10^{-6} and 1 x 10^{-7} centimeters per sec, representing one to two orders of magnitude reduction from the permeability of un-amended fly ash.	Summary of Results and Conclusions: • Un-amended fly ash is a non-plastic silt which settles quickly from suspension and consolidates relatively quickly following deposition. As a paste it is expected to compress fairly quickly from its initial condition of 68 percent solids to attain a dry density of about 81 pounds/cubic foot (pcf). • Addition of increasing amounts of powdered bentonite changes the material classification from non-plastic silt to high plasticity silt and eventually high plasticity clay. • Additional water must be added to the fly ash paste as the bentonite content increases to maintain the same consistency for transport and placement. As a result, the solids content decreases from 68 % to 48 % for a 16 % bentonite mix. • Bentonite modification will reduce the permeability of the paste ash across the range of consolidation pressures. However, the target permeability of 1 x 10^{-6} cm/sec or less is consistently attained only for consolidation pressures of 4 psi or more and bentonite addition rates of 8 % or more. • At least a 5-foot thick deposit of paste fly ash will be required to achieve the required minimum effective consolidation pressure of 4 psi.
April 17, 2002	Evaluation of 2001 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana, CPD/EED	Annual Water Resources Report	Piezometers DP5-1, DP5-2, DP5-3, and DP5-4 were installed to monitor the Drain Pit # 5 Interception Trench area. Piezometers 636P, 637P, 638C, 639C, and new wells 644D and 645D were installed to monitor the EHP Main Dam in 2001. Piezometers 640P, 641P, 642P, and 643P were installed to monitor the area in the vicinity of the northwest corner of the process ponds associated with seep SP-15. Wells 646D and 647D were installed and converted to dewatering wells immediately downgradient of the 3&4 Saddle Dam sump to mitigate effects of the saddle dam seepage. In 2001 excavation, repair, and reconstruction of the 1989 interception trench was begun in June and completed in July. The trench was also extended to the west by 40 feet. A permanent interception trench was completed upgradient of the Main Dam Sump in July 2001 to address seeps observed between 604A and 605A-2. Well 606A continues to exhibit an upward trend of dissolved constituents. Downward trends in dissolved constituents continue below Drain Pit #5. WA-142 exhibited a significant decrease in dissolved parameters in 2001, as it did in 2000. WA-135 also exhibited a significant decrease in dissolved parameters.
May 2002	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2001, Battelle Pacific Northwest Laboratories	The objectives of the 2001 study were to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed and to establish the current conditions of water quality so that the effects of ongoing or future events associated with EHP and related operations could be evaluated. Conductivity, boron, and sulfate concentrations have been monitored since 1985 as indicators of leakage from the EHP.	Hydrologic measurements for this study were taken in May and October 2001. Water level declines were observed in most wells during the past year, based on comparisons of the October 2000 and October 2001 data. Precipitation in 2001 was 3.5 in. less than the long-term average, and this appears to have resulted in the water-level decline in the alluvium. Statistical analysis of the 2001 and pre-2001 results identified four sites where the water quality data changes from previous years were statistically significant. At the drainage level, a statistically significant decrease in sulfate concentration was observed in the Cow Creek drainage. No other strict trends were observed at the drainage level. These results, directed at recent trends, suggest there are currently no impacts on water quality from operations of Colstrip Power Plant Units 3and 4 effluent holding pond.

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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
January 20, 2003	PPLM submits results of pond sampling for 51 parameters to MDEQ, including the 3&4 EHP Clearwell	Ponds sample at ponds most likely to receive chemicals of concern.	Results indicated F, Cd, Ni, and Se concentrations above WQB-7 human health standards in the 3&4 EHP Clearwell.
February 2003	2002 Groundwater Investigation Report PPL Montana, LLC Hydrometrics, Inc.	Investigation conducted in the area west of the EHP, including installation of groundwater capture trenches and conversion of monitoring wells for capture.	A supplemental groundwater investigation was conducted west of the Units 3&4 EHP to delineate areas of impacted water in the Rosebud and McKay intervals. Evaluation of data collected during the investigation concluded that a narrow band of impacted water occurs in the Rosebud interval from piezometers 640P and 641P to SP-15. The Rosebud interval was dry to the west. Areas containing impacted water in the Rosebud interval appear to be controlled by a structural low that is present west of the ponds. Impacted water is present in the McKay interval, sub-McKay bedrock near well 643P and towards SP-15, and an ephemeral drainage south of piezometer 642P. Data suggest that vertical fractures may have formed in the vicinity of 643P as the result of burning and subsequent collapse of the coal seams. These fractures allow downward flow of groundwater from the Rosebud to the McKay interval. A groundwater capture trench (South SP-15 Trench) was installed in the ephemeral drainage south of SP-15. The trench was installed to capture groundwater that is potentially impacted by process pond water. A second trench is currently under construction at SP-15 and will begin capturing water in January 2002. Recommend installation of a monitoring well northeast of SP-15 to confirm the Rosebud and McKay intervals are dry. Wells 646D and 647D were converted for capture. Evaluation of water levels measured during routine system monitoring indicates effective groundwater capture from the wells. Wells 648D and 649D were installed to further evaluate water quality in the vicinity of the Units 3&4 Saddle Dam Valley Drain Sump. Both wells had much better water quality than capture well 646D; and neither exhibits conclusive evidence of pond water impacts. A combination well/interception trench (654A) was installed and was outfitted for capture. Monitoring data indicate the 654A is effectively capturing water. The Units 3&4 Main Dam Drain Trench continued to operate as designed in 2002. Water levels in piezometer MDS-1 dropped about four feet during, and immediately after, installation of the drain trench. Water levels at MDS-1 have remained low indicating the alluvium upstream of the trench is being dewatered.
March 24, 2003	Evaluation of 2002 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana, CPD/EED	Annual Water Resources Report	A modified recovery trench/well was installed approximately twenty feet upstream of well 607A to provide capture of groundwater that may have flowed past the Main Dam Lower Interception Trench. Water levels in the wells around the WA-133 area continue to decrease. Well 654A was installed below the main dam lower interception trench. In 2002, new wells 648D and 649D were installed for further monitoring of the Saddle Dam Sump area. Piezometers 650M, 651M, 652M, 653M, and 655M were installed in the west EHP area. An interception trench (SP-15 South Trench) was constructed to the west of the EHP ponds and just south of the haul road to intercept seepage in that area. Another interception trench (SP-15 North Trench) was constructed to the west of the ponds and just north of the haul road. As in 2001, groundwater data collected in 2002 from the trench below Drain Pit#3 and other wells in this area indicate that impacts from a 2001 spill are being contained by the collection trench. Dissolved constituent levels increased in the upgradient well, DP3-636R, but remain stable downgradient of the trench. Dissolved constituent levels increased at WA-135 below Drain Pit #5.

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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
May 2003	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2002, Battelle Pacific Northwest Laboratories	The objectives of the 2002 study were to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed and to establish the current conditions of water quality so that the effects of ongoing or future events associated with EHP and related operations could be evaluated.	Water levels remained approximately constant in most wells during the past year, based on comparisons of the October 2001 and October 2002 data. Precipitation in 2002 was nearly equal to the long-term average. Statistical analysis of the 2002 and pre-2002 results identified two sites where the water quality changes from previous years were statistically significant. There were no trends found at the drainage level.
May 20, 2003	Units 3&4 EHP Saddle Dam Slope Inclinometer Monitoring. Hydrometrics, Inc.	Report of results of slope inclinometer monitoring at the Unites 3&4 Saddle Dam.	Data indicate the dam has not experienced large deflections, and the dam is judged to be safe to operate at current pool level. There are many cracks in the dam embankment, mostly on the upstream side of the cutoff wall, apparently caused by settlement of the foundation. Repairs are recommended to prevent enlargement of the cracks.
July 30, 2003	Memorandum: North SP-15 Interception Trench Installation. Hydrometrics, Inc.	This memorandum contains a description of the North SP-15 Interception Trench installation, construction drawings and a photo log.	The North SP-15 Interception Trench consists of one drain lateral that directs water to a 24-inch HDPE sump. The lateral trench was constructed roughly perpendicular to the drainage axis (west and east), and is at a grade of 0.5%, or greater. The drain lateral pipe extends approximately 540 feet west from the sump. A 30 mil PVC liner was installed on the downstream side of the lateral. Graded filter sand was placed over the entire drain lateral. The lateral drain trench was excavated to below the depth at which impacted water was encountered in McKay Coal and alluvium. Approximately 10 to 20 gallons per minute of groundwater was flowing into the excavation during construction. Following trench and discharge line installation, the site was graded and prepared for reclamation. A small dam was constructed below the interception trench in the drainage bottom.
April 6, 2004	Evaluation of 2003 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana, CPD/EED	Annual Water Resources Report	Wells 656R and 657M were installed to the west and northwest of the EHP. Water levels in the wells around the WA-133 area continue to decrease. In 2003 PPLM completed the engineering design and constructed a paste plant. The paste plant was started in the last part of 2003 and the first of 2004.
May 2004	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2003, Battelle Pacific Northwest Laboratories	The objectives of the study are to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed and to establish the current conditions of water quality.	Hydrologic measurements for this study were taken in June and October 2003. Relatively small fluctuations in water levels were observed in the alluvial wells over the past several years. Water levels in the deep wells showed even less variation, as expected. Some water level gains (<1.0 ft.) since October 2002 were observed in several Genie New Wells (GNW) in October 2003. The notable exception is at GNW 8, where approximately 3 ft. of recovery was observed since 2002. The above-average precipitation in 2003 appears to have caused water level recovery from the dry years earlier in the decade. Four sites were identified where water quality changed from previous years. No trends were detected at the drainage level. These results suggest that there are currently no effects on water quality from operations at Colstrip Power Plant Units 3and 4 effluent holding pond.
May 2004	PPL Montana, LLC, 2003 Groundwater Investigation Report Colstrip, Montana. Hydrometrics, Inc.	Evaluation of groundwater in the area of the 3&4 EHP.	Two wells were installed in the vicinity of wells 640P and 641P. Well 657D, installed northeast of SP-15 does not show pond water impacts. Well 656R, installed between wells 640P and 641P shows process pond water impacts. The well will be used to monitor water levels during recovery efforts using 640P and 641P. Water quality and flow conditions in the vicinity of well 623D were evaluated. Well 623D does not show definitive effects of process pond water. Water quality in this well has fluctuated since installation but has generally remained within normal ranges of seasonal variation. The well is downgradient of the Well 552D capture system. Water levels in Wells 644D and 645D respond rapidly to changes in clearwell water levels. The wells were converted to capture wells in late 2003 and early 2004 and are currently pumping.

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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
June 14, 2004	Units 3&4 EHP Saddle Dam Slope Inclinometer Monitoring, April 2004. Hydrometrics, Inc.	Report of results of the slope inclinometer monitoring at the Units 3&4 Saddle Dam in April 2004.	The data indicate the dam has not experienced large deflections, and the dam is judged to be safe to operate at current pool level. There are many cracks in the dam embankment, mostly on the upstream site of the cutoff wall, apparently caused by settlement of the foundation in 1999. Repairs are recommended to prevent enlargement of the cracks. Monitoring of inclinometers should continue on a regular basis as long as water is stored behind the embankment.
January 13, 2005	Geophysical Results for the Process Water Retention Pond, PPL-Montana Site, Geophysics, Inc.	Four high resolution resistivity geophysical surveys were conducted at various distances south of the 3&4 EHP.	A high resistivity layer was identified between ground surface and about 40 feet below ground surface and was interpreted to be clinker. A conductive horizon was identified below the resistant layer and was interpreted as groundwater. A shallow conductive layer was identified near the slurry wall and was interpreted as shallow water possibly inside the wall. Test hole drilling was recommended along line D to confirm the results.
March 5, 2005	Evaluation of 2004 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana, CPD/EED	Annual Water Resources Report	New wells installed include 658R, 659D, 660P, 661D, 662D, 663D, 664D, 665A, 666A, 667A, 668A, 669A, 670A, 671A, 672A, 673A, 674R, 675M, 676R, 677M, 678D, 679A, 680A, 681A, 682A, 683A, 6$4A, 685A, 686A, 687A, and PSW-3 (stock well). Flow at SP-14 was greater than usual and increased ponding below the spring was observed. Water quality did not show a significant change. In early 2004 wells 644D and 645D, located along the top of the 3&4 main dam, were converted to dewatering wells. Water levels in the WA-133 area continue to decrease. A seep on the south side of the 3&4 Effluent Holding Pond was discovered on September 27th, 2004 by PPLM personnel. Water quality analysis indicated the seep was coming from the 3&4 pond. A flume was installed on September 30th and the seep flow was measured at thirty-one gallons per minute. Design for a surface water collection system was initiated on October 4th, 2004. By October 13th, 2004 a dam and sump system were in place and collecting surface water impacted by the seep. Two collection pits were dug in the South Fork Cow Creek drainage to begin collecting water that had moved down the drainage. Test holes and wells were installed in the drainage downstream of where the seep had entered the stream bed. Fourteen wells were completed in the South Fork Cow Creek drainage. Five collection wells were installed in the drainage. By years' end the surface flow from the south seep had decreased from an initial rate of thirty-one gallons per minute to two gallons per minute. The spring 2004 water quality sample for well PSW-1, a stock well, indicated the well was being impacted by poor quality water. There appeared to be a problem with the casing and the well was re-drilled in July 2004. The problem with the well casing was confirmed during well re-completion. Water was purged from the well until chemical constituents returned to normal levels. In the meantime, well PSW-3 was drilled as a replacement stock well. Piezometers west of the EHP slurry wall exhibited increases in groundwater elevations between 2002 and 2004. A seep on the west side of the EHP was reported on November 23, 2004, the seep flowed into the Drain Pit #5 drainage and upstream of a groundwater interception trench. Test pits and wells were installed revealing a band of water approximately 1000 feet wide moving from the south wall of the EHP to the northwest where it surfaced. Flow was measured at six gpm. Collection wells and a collection dam will be installed in 2005.
May 2005	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2004, Battelle Pacific Northwest Laboratories	The objectives of the study are to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed and to establish the current conditions of water quality.	Hydrologic measurements for this study were taken in June and September 2004. Water levels declined in all wells during the past year, based on comparisons with data from October 2003. Declines ranged from 0.5 to 3 feet in the alluvium and up to 0.5 feet in the deeper wells. Precipitation in 2004 was about 6 inches less than the long-term average; and this appears to have caused a water level decline in the alluvium in all drainages of the study area.

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May 2005 (continued)			At the site level, statistically significant time trends were found at six sites. No statistically significant drainage-level time trends were observed in any of the drainages for any parameter. These results suggest there are currently no effects on water quality from operations at Colstrip Power Plant Units 3and 4 effluent holding pond.
June 2005	PPL Montana, LLC 3&4 Seep Investigation Progress Report. Hydrometrics, Inc.	The report summarized results and actions taken in response to discovery of the South Fork Cow Creek Seep (SFCC Seep) in September 2004 and the West Seep in November 2004.	PPLM personnel observed water flowing from a hill slope about one-half mile south (SFCC Seep) of the 3&4 EHP in September, 2004. Water was also discovered flowing in a drainage about one-half mile west of the 3&4 EHP. PPLM immediately began investigation and mitigation efforts. Initial responses included installation of surface water containment and pump back systems, evaluation of aerial photos, test pit excavation at both seeps, surface water capture system installation, increased groundwater monitoring, and installation of groundwater monitoring wells. Flow at the SFCC Seep was originally estimated at 60 gpm, although flows measured approximately one week later were about 31 gpm. Flow from the seep progressively decreased to near zero. Based on observations from test pits it was concluded that water issuing from the SFCC Seep was flowing through the base of the Rosebud Unit. Aerial photographs for the area showed a potentially wetted area at the SFCC Seep in both 2003 and 2004. This timing is coincident with water reduction inventory efforts by PPLM, which included flooding of Cells F and H to increase evaporation. Two test pits were excavated to expose the top of the slurry wall adjacent to Cell F to evaluate the possibility that water may have overtopped the wall. Elevations of the top of the wall and the high water mark in Cell H were surveyed. Surveyed elevations of the slurry wall were above those of the high water mark suggesting flow over the top of the wall likely did not occur. A surface water capture system (South Fork Diversion) was installed between October 9 and October 13, 2004 to capture water issuing from the SFCC Seep and pump it to the EHP. Pumping from the diversion began October 13, 2004. Surface water capture systems were installed to divert water to collection sumps from which water is pumped to Cell G of the 3&4 EHP. Water from the West Seep is currently being pumped to Cell A of the 3&4 EHP. Twenty-five monitoring wells and pyrometers were installed in the SFCC alluvium. In addition, one bedrock well and 16 “plug” boreholes were drilled in the SFCC drainage. An area of mounded and impacted water was identified in the alluvium downstream of the SFCC Seep. Pumping tests were conducted and a groundwater capture system was installed and started by December 25, 2004. Water from the wells is pumped to Cell G of the 3&4 EHP. Water levels in the alluvial wells have dropped near the pumping wells indicating effective groundwater capture in the alluvium. A lift station was designed and installed to operate in conjunction with the groundwater collection system. Pumping at the lift station started April 7, 2005. Water from the groundwater capture wells is currently pumped to Cell G through the lift station. A flow of about 30 gpm was originally measured at the West Seep. This flow likely included contributions from snowmelt. Flow at the west seep had reduced to about six gpm at the time the report was prepared. Two test pits were excavated uphill and east of the seepage area. Water was observed entering both test pits from the east. Water was flowing from the base of the Rosebud unit, which in the vicinity of the seep,

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June 2005 (continued)			consists of clinker. The Drain Pit #5 Trench was altered to allow surface water to enter. This would allow surface water from the West Seep to be captured if it reached the site. Surface water did not flow to the site and capture was not necessary. A surface water diversion was installed to capture the West Seep on March 17, 2005. The west side diversion sump was started up on March 21, 2005. Over two million gallons of water have been pumped from the west side diversion sump. A high-resolution resistivity survey was conducted south of the EHP in an attempt to identify potential groundwater flow paths. Hydrogeophysics conducted the high resolutions resistivity survey and concluded conductive water was present in the clinker interval and potentially at deeper intervals. Potential drilling targets were identified based on the geophysics studies. Thirty wells were installed into the Rosebud coal interval, McKay Coal, and sub-McKay intervals. Water quality samples were collected from wells and it was concluded that impacted water was present in the Rosebud clinker interval; but the McKay and sub-McKay units did not appear to be impacted. Elevated concentrations of chemical constituents in wells previously completed in the McKay (586M and 589M) were concluded to be the result of poor annular well seals. Groundwater flow through the Rosebud Unit is controlled by several factors including the bottom structure of the unit, lateral variations in the unit (burned vs. unburned coal), and other potential boundary conditions (Spoil) that would tend to reduce flow away from the EHP. Hydraulic conductivity, calculated from pump test data for wells completed in the Rosebud interval, exceed 2,500 feet per day. This contrasts with lower permeability in unburned portions of the unit. Pumping tests were conducted on Well 1002R on January 27, 2005. The pumping tests showed that water levels as far away as 696R (~1250 feet away) were being affected by pumping at 1002R. Based on the results of the testing, it was decided to continue pumping from well 1002R as other groundwater mitigation measures were implemented. Pumping rates varied from zero to 400 gpm, with an average rate of 280 gpm. Pumping at 1002R demonstrated that water within the Rosebud interval can be effectively captured using a minimal number of wells. Placement of wells at strategic locations, such as structural lows, will allow capture of water from large distances. A new groundwater storage pond in Cell F was planned to hold water pumped during mitigation measures.
November 7, 2005	Report of 2005 Activities on 1&2 and 3&4 Ash Disposal Ponds. MSU Reclamation Research Group	Report of studies conducted on the Saddle Dam and South Seeps. Specifically, the evaluation of vegetative cover, measurement of boron in plants, and measurement of soil pH, EC, chloride, boron and selenium where native rangeland was impacted by the seeps.	Vegetation near the two seeps adjoining the 3&4 Ash Pond was impacted by the effluent from the pond. High salt concentrations, elevated levels of boron and in some instances elevated levels of chloride, have restricted the germination and growth of grasses and forbs. The only observed plant species still remaining in the Saddle Dam seep area was the seeded Tall wheatgrass. On the soils of the South Seep, Western wheatgrass was a component of the original plant community and has prospered and formed a monoculture in much of the area. The Saddle Dam impact site could be enhanced by seeding some boron tolerant species, but any manipulation of the soils near the South Seep would only intensify damage to the vegetation by destroying the stability of the channel resulting in erosion. Both boron and chloride concentrations will decline in surface soils as rainfall leaches them deeper into the soil profile. As this occurs additional species will invade the impacted sites.

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January 4, 2006	Units 3&4 EHP Saddle Dam Slope Inclinometer Monitoring, October 2005. Hydrometrics, Inc.	Report of results of the slope inclinometer monitoring at the Units 3&4 Saddle Dam in October 2005.	Results indicate the dam has not experienced large deflections, and the dam is judged to be safe to operate at current pool level. There are many cracks in the dam embankment, mostly on the upstream site of the cutoff wall, apparently caused by settlement of the foundation in 1999. Repairs are recommended to prevent enlargement of the cracks. Monitoring of inclinometers should continue on a regular basis as long as water is stored behind the embankment.
April 28, 2006	Evaluation of 2005 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana, CPD/EED	Annual Water Resources Report	New wells drilled in 2005 were: 698R, 699R, 1000M, 1001R, 1002R, 1003R, 1004M, 1005R, 1006M, 1007R, 1008D, 1009D, 1010R, 1011R, 1012M, 1013R, 1014R, 1015R, 1016R, 1017R, 10 18D, 101 9AM, 1020D, 1021A, 1022A, 1023AM, 1024AM, 1025AM and 1026AM. A surface water collection dam was designed and installed in 2005 just downstream of the origin of the West Seep. In late October 2005, pumping at this surface seep collection was discontinued due to near cessation of the surface flow. Investigation into the South and West Seeps observed in 2004 indicated that a likely source area of the seeps was the south slurry wall, most likely in the southeast corner of the EHP. It is believed that by flooding the F and H cells during the summers of 2003and 2004, the water elevation inside the slurry wall reached a weak point in the slurry wall in this area and allowed for pond water to escape the slurry wall. This water then built up in the baked shale on the south side of the pond and appeared to be bounded by the geology in the area until it reached an elevation that allowed it to flow toward the south and west seep locations. To mitigate the water that built up outside the slurry wall, a system of collection wells was installed in 2005 to collect this water and return it to the EHP. Groundwater capture in South Fork of Cow Creek has lowered groundwater elevations by five to 13 feet. Monitor wells in this area showing water quality decline include 568A, 569A and WA-136. In late July 2005, a small surface flow of approximately 2 gpm was noted emanating 25 to 40 yards in the drainage upgradient of DP-5 Trench sump. Six test pits were dug and the pumping capacity of DP-5 Trench was increased. A diversion dam that had been installed in the drainage adjacent to the trench sump was strengthened and appeared to be completely cutting off the down-drainage movement of the surface seepage. On August 2, 2005, improvements to the SP-15 North interception trench began. These efforts reduced the amount of water moving into the Drain Pit 5 tributary and eliminated the surface flow.
May 2006	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2005, Battelle Pacific Northwest Laboratories	The objectives of the study are to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed and to establish the current conditions of water quality and hydrological parameters so the effects of any ongoing or future events associated with the effluent holding pond and related operations could be evaluated.	The above-average level of precipitation in 2005 (23.44 inches) mostly offset the effects of the dry year in 2004. Water levels generally were maintained in all wells during the past year, based on comparisons of the September 2004 and October 2005 data. Statistically significant increasing drainage-level trends were observed for conductivity and sulfate in South Fork Cow Creek. No statistically significant drainage-level time trends were observed in Cow Creek or Pony Creek drainages for any parameter. However, if the trend for increasing conductivity values and sulfate concentrations continues in the South Fork Cow Creek in future years, this behavior may suggest that there are impacts to this drainage from leaks associated with 3&4 EHP, particularly if it is accompanied by similar behavior at the site level. Overall, these results suggest that there are currently no effects on water quality from operations at Colstrip Power Plant Units 3and 4 effluent holding pond in the Cow Creek drainages.
November 17, 2006	Report of 2006 Activities on 1&2 and 3&4 Ash Disposal Ponds. Reclamation Research Group	Report of 2006 studies conducted at the Saddle Dam and South Seep areas near the 3&4 Ash Disposal Pond.	The Western wheatgrass observed on the contaminated soil of the South Seep continues to persist and form a monoculture on the site. The extent of this community is small and production is quite high. Yellow sweetclover plants observed on this site in 2005 were not found in 2006. This species is a strong accumulator of boron and plants growing in the impacted soil were probably killed by this element. Tall wheatgrass continues to dominate the Saddle Dam seep site to the exclusion of other perennial grasses and forbs. Soils of this site have been stabilized by this species. Soils of the two seep sites should not be disturbed since they are stabilized by the wheatgrasses present at each.

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March 21, 2007	Units 3&4 EHP Saddle Dam Slope Inclinometer Monitoring, November 2006. Hydrometrics, Inc.	Report of results of the slope inclinometer monitoring at the Units 3&4 Saddle Dam in November 2006.	The data indicate the dam has not experienced large deflections. The dam is judged to be safe to operate at current pool level. There are many cracks in the dam embankment, mostly on the upstream site of the cutoff wall, apparently caused by settlement of the foundation in 1999. Weathering has caused apparent filling of the cracks and significant enlargement has not been observed. Monitoring of inclinometers should continue on a regular basis as long as water is stored behind the embankment.
May 2007	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2006, Battelle Pacific Northwest Laboratories	The objectives of the study are to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed and to establish the current conditions of water quality and hydrological parameters so the effects of any ongoing or future events associated with the effluent holding pond and related operations can be evaluated.	The below-average level of precipitation in 2006 (11.51 inches) mostly offset the effects of the extremely wet year in 2005. Water levels generally were maintained in all wells during the past year, based on comparisons of the October 2005 and October 2006 data. Statistically significant drainage-level trends were observed for sulfate concentration in South Fork Cow Creek (increasing trend) and in Pony Creek (decreasing trend). However, sulfate concentrations will continue to be monitored in South Fork Cow Creek. Overall, these results suggest that there are currently no effects on water quality in the Cow Creek and South Fork Cow Creek drainages from operations at Colstrip Power Plant Units 3and 4 effluent holding pond.
August 2007	PPL Montana, LLC Colstrip Steam Electric Station Units 3&4 EHP Data Report 2004-2006, Hydrometrics, Inc.	Report of expansion of groundwater capture system north of Cell A, Expansion of Saddle Dam Sump groundwater capture system, Investigation of the South Fork Cow Creek Seep, Expansion of groundwater capture in South Fork Cow Creek, West Seep Monitoring, Installation of the south EHP capture system, Installation of the Northwest SP-15 Trench Sump (also referred to as North SP-15 Secondary Sump), Investigation of the North SP-15 Trench Area, Drain Pit 5 interception trench upgrades and well installation, rehabilitation of private stock well PWS-1 and installation of an alternative stockwater supply well.	Well 618D was converted to a groundwater capture well due to slightly declining water quality. Pumping from the well began November 7, 2004 and is still operational. Well 648D was installed near the 3&4 EHP Saddle Dam Toe Drain sump. The well was converted to a groundwater capture well based on an evaluation of the analytical results. Pumping began November 7, 2004. Extensive investigation, evaluation, and mitigation was conducted in response to flow of process water of about 60 gpm discovered south of the EHP (SFCC Seep). The seepage was the result of flooding of Cells F and H to enhance evaporation. Pond levels were immediately removed and flow at the SFCC seep rapidly reduced. Several monitoring wells were installed, sampled, and pump tested. Monitoring frequency at numerous wells was increased to a quarterly frequency. Results of the initial investigation found impacts in alluvium downstream of the SFCC Seep. Multiple capture wells were installed throughout the drainage. Plans were made to install an interception trench downgradient of the impacted groundwater. Dewatering points were placed at the proposed site to dewater the alluvium prior to construction. Dewatering using wells was evaluated and it was concluded that dewatering by wells was sufficient to stop downgradient flow of impacted groundwater in the alluvium. The alluvium in this area was essentially pumped dry indicating the effectiveness of this strategy. Backup capture wells located downgradient of the proposed interception trench have remained dry. An additional well (1030A) was installed about ½ mile downgradient from the capture wells to evaluate recharge and quality of the alluvial groundwater. Results show variable water quality but indicate the alluvium below the capture systems was recharging. Wells PSW-4, 1019AM, 1024AM, 1025AM, and 1026AM were converted to groundwater capture wells. PPLM discovered and evaluated seepage (about 30 gpm) west of the 3&4 EHP (West Seep). A containment dike was installed across the drainage and a sump to house pumps was installed. Water is pumped from the diversion to the 3&4 EHP. Flow at the seep diminished and eventually stopped after upgradient capture wells 694R, 695R, and 1017R began pumping. The seep was dry after May 2006. Wells EAP-529 and 586M were abandoned after it was concluded the seals were bad, thereby allowing water in the Rosebud clinker interval to flow down the annulus and into the wells. Well 586M was plugged back to the just below the base of the Rosebud interval and was converted for capture. Deeper wells were installed in the vicinity of these wells, near the slurry wall. Impacts to groundwater at these areas have not been observed.

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August 2007 (continued)			Impacted groundwater was discovered in the Rosebud Clinker interval south of the EHP. Larger diameter capture wells were installed. Capture began from these wells with high volumes of groundwater being pumped. Pumping was interrupted to allow construction of lined F cell that was constructed as a groundwater storage pond. Pumping continued once the pond was completed. By the end of 2006, an estimated 109,100,000 gallons of water had been pumped. Water levels continually declined in the wells and yield began decreasing in some cases to the point of being completely dewatered. Water quality at stock well PSW-1 exhibited an increase in yield and diminished water quality. The well was evaluated and water was observed flowing into the well a short distance below ground surface. The casing was removed, either by pulling or drilling out. The casing pulled from the well was observed to have holes drill at the top of each pipe joint, presumably used as lifting points during well construction. Once the casing was removed a decision was made to recomplete the well using better methods. The well was drilled out to a depth of 280 feet and recompleted. A second well PSW-3 was installed to a depth of 300 feet to serve as an alternative well, if necessary. Water was observed flowing in the drainage downstream of the North SP-15 interception trench. A second, smaller, trench was installed about 450 feet downstream of the main trench. The secondary trench was designed to allow surface water to infiltrate and enter the sump, as well as intercepting shallow groundwater. Further evaluation of the area was conducted by excavating six test pits in the drainage below the North SP-15 Interception Trench. Based on test pit observations it was concluded that water entering the drainage downstream of the trench was sourced by a coal seam (probably McKay) on the east side of the drainage. Pumping systems for the Drain Pit 5 interception trench were upgraded by installing a larger four-inch diameter pipeline and installing a second submersible pump that operated when higher volumes of water enter the trench.
October 2007	Evaluation of 2006 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana, CPD/EED	Annual Water Resources Report	Monitoring was conducted at 165 sites in the spring and 143 sites in the fall. An additional 15 sites were checked monitored during various parts of the year. Four new wells were installed in 2006. The SP-15 Northwest Secondary sump was installed. G Cell in the 3&4 EHP was divided into north and south segments. Surface water monitoring conducted in Cow Creek showed that only site CC4 contained water. Crest gage height maximums in Cow Creek were 0.12 and in South Fork Cow Creek were 0.85 feet. A paste plant was designed and constructed in 2006. Paste produced is about 65% solids and has the capacity to retain water with little free water available. The effect is to reduce the amount of free water (~10% of slurry) in the process pond cells and shorten process water loop. Paste processing along with forced evaporation will result in less potential for seepage by reducing overall pond water, extending flow paths through low permeable material, and by lowering heads. In 2006, the paste plant operated at 95% efficiency. Groundwater capture continued with a network of interception trenches and groundwater capture wells. The majority of wells in the area showed improved water quality. Well 626D showed a slight degradation of water quality. Groundwater capture in the 3&4 EHP east abutment area continued to operate and lowered water levels by 14 to 51 feet. Water quality in the area has been variable with some improvement and some declines.

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October 2007 (continued)			Saddle dam collection wells 646D, 647D and 648D operated throughout 2006. Water levels in this area have been lowered by 12 to 32 feet. Wells 632M and 633M showed slightly declining water quality in 2006. Additional investigation in this area was planned for 2007. The Saddle Dam Interception Trench should collect any groundwater flowing in this interval at 632M and 633M. Wells in the North Saddle Dam area have lowered water levels by 30 to 35 feet since collection began. Water from well 621D showed improved quality in the past three years. Other wells in this area did not show significant improvement in 2006. Wells 640P, 641P and 656R operated poorly in 2006 with little groundwater being captured from wells 640P and 641P. Water quality has also declined. Further evaluation and further capture are planned for this area in 2007. Trenches SP-15 South and SP-15 North operated as designed in 2006. However, water quality in the area deteriorated. Stock well PSW-1 showed an increase in yield and declining water quality. The casing was removed and poor installation methods were discovered (holes in casing to lift pipe during original installation). Groundwater was entering the casing about 25 feet bgs. The well was re-drilled in the same hole and recompleted. Pumping was conducted and water quality was improving rapidly. Stock well PWS-3 was installed to serve as a replacement well. The West seep diversion and collection system were monitored 2006, however, no flow was observed. Water levels in wells upgradient of the seep were lowered by pumping by 4-16 feet. In 2006, water levels in these wells dropped about four feet more than the previous year. Groundwater collection from the alluvium in South Fork Cow Creek continued throughout 2006. Two main capture areas exist. The upstream site, located near well 1023AM, operated throughout the year. Average groundwater collection in 2006 was about 33 gpm as compared to 44 gpm in 2005. Downstream, water quality improved compared to the previous year. Drain Pit #3 is located at the far west side of the 3&4 EHP Site Area. Impacts to this area are not from the process ponds but from past problems at Drain Pit #3. Very little water is typically captured at the trench (0.5 gpm combined in 2006). Drain Pit #5 operated throughout the year as designed.
November 2007	Report of 2007 Activities on 1&2 and 3&4 Ash Disposal Ponds. Reclamation Research Group.	Evaluation of vegetation and soils at the Saddle Dam and South Seep areas and of boron concentrations in Ponderosa pine needles subject to wind blown effluent from the 3&4 Ash Disposal Pond evaporators.	There are weak indications that some boron may be moving down the soil profile at the two impacted sites. However, boron levels in vegetation growing on the impacted soils are still high and plant diversity continues to be a problem on these soils. The grasses and forbs growing on these sites are not toxic to livestock or wildlife. Three year old needles were the oldest needles found on trees in the zone of highest impact. Ponderosa pine trees in the Colstrip area typically retain 4 to 5 years of needles, indicating that the trees are impacted by the air borne effluent from the evaporators. In addition, there was a clear gradient of boron concentrations in needles related with position with respect to fallout.
May 2008	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2007, Battelle Pacific Northwest Laboratories	The objectives of the study are to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986	Above-average precipitation in 2007 caused groundwater levels to increase by an average of about 1.3 ft. over the relatively low levels of 2006.

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May 2008 (continued)		baseline study was completed and to establish the current conditions of water quality and hydrological parameters so the effects of any ongoing or future events associated with the effluent holding pond and related operations could be evaluated.	Statistically significant increasing time trends were found at four sites, two in the Pony Creek drainage and two in the South Fork Cow Creek drainage. No site-specific trends were observed in Cow Creek. Additionally, no statistically significant drainage-level trends were observed in any of the drainages. No major changes in groundwater flow patterns were indicated in Cow Creek or South Fork Cow Creek. These results suggest there are currently no effects on water quality from operations at the Colstrip Units 3 and 4 effluent holding pond.
July 24, 2008	Test Pit Investigation Near Well 624D – Memorandum from Hydrometrics to PPLM. July 24, 2008	Summary of investigation of subsurface conditions in the vicinity of dead and/or dying Ponderosa Pine trees uphill from well 624D. Investigation included excavation of four test pits in the subject area. Water quality samples were collected if groundwater was present.	Test pits TP624-1 through TP624-4 were excavated through the unconsolidated materials and into the underlying unaltered bedrock. Groundwater was observed entering the TP624-1 and TP624-2. Laboratory analysis of groundwater samples did not conclusively show process water impacts although boron levels were somewhat elevated. It was recommended that water quality monitoring at the site be continued either by installing a standpipe for sampling purposes or by constructing a developed spring in the vicinity of TP624-2. Soil above the contact in TP624-3 and TP624-4was slightly moist to very moist but did not yield free water.
July 2008	PPL Montana, LLC North SP-15 /1031 Area Well Installation/Conversion & Pipeline Colstrip Steam Electric Station, Hydrometrics, July 2008, Revised August 2008	Eight wells were installed west of the 3&4 EHP and two wells northwest of the 3&4 EHP. Wells were either pump or slug tested. Water quality samples were collected and analyzed.	Based on the water quality results, height of water column, and yield, wells 1031R, 1034R and 1037R were converted to supplement groundwater capture in the 656R area. Pumping from 1031R, 1034R and 1037R began in April 2008. In the first month of pumping water levels in nearby observation wells had dropped by about 2.5 to three feet.
August 1, 2008	Geophysical Survey Services Electromagnetic Induction (EMI) Conductivity Mapping PPLM Montana, LLC 560A Area Expanded Investigation Colstrip, MT. Utility Mapping Services, Inc.	An EMI investigation was conducted in June 16-19, 2008 in the vicinity of wells 560A and 1051A. In addition two traverses (840 and 140 meters long) were conducted upgradient of 560A near spring SP-14.	EMI data quality was generally good with some cultural noise. Background electrical conductivity (EC) averaged 50 mmhos/m. An “end of line” anomaly (high EC) was experienced at the northern edge of the survey grid. It was unclear if this anomaly indicates a flow path for groundwater with elevated SC or was the result of high topography and high clay content of the underlying materials. An obvious groundwater flowpath was not identified. An 840 meter long traverse was conducted from well 1064D on a trend of approximately north 30 degrees east. Three zones possibly indicative of high conductivity groundwater were identified. One of the anomalies was consistent with the wet area formed by flow from spring SP-14. The other two areas were near current well 1073A and the main access road to the 560A area. A slight anomaly was noted on the second transverse conducted across the drainage directly upstream of the stock pond upstream of 560A. It was unclear if this anomaly was indicative of groundwater flow with elevated SC.
September 16, 2008	560A Area – Status Memorandum. Memorandum from Hydrometrics to PPLM September 16, 2008	Status report with attached geophysical report for the 560A/1051A area.	A summary of Phase I work was included. The Phase I work included installation of seven two-inch diameter wells downgradient of well 560A (wells 1053A-P through 1059A-P). PPLM decided to install an interception trench downgradient of 560A based on the water quality results from the wells. The trench began collecting groundwater on March 20, 2008. Test pits 1050A and 1051A were excavated near the property boundary in the bottom of the main drainage and a secondary drainage. Test pit 1050A, excavated in the secondary drainage, extended to bedrock and no groundwater was encountered; therefore no well was installed. Test pit 1051A was excavated in the main drainage. Groundwater was encountered that exhibited elevated SC. An interception trench was installed across the drainage to intercept groundwater flowing in the alluvium. Pumping began in 2008. Phase II of work conducted in the area included installation of wells 1061D through 1064D. Water quality results from the wells showed possible process pond impacts at well 1062D. Elevated concentrations of sulfate and TDS were observed at 1064D. However, process pond impacts were not suspected at 1064D because Ca:Mg were above one, and concentrations of chloride and boron were low. Six additional wells were recommended. A geophysical report was attached (see August 1, 2008 UMS Report).

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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
October 27, 2008	Test Pit 624-2 Sample Tube Installation – Technical Memorandum from Hydrometrics to PPLM October 27, 2008	Installation of sample point for Test Pit TP624-2.	On September 26, 2008, the original site of test pit TP624-2 was excavated to a depth of approximately nine feet, where bedrock was encountered. Two six-inch diameter by five feet long U-Pack screens, filled with 10/20 silica sand, were placed horizontally into the excavation. The screens were placed on the bedrock just below the contact of unconsolidated sediments, and covered with filter fabric. The screens where connected together with a four- inch diameter PVC "tee" fitting and capped on the outside ends. The branch end of the "tee" fitting was reduced in size to two-inch PVC and connected to two-inch PVC that would serve as sample tubing. This two-inch PVC pipe was extended sixty feet to the northeast to a point that it would daylight and gravity drain to the ground surface. Flow from the pipe was measured at about 0.1 gpm. SC of the water was measured at 3,554 µmhos/cm.
November 6, 2008	Units 3&4 EHP Paste Infiltration Studies - Memorandum from Hydrometrics to PPLM November 6, 2008	Report of infiltration studies conducted on paste within the Units 3&4 Clearwell.	Calculated hydraulic conductivities for tests conducted using 22-inch diameter HDPE and 36-inch diameter CMP were 9.3 $x10^{-6}$ cm/sec and 1.2 x 10^{-5} cm/sec, respectively. These values are consistent with hydraulic conductivity values for silt and clay mixture, similar to what is found in Clearwell paste.
November 13, 2008	Test Pit 624-2 Water Quality Results – Technical Memorandum from Hydrometrics to PPLM November 13, 2008	Report of water quality results for samples collected from original test pit and recently installed sampling tube.	A water quality sample was collected on May 21, 2008 from water encountered during the initial excavation of TP624-2. This sample was collected from a pool of groundwater that had accumulated in the bottom of the test pit during the initial investigation. A second sample was collected on October 22, 2008 from water draining out of the recently installed sample tube at the TP624-2 location. Water quality from the two samples is very similar, within expected seasonal variations for shallow groundwater. Water quality is not indicative of process water impacts.
December 2008	Interim Report of 2008 Activities on 1&2 and 3&4 Ash Disposal Ponds. Reclamation Research Group	Evaluation of vegetation and soils at the Saddle Dam and South Seep areas; and discussion of boron concentrations in Ponderosa pine needles, grasses and soils in select areas surrounding the 3&4 Ash Disposal Pond.	Boron levels in impacted soils and vegetation growing on impacted soils are still high and plant diversity continues to be low at the two seep areas. However, vegetation at both sites has stabilized the soils and provides forage for wildlife and livestock. Limited selenium analyses did not detect any elevated concentration of this element in the vegetation sampled. Boron levels in grasses collected in May 2008 were at the lower part of the range of concentrations reported in native plant communities of the region. A total of 16 of the 26 pine needles sampled exhibited boron concentration of greater than 100 mg/kg. Boron levels greater than 100 mg/kg in pine needles is considered elevated. Unlike the pine needles, soil collected from corresponding test pits north and west of the pond did not reveal any elevated levels of boron.
December 12, 2008	Evaluation of 2007 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana, CPD/EED	Annual Water Resources Report	170 sites were monitored in the 3&4 EHP in the spring and 148 sites in the fall. 29 nine new wells (28 monitoring and one private stock well) were installed. Cow Creek monitoring sites were dry throughout 2007. The paste plant operated at 95% availability and paste was deposited in Cell G along the face of the Saddle Dam and in the Old Clearwell. The Main Dam Interception Trench operated throughout 2007. Alluvial wells 606A, 606A, 625A and 626A showed a slight improvement in quality. Plans to replace well 581A, which has a failed annulus, are scheduled for 2008. Groundwater continued to be captured by wells in the vicinity of well 552D. Well 638C, located on the east dam abutment, showed a decline in water levels. Capture systems east of the Saddle Dam continued to operate throughout 2007. Water levels in the wells have been lowered by 12 to 32 feet since collection started. A change in water quality was observed at SP-14, but the concentrations remained within historical ranges. A work plan was developed to evaluate the well 560A area. Additional capture began in the 560A area as a result of this investigation. Groundwater levels in capture wells 556D, 609D, 610D, and 621D have lowered water levels in the vicinity of the wells by 30 to 35 feet since pumping began. Water quality at 621D continued to show improvement.

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Dec. 12, 2008 (continued)			Well 565R continued to pump groundwater at an average rate of 4.9 gpm in 2007. Additional wells were installed in the area and additional capture is planned in the area. North SP-15 and South SP-15 operated throughout 2007. Water quality at nearby PSW-1, which was re-drilled and completed, showed continued water quality improvement through 2007. Groundwater collection wells continued to operate throughout 2007. Capture volumes have decreased substantially since the systems were started in 2005. Decreased capture volumes are a function of dewatering the clinker on the south side of the ponds. In general, water quality has shown a slight improvement since capture began. Collection systems in South Fork Cow Creek, which began pumping in 2004, continued to pump throughout 2007. Water levels have been lowered from 3 to 23 feet; and the alluvium is essentially dry at the downstream end of capture. Many wells showed a general improvement in water quality. Three wells 592A, 672A, and 685A all showed declines in water quality. Water quality generally improved in the Drain Pit #3 in 2007, although water entering the capture trench showed a slight decline.
May 2009	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2008, Battelle Pacific Northwest Laboratories	The objectives of the study are to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed and to establish the current conditions of water quality and hydrological parameters so the effects of any ongoing or future events associated with the effluent holding pond and related operations could be evaluated.	Precipitation during 2008 totaled 20.67 in., well above the long-term average of 15.5 in. Water levels in most of the wells monitored during 2008 were similar to the 2007 measurements for both the June and October monitoring events. The water levels in 2007 and 2008 were higher than 2006 because of the increased precipitation during the last 2 years. Some of the observed changes in water chemistry and water-level elevation may be climate related, the former possibly being caused by changes in solute concentration and the latter to precipitation-induced changes in hydrologic flow parameters. The last few years have been marked by large fluctuations in annual precipitation, compared with much of the 1990s when precipitation was nearly normal. Five sites were identified where water quality had changed from previous years: Genie new well (GNW) 4, GNW 7, Genie old well (GOW) 4, Genie spring (GSP) 4, and GSP 6. At the drainage level, South Fork Cow Creek had statistically significant increases in boron and sulfate. No drainage trends were observed for Cow Creek or Pony Creek. Some of the observed changes in water chemistry and water-level elevation may be climate related, the former possibly being caused by changes in solute concentration and the latter to precipitation-induced changes in hydrologic flow parameters. The last few years have been marked by large fluctuations in annual precipitation, compared with much of the 1990s when precipitation was nearly normal.
March 2009	PPL Montana, LLC North SP-15 and South SP-15 Area Well Installation and Testing. Hydrometrics, Inc.	Scope of investigation to further characterize and evaluate groundwater flow pathways and conditions in the North and South SP-15 Area. Work included installation, testing and sampling of seven wells and assessment of groundwater recovery systems.	Groundwater quality in the seven new wells varied from water with no apparent impact from EHP to water that was noticeably impacted by pond effluent. Water encountered in deeper sub-McKay wells, completed in sandstone bedrock, was not impacted by process water, suggesting that impacted groundwater has not migrated vertically to deeper horizons beneath the SP-15 area. Concentrations of TDS and sulfate in the McKay aquifer are greater than those observed in the sandstone of the sub-McKay but not suggestive of impacts by the EHP. Wells completed in the alluvium (1068A) and shallower bedrock (1071D) had water quality indicative of process water impacts. Recommendations included 1.) replacing submersible pumps in the North and South SP-15 Interceptor trenches with bottom intake pumps to increase drawdown in the sumps; 2) converting 1068A for capture; and 3) conducting additional groundwater investigation in the area to the west and northwest (downgradient) of the SP-15 capture systems.

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April 2009	Evaluation of 2008 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System Colstrip Steam Electric Station Colstrip, Montana, Hydrometrics, Inc.	Annual Water Resources Report	Monitor wells 1051A through 1078D were installed. Six wells were converted for groundwater capture. Cow Creek surface water sites were dry in 2008. The 3&4 EHP Paste Plant operated at 97% availability. Interception trenches and groundwater capture wells operated as intended in 2008. Well 581D was recompleted in shallow bedrock to repair a suspected poor annular seal. The well was re-numbered as 581D2. Water quality impacts were not observed in the new well. Declining water quality was observed at wells 602S, 625A, and 626A. Further evaluation was planned for this area. Water quality improved at capture trench/well 654A and 607A, both located directly upgradient of 625A and 626A. Well 1060C was installed east of 638C which had shown groundwater quality declines. Well 1060C was dry following installation. Additional investigation is planned in this area. Investigation into groundwater uphill of well 624D concluded that the ponds were the affecting the area. Some Ponderosa Pine trees had died in this area which initiated the investigation. Groundwater capture was expanded in the Saddle Dam Valley Drain Sump area, and downstream. Water levels have dropped from 12 to 32 feet since pumping began. Capture wells 646D and 648D showed a decline in water quality. Well 562A, which had been dry since its installation in 1982, but had water in both the spring and fall events of 2007, was dry again in 2008. Water present in the well was believed to be the result of a local recharge event. Concentrations of some indicator parameters increased at wells 662D, 590M, 632M, and 633M. Spring SP-14, which had shown a decline in water quality in 2007, showed improvement in 2008. Capture wells continued to operate in the north Saddle Dam area. Water quality is variable and installation of additional wells is inhibited by the sediment heterogeneities that result in highly variable hydraulic conductivity and well yield. Work was conducted downstream of the 3&4 EHP Saddle Dam Valley Drain Sump including installation of a capture trench (560A trench), installation and conversion to capture of well 1039A, and installation of the 1051A-Trench. Eighteen additional monitoring wells were installed in this area in 2008. Water from well 1073A was impacted and conversion to groundwater will be conducted. Additional investigation was conducted west of the 3&4 EHP. As a result wells, 1031R, 1034R, and 1037R were converted to capture wells. Groundwater capture continued at the North SP-15 and South SP-15 interception trenches. A secondary trench, SP-15 Northwest trench, was installed downstream of the North SP-15 interception trenches. Groundwater capture continued at the South EHP systems. Approximately 1.8 million gallons less was captured in 2008 than in 2007, a function of a reduction of available water in the clinker. Water quality at these capture wells is still poor but showing improvement.

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April 2009 (continued)			South Fork Cow Creek capture systems showed general improvement. Several of the wells were dry from capture system pumping. Well 1065A was installed adjacent to well WA-136 and will be converted to a capture well.
May 29, 2009	3&4 EHP Main Dam Observations and Stability Review Update. Letter Report from Womack and Associates, Inc. to PPLM	Summary of subsurface conditions and stability of 3&4 EHP Main dam as ascertained from surface observations and review of subsurface information and stability analysis performed in 2000 and 2001.	Observations during May 2007 and 2009 site visits indicated no evidence of surface displacement or seepage from the downstream face of the embankment. On May 27, 2009 a small seep in the left upstream groin emerged from the clinker but was observed to have no effect on stability. The slope stability analyses indicate a minimum factor of safety against embankment failure of about 1.5 at pore pressure conditions that existed in October 2007. The piezometric surface was about 80 feet below the Main Dam crest and is clearly drawn down by the chimney drain on the downstream side of the core. The piezometric surface in the embankment core does not create seepage on the face of the embankment.
June 1, 2009	560A/1051A – Status Report – Technical Memorandum from Hydrometrics to PPLM June 1, 2009	Memo providing summary of tasks performed under phase 3 of work performed in this area. Seven monitoring wells were installed. A modified trench/well was installed at 1079A. Groundwater quality samples were collected from each site. Pumping and or slug testing were conducted on select wells. Five test pits were excavated to evaluate shallow groundwater	The quality of shallow groundwater encountered in well 1073A indicated impacts by process water ponds. Groundwater quality in the bedrock interval monitored at well 1074D was much different than alluvial groundwater quality in 1073A. Despite a dissolved solids concentration of 4,820 mg/L, impacts from the process ponds are not evident in samples from this well. The other four deep wells (1075D, 1076D, 1077D, and 1078D) had a groundwater quality signature similar to that of 1074D. Groundwater quality at well 1079A-Trench was poor and prompted the temporary capture activities. Concentrations of dissolved solids, boron, and chloride were 12,400 mg/L, 17.4 mg/L, and 142 mg/L, respectively. The calcium-magnesium ratio was 0.29. Full conversion of 1079A-Trench to a capture system well is anticipated following spring thaw.
June 22, 2009	Technical Memorandum: Boron in vegetation and cattle grazing. Frank Munshower, Reclamation Research Group, LLC	Memorandum discussing levels of boron in vegetation and toxicity to cattle.	Boron levels toxic to livestock are known to be relatively high with respect to concentrations of this element found in vegetation. Toxicity signs are probably in livestock with levels greater than 100 mg/kg body weight. In the small impacted area (about 1 acre) of the South Seep, vegetation contains boron levels of 100 to 300 mg/kg of plant weight. Permitting the cattle to graze the pasture containing the South Seep will not pose a threat to the animals unless there are portions of the landscape that are much more seriously impacted than the areas already studied.
July 28, 2009	PPL Montana, LLC 2009 Pond Capacity Survey, Hydrometrics, Inc.	A bathymetric survey of the Old Clearwell, cell C, cell G north, and cell G south was conducted to estimate remaining capacity and current water volumes.	A bathymetric survey was conducted in the Old Clearwell, cell C, cell G north, and cell G south of the 3&4 EHP. The cumulative calculated volume of water in all cells was about 2.7 million cubic yards (538 million gallons). The cells held 8.6 million cubic yards of flyash. Assuming no water is present at capacity, approximately 6.0 million more cubic yards of flyash can be placed in the surveyed cells. Based on the current slopes of the flyash, an addition14.3 million cubic yards of soil could be stacked at a 5% slope. Higher volumes could be achieved if paste with more solids is developed and/or if a drying technique such as a filter press is used.
July 8, 2009	3&4 Bottom Ash Pond Clearwell Sampling Technical Memorandum from Hydrometrics to PPLM July 8, 2009	Memorandum summarizing sample results of the Units3&4 Bottom Ash Pond Clearwell following a malfunction of the plant turbine lube oil conditioning system. The malfunction resulted in an overflow of the oil-water separator sump; and un-separated oil and water was pumped to the clearwell.	A contractor was hired to remove the oil using vacuum trucks and sorbent pads. A grab sample was collected from the northeast corner of the pond on December 4, 2008. A sheen was noticed on the water at the time of sampling. Results of the analysis indicated oil was still present. PPLM conducted additional cleanup by removing a portion of the dike wall. A follow-up sample was collected from the same location on June 16, 2009. No sheen was observed and petroleum hydrocarbons were not detected in laboratory samples. Based on these results it was concluded that the hydrocarbons had been removed.
July 17, 2009	Well Installation, Testing, and Sampling – PW-734, PW-735, and PW-736. Technical Memorandum from Hydrometrics to PPLM July 17, 2009	Installation, sampling, testing of three monitoring wells on the Kluver Ranch downgradient of the 1051A Trench.	Wells PW-734, PW-735, and PW-736 were installed using air rotary methods. Wells PW-734 and PW-736 were installed into the unconsolidated alluvial sediments. Well PW-735 was installed into sub-McKay sandstone. A very low yield and thin water column were present at PW-734 and it was not slug tested. Pumping tests were conducted on wells PW-735, and PW-736. Transmissivities of 524 ft^2/day and 3,325 ft^2/day were calculated for PW-735, and PW-736, respectively. Groundwater quality results were not indicative of process water impacts. All cuttings and water generated during drilling and testing was contained and moved off site.

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August 5, 2009	Well Testing – Well 626A: Technical Memorandum from Hydrometrics to PPLM August 5, 2009	Well 626A was pumped for 300 minutes at an average rate of 34 gpm. Water level responses to pumping were measured. Specific conductivity (SC), temperature, and pH, were measured throughout the pumping period. Water level recovery was measured after the pump was turned off.	Data were analyzed using Aqtesolv analytical software. Measured values of SC and pH were consistent throughout the test. Water quality samples were collected and submitted to an analytical lab. Results were presented separately.
October 2, 2009	TP624-2 Stock Tank Installation – Technical Memorandum from Hydrometrics to PPLM. October 2, 2009	Development of subsurface water and installation of stock tank.	Soil had been excavated in the vicinity of TP624-1 & 2 and perforated pipe was installed. Filter material was placed around the pipe. The pipe was extended downhill and day lighted. Cattle had disturbed the area and the decision was made to divert the water further downhill to a stock tank. A valve box was installed to allow the water to be directed either to the stock tank or to ground surface.
November 2009	Field Observations Report Colstrip Steam Electric Station Colstrip, Montana August 31- September 3, 2009, U.S. EPA	The Waste and Chemical Enforcement Division, Office of Civil Enforcement in conjunction with the Office of Compliance and U.S. Environmental Protection Agency conducted an investigation into a variety of industrial sectors to evaluate the extent of illegal disposal of hazardous wastes in surface impoundments. The purpose of the inspection was to determine compliance with RCRA, Clean Water Act Emergency Planning and Community Right to Know (EPCRA) and other statutes. This report contained a summary of that investigation. The investigation included meetings with company representatives, site walkthrough, soil and water sampling, and closing conference.	This sampling was conducted on the plant site for water streams going to various operating areas. None of the samples were directly collected from the 3&4 EHP area. However, a review is provided due to possibility that some of the water could potentially reach the 3&4 EHP, except for oil/water separator samples, which are restricted to, and managed at, the Plant Site. Nine aqueous and one solid sample were collected and analyzed for volatile organic compounds, semi-volatile organic compounds, metals and for TCLP. None of the samples analyzed exceeded the TCLP regulatory limit. Arsenic was the only metal above detection by TCLP analysis but was well below the 5 mg/L regulatory limit. Results of total metals analyses were all relatively low or non-detect. Elevated levels of several organic and inorganic constituents were present in the soil sample from the oil/water separator near the entrance to the Buildings and Grounds Maintenance.
November 18, 2009	PSW-9 Well and Stock Tank Installation – Technical Memorandum from Hydrometrics to PPLM	Report of private stock well completion and an overview of methods and materials used to install a pipeline and stock tank at the site.	Stock well PSW-9 was installed on PPLM property leased for livestock grazing. The well was screened across a water bearing sandstone from 100 to 160 feet bgs. Electrical service was provided via an overhead drop to the well. The well was outfitted with a submersible pump and a 900 gallon stock tank with a float switch. Based on the operating performance of the well to date and on laboratory analytical results, PSW-9 provides water of sufficient yield and quality for livestock watering. Recommend PSW-9 be monitored at least annually to evaluate any changes in groundwater quality that may occur.
November 17, 2009	Well Installation, Testing and Sampling – 602S Area, Hydrometrics, Inc.	Report summarized the installation of monitoring wells, well testing and water quality sampling.	Eight monitoring wells were installed north of the 3&4 EHP to further evaluate groundwater conditions in the local clinker and sub-McKay sandstone. Pumping or slug tests were conducted on each well. Calculated hydraulic conductivity ranged from one foot per day (ft./day) to 72 ft./day. Analytical results for six of the seven bedrock wells were indicative of process water impacts. The lone alluvial well (1084A) also showed process water impacts. Recommendations included abandoning well 581D, converting well 1084A to a capture well, expanding groundwater capture in the sub-McKay sandstone between the Main and Saddle dams, installing additional wells to monitor capture well effectiveness, evaluating the possibility of a horizontal well for capture, and evaluating fracture trends in bedrock.
December 10, 2009	560A/1051A Area Phase IV – Status Report. Technical Memorandum from Hydrometrics to PPLM	Tasks included in phase IV were: installation of six new monitoring wells; one borehole, groundwater sampling; pump/slug testing; geophysical survey; potentiometric surface construction; and groundwater capture activities.	Three wells (PW-734, PW-735 and PW-736) were installed on private property east of the PPLM owned lands. PW-734, PW-735, and PW-736 had TDS concentrations of 3,180 mg/L, 3,730 mg/L, and 4,020 mg/L, respectively. These TDS concentrations are consistent with values observed in proximal wells prior to 3 & 4 EHP construction. Well 1088A was completed in a dry borehole in the channel of an un-named drainage approximately 300 feet east of 1079A-Trench. To date, process pond water impacts to water quality and quantity observed at 1079A-Trench have not been identified at 1088A. Two bedrock wells (1089D and 1090D) completed between the two un-named drainages of Cow Creek had a groundwater quality signature that was indicative of probable pond water impacts with TDS of greater than 9,000 mg/L, sulfate concentrations around 7,000 mg/L, boron concentrations of nearly 10 mg/L, chloride concentrations near

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Dec. 10, 2009 (continued)			90 mg/L, and calcium-magnesium ratios less than 0.4. Based on results of water quality samples and pump tests, wells 1089D and 1090D were converted to temporary capture wells in June 2009. Variable aquifer characteristics noted from pump testing (i.e. transmissivity and hydraulic conductivity) reinforce the heterogeneity of subsurface strata in the 560A/1051A area. Two Electromagnetic Induction (EMI) profiles were completed in order to identify possible groundwater flow paths between the 3&4 EHP Saddle Dam and the 560A/1051A Area. The survey identified several EMI anomalies indicative of possible flow paths at depths from approximately 30 feet to 130 feet below ground surface. The EMI anomalies measured during the 2009 survey corresponded favorably with anomalies encountered during the June 2008 geophysics survey completed as part of phase II of the 560A/1051A investigation. Potentiometric surface mapping indicates groundwater in the 560A/1051A Area flows from southwest (near the ponds) to the northwest (toward Cow Creek) in both hydrostratigraphic intervals mapped. The highest groundwater potential exists at wells near the 3&4 EHP. Based on groundwater potential observed in shallow bedrock and alluvial wells, shallow bedrock in the upper hydrostratigraphic interval appears to be discharging to alluvium of the un-named drainages of Cow Creek. Recommendations include installation of additional monitoring and collections wells in this area, excavate test pits upstream of 1073A toward the 3&4 EHP, excavate test pits and install wells to evaluate geophysical anomalies near the 1999 seep and the Saddle Dam Interception Trench.
December 2009	Interim Report of 2009 Activities on 1&2 and 3&4 Ash Disposal Ponds. Reclamation Research Group	Evaluation of vegetation and soils at the Saddle Dam and South Seep areas; and of boron concentrations in Ponderosa pine needles, grasses and soils in select areas surrounding the 3&4 Ash Disposal Pond	Boron levels in vegetation growing in impacted soil were still high and plant diversity continues to be low at both seep sites. Boron levels in soil and vegetation along the south Fork of Cow Creek were almost low enough to be considered background concentration. Changes in soil boron concentrations from up gradient sites to the lowest site continue. The changes indicate slight impacts down the drainage from the EHP but no indication of on-going effluent discharge. Boron concentrations in vegetation are elevated at the Saddle Dam and South Seep but not sufficiently elevated to impact livestock health.
January 26, 2010	Results of Investigation at Area East of Units 3&4 Effluent Holding Pond Saddle Dam and 560A/1051A Area - Memorandum from Hydrometrics to PPLM	Installation of sixteen monitoring wells, 11 in the 560A/1051A area and five between this area and the 3&4 EHP Saddle Dam. The wells were sampled and pumping and/or slug testing conducted. Seventeen test pits were excavated to evaluate groundwater conditions in the shallow unconsolidated sediments. Ten were near the 3&4 EHP Saddle Dam and six were up the drainage from well 1073A. Test pits were observed for the presence of water and field SC measured, if groundwater was present.	Wells 1093D, 1095D, 1100D, 1102D, and 1104D, installed in shallow bedrock, showed probable process water impacts. Transmissivity, calculated from pumping or slug tests ranged from 0.1 to 1000 $feet^2$/day. Impacted groundwater was detected in two test pits near the original Saddle Dam Seep. Groundwater was entering the pits at extremely low rates (less than 1 gallon per hour). SC exceeded 10,000 µmhos/cm. Salt crystals were observed in soil excavated from the two test pits. Precipitation water moving vertically through the water column would be expected to mobilize some of these salts. Groundwater with SC exceeding 10,000 µmhos/cm was found in three of six test pits excavated in the drainage upstream of well 1073A. The other three test pits were dry. Groundwater was encountered at the contact between basal alluvial gravel and bedrock. Recommendations were made to convert eight wells in the 560A/1051A area to enhance groundwater capture. Additional investigation was recommended in the drainage upstream of 1073A in areas too deep for test pit excavation. Mitigation measures including test pit groundwater recovery or an interception trench was recommended.
January 26, 2010	PPL Montana Colstrip Steam Electric Station 1073A Area Alluvial Capture Options – Letter from Hydrometrics to PPLM dated January 26, 2010	Evaluation of two groundwater capture alternatives for the alluvium in the vicinity of well 1073A	Alternative 1 involved installation of a series of up to three capture trenches perpendicular to the direction of groundwater flow across the narrow alluvial channel upgradient of well 1073A. Alternative 2 involved installing a single trench parallel to the alluvial channel with a sump located near well 1073A.

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February 5, 2010	Geophysical Survey Services Electromagnetic Induction (EMI) Conductivity and Streaming Potential (SP) Survey, PPL Montana, LLC Units 3 and 4 Effluent Holding Ponds Area Colstrip, Montana. UMS Inc.	Report summarizes results of geophysical surveys conducted by Utility Mapping Services in the 3&4 EHP area in 2009. Conductivity surveys using electromagnetic inductive (EMI) and streaming potential (SP) methods were conducted along transects northwest, north, and northeast of the 3&4 EHP. EMI devices measure the electrical conductivity of subsurface materials by inducing a current through the materials. SP surveys measure the natural electrical potential between two non-polarizing electrodes.	Background terrain electrical conductivities had a high average of 40 to 50 mmhos/m; probably due to the high clay content of soils. Some variability in background measurements due to terrain changes were experienced. Three areas with high electrical conductivity anomalies were identified northwest of the pond, one shallow (<50 ft.) and two deeper (>50 ft.). Low amplitude anomalies, potentially suggesting shallow groundwater flow, were identified northeast of the ponds. Two negative anomalies, in both SP and EMI, were identified along the easternmost portion of the survey, possibly indicating downward groundwater flow. Electronic interference was encountered from both underground and overhead utilities at some locations. These interferences result in positive or negative responses in instrumentation readings. In addition, interferences from atmospheric conditions, such as distant thunderstorms, were experienced in some cases.
March 12, 2010	Well 1084A Conversion/Well 581D Abandonment – Technical Memorandum from Hydrometrics to PPLM dated March 12, 2010	Installation of two monitoring wells (581D-2 & 1084A) and abandonment of well 581D. Also addresses conversion of well 1084A for groundwater capture.	An evaluation of well 581D water quality and well completion concluded that groundwater from unconsolidated sediments was issuing to bedrock at the well. Based on these conclusions capture well 581D was abandoned and replaced with wells 581D-2 & 1084A (see also Technical Memorandum November 17, 2009). It was recommended that well 1084A be converted to a capture well as a replacement for well 581D and that 581D-2 be maintained as a bedrock monitoring well. Well 1084A was converted and plumbed into existing piping that served 581D. Pumping from well 1084A began on October 22, 2013.
March 25, 2010	Joint Trend Study – DRAFT: Memorandum from Hydrometrics to PPLM dated March 25, 2010	A joint trend survey was conducted to measure the attitude of joints in sandstone bedrock north, northeast, and southeast of the 3&4 EHP. Test pits were excavated, potential joints were identified, and the orientations measured. In place outcrop fractures were also measured, where possible.	Joint orientations were measured in 10 test pits. In addition, fractures present in outcrops that were interpreted to be representative of actual conditions (not moved by erosion, ground slumping, or other ground moving events) were measured. A total of 58 measurements were recorded. The majority of joints were steeply dipping (80 to 90 degrees). Trends were further evaluated by plotting the poles of the measured orientations on stereonets. Mean lineation azimuth, (average pole to the plane of the measured joint) calculated for the joints was 238 degrees. The average orientation of all the planes was 328 degrees with a dip of 86 degrees. Four clusters poles were identified and were indicative of two primary orientations (340 and 315 degrees). Two less prominent orientations of 45 and 95 degrees were calculated. Evaluation of regional aerial photos show a trend of 340 to 350 degrees, corresponding to the primary joint sets measured in the field. This orientation is expressed in patterns to the south of the 3&4 EHP.
April 26, 2010	Interpretive Summary of October 2009 Geophysics Survey. Technical Memorandum from Hydrometrics to PPLM	The surveys were completed in order to locate potential groundwater flow pathways that may be attributable to the 3&4 EHP. An attempt to account for each anomaly with prior knowledge specific to each site was made. For example, the proximity of each anomaly to known subsurface flow paths (e.g. alluvial channels and/or active capture systems) was considered. Existing wells near mapped anomalies, were reviewed for lithology and water quality trends that could account for increased subsurface electrical conductivity.	Six Electromagnetic Induction (EMI) survey lines were mapped in October 2009 by Utility Mapping Services. A total of 1,348 conductivity readings were collected at 337 individual locations on the six survey lines. Numerous high conductivity anomalies were recorded north of the 3&4 EHP Area at locations where groundwater flow paths are known to exist or are likely to exist based on prior knowledge of the site. High conductivity anomalies were also recorded at locations where groundwater (possibly impacted by process pond water) has not been monitored. It was recommended that up to 11 monitoring wells be installed near selected geophysical anomalies. Copies of the UMS reports were included in this memorandum.
May 2010	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2009, Battelle Pacific Northwest Laboratories	The objectives of the study are to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed and to establish the current conditions of water quality and hydrological parameters so the effects of any ongoing or future events associated with the effluent holding pond and related operations could be evaluated.	In June, three new monitoring wells were installed on Cow Creek near the property line between Genie Land Company and PPL, Montana. Initial data from these wells were collected during September, and the levels of conductivity, sulfate, and boron were higher than those from all downgradient monitoring locations except for the most downgradient site, W-1. Additional monitoring data are required to determine if a plume of contaminated water is impacting the new sampling locations. Six sites were identified where water quality had changed from previous years: GNW 6, GNW 7, GOW 4, GOW 11, GSP 4, and GSP 6. At the drainage level, South Fork Cow Creek had statistically significant increases for all three parameters. Compared to the past 3 years, the changes are negligible, and additional data are needed to assess whether these increases are part of an extended long-term trend. Statistically

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May 2010 (continued)			significant increasing and decreasing drainage-level trends were observed for boron and sulfate, respectively, at Pony Creek. Precipitation during 2009 totaled 13.45 in., about 13% below the long-term average of 15.5 in. Water levels in most of the wells monitored during 2009 were similar to the 2008 measurements for both the June and September monitoring events. No major changes in groundwater flow patterns were indicated in Cow Creek or South Fork Cow Creek.
May 21, 2010	1073A Area Borehole Drilling – Technical Memorandum from Hydrometrics to PPLM	Fifteen boreholes, ranging in depth from 15 to 60 feet below ground surface, were advanced to investigate groundwater conditions east of the 3&4 EHP. In addition, two monitoring were installed. The intent of the investigation was to identify groundwater flow paths between the 3&4 EHP and well 1073A.	A shallow groundwater flow path that would account for the groundwater conditions observed at well 1073A was not identified. It is possible that fracture flow may exist that transports impacted groundwater to the alluvium upgradient of well 1073A. Alternately, impacted groundwater at 1073A may have originated following infiltration of surface water leaking previously from Cell G. Since a distinctive flow path near the ponds was not identified, construction of a capture system near well 1073A was recommended. Based on the results of this investigation an interception trench method of mitigation was recommended. Several other observations were made relating to groundwater conditions in the area. Well 1108D is completed in a confined sandstone interval. The potentiometric surface at this well is about 27 feet above the groundwater table at well 1073A. Wells 1064D and 1114D are completed at a similar elevation to 1108D and have potentiometric heads well above the alluvium at 1073A. It is believed that water from this interval flows into the alluvium near well 1073A. Although high in TDS, sulfate, and sodium, the water quality in these wells is inconsistent with that observed at well 1073A, which exhibits high boron and chloride and has a low calcium to magnesium ratio. Water from this interval may be contributing to the poor quality groundwater observed at well 1073A but is not the primary source. Water from the confined sandstone is not believed to be sourced from the 3&4 EHP.
May 28, 2010	Drain Pit #3 Investigation - Technical Memorandum from Hydrometrics to PPLM	Results of a surface and groundwater investigation at the Drain Pit #3 Collection pond during February 2010. Work was done in response to observation of ice buildup in drainage east of the pit where water below the ice showed elevated field SC (18,000 µmhos/cm).	Two surface water samples and corresponding soil samples were collected from the pond. Test pits were excavated on the west bank of the drainage and samples of water from within the test pits were collected. Geoprobe boreholes were advanced along the east side of the clean water return and slurry pipelines. Results indicate that the seepage water discovered by PPLM did not originate as leakage from either the 3&4 EHP clean water return or the 3&4 EHP slurry pipelines, but was most likely from the Drain Pit #3 Pond. However, data collected during this investigation were not duplicative of field SC measurements initially obtained by PPLM personnel. Based on this fact, observations, and analytical results it is concluded that elevated field SC measured by PPLM were likely related to remobilization of salts following the initial snow melt and are not the results of widespread problems at Drain Pit #3. Two general recommendations were made: 1.) if the pond remains in service, a monitoring well should be installed directly downgradient of the pond, water in the pond should be removed frequently, and the pond should be lined if future problems are discovered; 2.) the pond should be removed.
June 8, 2010	Evaluation of 2009 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System Colstrip Steam Electric Station Colstrip, Montana, Hydrometrics, Inc.	Annual Water Resources Report	Work conducted in 2009: • Installation of wells 1079A-Trench through 1099D, and 1100D through 1107D; • Conversion to capture wells: 1079A-Trench, 1084A, 1089D, 1090D, • Investigation near well 1073A; • 602S Area Investigation; • Abandonment of 575D and 581D; • Saddle Dam Test Pit Investigation; • Geophysics Investigations • Installation of offsite private wells PW-734 through PW-736.

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June 8, 2010 (continued)			Cow Creek monitoring sites CC3 and CC4 were sampled, the other sites were dry. Water quality was similar to previous years. Groundwater collection continued from the 3&4 EHP Main Dam Sump/Interception Trench/Dam Abutment Areas. Water from monitor well 607A and collection well 654A showed similar to slightly better water quality than in 2008. Wells 625A and 626A are showing a slight degradation in water quality. Additional investigation was conducted in these areas in 2009. Additional investigation in the well 625A/626A vicinity may be conducted pending the results of the geophysics investigations. Eight new wells were installed in the 602S area north of the 3&4 EHP Main Dam. Groundwater sampling results from the new wells suggests impacts from process pond water in groundwater at six of the seven new bedrock wells and the new alluvial well. Expansion of mitigation efforts is planned for this area. Well 581D was replaced by well 581D-2 and was installed exclusively in sub-McKay strata. The original well 581D had packers installed near the contact with the unconsolidated sediments and deeper bedrock units. Water from new well 581D-2 does not show pond water impacts. However, a small amount of water was encountered at the bedrock contact during well installation. Subsequently, a new well, 1084A, was installed adjacent to 581D and completed at the alluvium/bedrock contact. This well was converted to a capture well in 2009 and 581D was plugged and abandoned. A geophysical investigation was conducted north of the 3&4 EHP in October 2009; six lines using geomagnetic methods were extended at different orientations along the north side of the ponds. Groundwater collection systems continued to operate to address impacts from a Saddle Dam leak that occurred in December 1999. These capture systems have continued to operate and have been expanded to improve capture of seepage from this area. The collection systems include the Saddle Dam Valley Drain Sump, Saddle Dam Interception Trench, and capture wells 646D, 647D, 648D, 560A Trench, 1039A, 1051A, 1079A Trench, 1089D and 1090D. Wells 646D and 648D continued to show increased concentrations of dissolved constituents in 2009. . Spring SP-14 showed improved water quality in 2009 as compared to previous years. Water at SP-14 has historically issued at the confluence of two drainages. Water sampled at SP-14 is now derived primarily from the south drainage. In addition, PPLM removed approximately one to 1.5 feet of topsoil and sediment in an attempt to increase flow for stock watering purposes. The combination of these two actions, as well as groundwater capture at upgradient well 1039A, is believed to be responsible for the improvement in water quality at SP-14. PSW-9 was installed to supplement SP-14 as a livestock water source. Well 632M located near the Saddle Dam showed increased dissolved constituents in 2009, appearing impacted by pond water. This well is upgradient of the Saddle Dam Interception Trench, so the Saddle Dam Interception trench should capture this water. Water quality at the 3&4 Saddle Dam Trench has declined slightly since 2007, possibly an indication that water from the 632M area, observed in 2005 and 2006, is reaching the trench. Five new monitoring wells (1103D, 1104D, 1105D, 1106D and 1107) were installed in this area during 2009. The well locations are coincident with anomalies identified in the March 2009 electromagnetic induction survey conducted in this area (560A/1051A Area Expanded Investigation, Hydrometrics, September 2009c). Two Electromagnetic Induction (EMI) profiles were surveyed on March 30 and 31, 2009 in order to identify possible groundwater flowpaths, which might exhibit higher SC concentrations between the 3&4 EHP Saddle Dam and the 560A/1051A Area. The survey identified several EMI anomalies indicative of possible

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June 8, 2010 (continued)			flowpaths at depths from approximately 30 feet to 130 feet bgs. Some investigation of these anomalies was completed in 2009 and additional work was planned for 2010. Wells 556D, 609D, 610D, and 621D continued to collect impacted groundwater in 2009. Water levels in these wells have been lowered by between 30 to 35 feet since collection was started. In the 560A area, capture continued at wells installed in 2008 that include the 560A and 1051A trenches. Additional investigation was also conducted in this area in 2009, including excavation of several trenches and installation of thirteen monitoring wells. A capture well was completed in one trench (1079A) and two monitoring wells were converted for capture in 2009. Eight more capture well conversions are planned for 2010. Additional investigation and groundwater capture is planned for 2010. In June 2009, three private wells (PW-734, PW-735 and PW-736) were installed off-site to evaluate groundwater conditions downgradient of 1051A. These wells do not appear to show process pond water impacts. Battelle will monitor these wells in the future when conducting monitoring under the 12D Stipulation. Water quality at well 1073A was indicative of process pond water and additional capture was installed in January 2009 (well 1079A). Additional investigation included installation of 13 monitoring wells and conversion of three wells for capture (1079A, 1089D and 1090D). This 556D capture system west of the pond (1031R Area) was expanded in 2008 to include capture at 1031R, 1034R, and 1037R. Capture rates diminished greatly since the system was started suggesting the volume of impacted groundwater in this area is being reduced. Any remaining source, if present, is likely of relatively low volume. SP-15 South and SP-15 North and Northwest Interception Trenches were installed to collect impacted groundwater in the area west of the 3&4 EHP. The overall volume of water captured in this area annually since startup of the systems has decreased. This reduction is likely due to increased groundwater capture at upgradient capture wells adjacent to the slurry wall (well 1031A Area), the likely reduction in source water outside the 3&4 EHP, and revised pond management practices. Chemical constituents show an increasing trend at 657M between 2003 and 2008. In 2009 concentrations were similar to 2008. Yield from capture wells south and west of the 3&4 EHP continued to decrease in 2009. The significant reduction in groundwater collected along with the lowering of water levels indicates that the collection systems are working effectively and seepage is being mitigated. South Fork Cow Creek Capture systems continued to operate in 2009 and water levels have been lowered from two to 24 feet during pumping. The alluvium directly downstream of the capture well network is essentially dry. The Drain Pit #3 interception trench continued to operate in 2009. Water quality in the area was variable with some wells improving and others declining. PSW-2 showed improving water quality in 2009. In 2001, a collection system was installed downstream of Drain Pit #5 to address potential impacts from spills that occurred in this area related to the pipeline and Drain Pit 5. The system continued to operate effectively in 2009.

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December 2, 2010	Results of Drilling and Testing at Geophysics Anomalies Technical Memorandum from Hydrometrics to PPL	Report of subsurface investigation of geophysical anomalies identified by EMI surveys conducted in EHP area. Work included drilling eight monitoring wells and two boreholes.	Groundwater conditions encountered in boreholes drilled at geophysical anomalies were variable with respect to process water impacts. Of the ten boreholes drilled at geophysical anomalies: • Three wells (1120C, 1123A, and 1121D) showed water quality that could be interpreted as process pond impacts. Wells 1120C and 1123A are completed at the bases of burns and water quality may reflect the local geology; • Three wells (1125D, 1126A, and 1127D) exhibited water quality that was inconclusive of pond water impacts; • Two wells (1122D and 1124D) showed no evidence of pond water impacts; and • Two boreholes were dry and were plugged with bentonite. Additional work recommended to assist with capture system selection includes installation of five new monitoring wells and six test pits.
December 2010	Capture System Expansion North of the 3&4 Effluent Holding Ponds Main Dam – 602S Area, Hydrometrics, Inc.	Report summarized the installation of monitoring wells, well testing, water quality sampling, capture system conversion details, startup procedures, and effectiveness north of the 3&4 EHP Main Dam.	New wells 1115D, 1116D, 1117D, 1118D, and 1119D were installed north of the 3&4 EHP Main Dam either as monitoring wells or expressly as groundwater capture wells. Groundwater capture north of the 3&4 EHP was expanded by converting monitoring wells 1080D, 1081D, 1083D, 1087D, and 1115D to capture wells. A new two-inch pipeline was installed to route groundwater from well 1087D to the 3&4 EHP Main Dam Sump. New capture wells 1080D, 1081D, 1083D, and 1115D and existing capture wells 556D, 609D, 610D, and 621D were routed in a new three-inch HDPE pipeline constructed from the 602S Area to cell B of the 3&4 EHP. Based on results of water quality samples, capture system monitoring, and potentiometric surface mapping, the addition of wells 1080D, 1081D, 1083D, 1087D, and 1115D to the capture system north of the 3&4 EHP has resulted in a significant increase in the volume of impacted groundwater collected and a measurable expansion of the overall capture radius. Monitoring wells paired with capture system wells (i.e. 1116D, 1117D, 1118D,and 1119D) proved to be instrumental in constructing potentiometric surface maps of the area and will be useful monitoring points for the continued evaluation of groundwater quality and groundwater flow direction throughout the life of the capture system.
December 2010	Plant Diversity and Boron Studies Adjacent to the Power Plant Ash Disposal Ponds, Colstrip, Montana 2010. Reclamation Research Group	Evaluation of vegetation and soils at the Saddle Dam and South Seep areas; and of boron concentrations in Ponderosa pine needles, grasses and soils in select areas surrounding the 3&4 Ash Disposal Pond	The number of plant species present was low at both seep sites. The number of forbs recorded at the South Seep site was greater this year than in previous years. Boron levels were high in Western wheatgrass at the Saddle Dam seep site, but at levels that would not restrict grazing. Soil boron levels were high with the exception of some of the Low Impact area samples. The differences in vegetative cover and species present indicated that the surface impact of the effluent that escaped from the EHP was limited to small areas of impact at the Saddle Dam and South Seep. These zones may enlarge as the contaminants are distributed by soil moisture into non-contaminated areas. This occurred immediately after effluent release but does not appear to be taking place at the current time. If changes are occurring they are doing so at a very slow rate. These areas may also decrease in size over time since sources of effluent have been stopped and plants use boron as a trace micronutrient. Elevated needle boron was present in Ponderosa pine needles indicating impacts from a source of boron. The source could be groundwater, soil, or air borne since elevated boron was present in soil horizons.
February 2011	PPL Montana, LLC 2010 Pond Capacity Survey	Water level and depth were measured on STEP Cell E and the Units 3&4 C Cell. Data were used to estimate remaining pond capacities and to develop rating curves for each cell.	A remaining service life for 3&4 EHP Cell C was calculated assuming a deposition rate of 73 tons of paste per hour. This further assumed a 95% run capacity. A dry density of 81 pounds per cubic foot was used to calculate a density of 1.1 tons per cubic yard of paste. At this rate, 3&4 EHP Cell C was projected to reach capacity in approximately 3.6 years from September 2010.

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February 2011	PPL Montana, LLC Capture System Construction, Startup, and Performance 560A/1051A Area and 1073A-Trench, Hydrometrics, Inc.	Installation, sampling, and testing of five monitoring wells in the 560A/1051A Area. Conversion of eight monitoring wells to capture wells in the 560A/1051A Area. Installation, startup, and performance of the 1073A-Trench. Descriptions of capture system startup and performance.	Monitoring wells 1093D, 1095D, 1097D, 1098D, 1099D, 1100D, 1101D, and 1102D were converted to groundwater capture wells. Water from the wells is routed via a three-inch diameter HDPE pipeline to the 3&4 EHP Saddle Dam Valley Drain Sump, which lifts water to the 3&4 EHP. Wells 1109D through 1113D were installed to monitor groundwater in the 560A/1051A Area so quality and capture system performance could be better evaluated. Pumping from the converted wells started April 13, 2010. Water levels were monitored in the pumping wells and selected nearby monitoring wells. Data were presented from startup through two months after startup. After two months of pumping water levels had been lowered forming depressions at wells 1101D, 1097D and 1099D. Groundwater capture was also evident at wells 1093D and 1102D. An interception trench was installed downgradient of well 1073A. Discharge piping was installed first to convey water to the 3&4 EHP Saddle Dam Valley Drain Sump. Dewatering of the construction area began after the discharge pipe was installed. The interception trench was constructed as dewatering points were in operation. The trench consists of one trench perpendicular to the drainage, across the entire width of the water bearing alluvium. A sump is installed at the low end of this portion of the trench. A second trench extends longitudinally up the drainage approximately 200 feet. Both trenches were excavated to below the contact with the underlying bedrock. Perforated pipe was placed in the bottom of the trenches. Permeable filter material was placed in the bottom of the trench sloping toward a sump located at the intersection of the two trenches. The sump was excavated about three feet below the bedrock contact. A pump was installed and pumping from the trench began June 28, 2010. Initial pumping rates were about 10.5 to 11.4 gpm. Pumping rates dropped to about four to five gpm once storage in the filter material had been depleted. The quality of groundwater captured by the trench was indicative of process water influences.
April 2011	Evaluation of 2010 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System Colstrip Steam Electric Station Colstrip, Montana, Hydrometrics, Inc.	Annual Water Resources Report	The following work activities were conducted in 2010 in the 3&4 EHP: • Conversion to capture wells: 1068A, 1080D, 1081D, and 1083D 1093D, 1095D, 1097D, 1098D, 1099D, 1100D, 1101D, and 1102D; • Installation and startup of 1073A Trench; • Installation of 17 bedrock monitoring wells: 1108D, 1109D, 1110D, 1111D, 1112D, 1113D, 1114D, 1116D, 1117D, 1118D, 1119D, 1121D, 1122D, 1124D, 1125D, 1126D, and 1127D; • Installation of capture well 1115D; • Installation of clinker well 1120C; • Installation of two alluvial wells: 1123A and 1126A; and • Drilling, logging and abandonment of 17 shallow boreholes (PH-2010-01 through -015 and PH-1008-01 and -02). Water at sites CC3 and CC4 was sampled, the other sites were dry. Water quality was within ranges previously observed at these sites. During 2010, the paste process continued to operate and paste was deposited in the old clearwell to help reduce seepage from the pond. In 2010, the excess water inventory was reduced by an estimated 272 million gallons. Since 2006, water inventory has been reduced by 1.044 billion gallons. Groundwater collection continued downstream of the 3&4 EHP at the Main Dam Interception Trench, Main Dam Sump Drain Trench, 654A well/trench, and several groundwater capture wells. Groundwater quality at monitor well 607A and collection well 654A was similar to the previous two years. Monitor well 593A, upgradient of capture well 654A, showed seasonal fluctuations and will continue to be monitored. Additional investigation of the area around wells 625A and 626A is planned for 2011. Work in the 602S area(east dam abutment) included installing capture well 1115D, converting wells 1080D,

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April 2011 (continued)			1081D, and 1083D to capture wells, and installing four bedrock monitoring wells (1116D, 1117D, 1118D, and 1119D) to measure capture system effectiveness in this area. Conversion of well 1087D is in progress and is expected to be completed in early 2011. Groundwater monitoring north of the Units 3&4 Main Dam detected several changes in water quality in 2010 which are summarized in the report. In the 3&4 EHP Saddle Dam Area, groundwater collection systems continued to operate and have been expanded westward to improve capture of seepage from this area. One new monitoring (1120C) well and two plugged boreholes were drilled in the area immediately east of the Saddle Dam in 2010. The drilling sites targeted geophysical anomalies mapped in 2009 by Utility Mapping Services (UMS, Inc., May 2009). Results of the investigation can be found in the investigation report (Hydrometrics, December 2010b). Groundwater quality changes or trends observed at wells in the Saddle Dam Area during 2010 monitoring are summarized in the report. Eight capture well conversions (1093D, 1095D, 1097D, 1098D, 1099D, 1100D, 1101D, and 1102D) and five new monitoring wells (1109D, 1110D, 1111D, 1112D, and 1113D) were added to the existing groundwater monitoring and capture network in the 560A Area in 2010. Operational monitoring at the capture wells and nearby monitoring wells indicates that capture system pumping has resulted in sustained water level drawdown in this area. Initial data collected in 2010 indicate that groundwater quality at 560A Area wells located nearer to the 3&4 EHP (e.g. collection wells 1089D and 1090D) is declining and groundwater quality at 560A Area wells further from the source (i.e. collection wells 1100D and 1101D) is improving. A collection system consisting of wells 556D, 609D, 610D, and 621D has been in operation in the north Saddle Dam Area for approximately 10 years. Water levels in these wells have been lowered by between 30 to 35 feet since collection was started. This collection system operated as usual in 2010, aside from down time to install a new pipeline re-routing captured water from this collection system from Cell G north to the new 602S Area pipeline. Captured water from both areas now discharges to the 3&4 EHP New Clearwell. Two new monitoring wells 1122D and 1123A were drilled in the North Saddle Dam Area in 2010 under the "Investigational Drilling at Geophysical Anomalies in the 3&4 EHP Area" (Hydrometrics, Inc. July 2010. These wells targeted a series of mapped geophysical anomalies (UMS, Inc., January 2010) and potentially impacted groundwater flow paths. Water quality at well 1123A was potentially indicative of process pond water impacts and additional investigation is planned in this area in 2011. Interception trenches SP-15 South and SP-15 North were installed in 2002 to collect impacted groundwater in the area west of the 3&4 EHP and continued to capture water in 2010. The overall volume of water captured at the SP-15 interception trenches has decreased annually since startup of the systems. This reduction is likely due to increased groundwater capture at upgradient capture wells adjacent to the slurry wall (well 1031R Area), the reduction in source water outside the 3&4 EHP, and revised pond management practices. Water quality trends are described in detail in the annual report. To mitigate the water that built up outside the slurry wall south and west of the 3&4 EHP, a system of collection wells was installed in 2005. A lined groundwater collection pond was built in Cell F to hold the collected groundwater. A reduction in capture volumes in the system and slight improvement in water quality suggest the system is effectively controlling groundwater flow in the area.

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April 2011 (continued)			Groundwater is effectively being captured in the alluvium, downstream of the SFCC Seep, as several wells near, or in the system are essentially dry, as observed at wells 665A, 666A, 667A, 668A, 669A, 670A, 671A, 682A, 684A, 685A, 689A and 690A. Reduction in water levels and lower SC are indicative of effective mitigation efforts in this area. The Drain Pit #3 Interception Trench continued to operate in 2010. Chemical concentrations upstream of the trench have shown a slight but gradually increasing trend. Water quality downgradient at PSW-2 and DP3-639D, located downgradient of the DP3 Trench and PSW-2 have shown consistent water quality over the period of record. The Drain Pit 5 interception trench captures groundwater flowing through the shallow unconsolidated sediments downstream of the West Seep, SP-15 North and SP-15 South areas. The capture system operated as designed in 2010.
April 18, 2011 DRAFT	Data Analysis and Statistical Evaluation of Unimpacted Groundwater Quality, Units 3&4 Effluent Holding Pond Area, Colstrip Steam Electrical Station, Colstrip, Montana. DRAFT External Memorandum from Exponent to Arnold and Porter	This memorandum describes the process used to generate background screening levels (BSL) which represent groundwater quality that is natural and un-impacted by the EHP in this area. This included selection of representative well locations, selection of representative background water quality data prior to pond operation in the study area, and assessment of temporal trends.	Water quality data from the following sources were included in an initial data review: MBMG, Big Sky Mine, Western Energy, Hydrometrics, and ARCADIS. Wells were categorized based on hydrogeological characteristics, with screened intervals or units of completion within four unique zones: alluvium, bedrock, coal, and spoils. Maps of well locations as well as plots of concentration data were used to review data and to select the representative background data set for use in the statistical analysis. Dates of pond operation were researched to determine an initial background water quality data set not influenced by the pond. Data collected prior to October 1, 1983 were evaluated for inclusion in the statistical analysis. Data evaluation focused on individual apparent anomalous values that may define or have a significant influence on the selected BSL value. The review was biased toward removing high concentrations if available data indicated the value was anomalous or otherwise not representative. The review process did not focus on low anomalous values since these low values do not have a direct impact on the BSL calculations. BSL calculations are based on the upper portion of the distribution of concentrations and therefore are not significantly impacted by changes in the lower portion of the distribution. The final BSL concentrations were generated using a non-parametric method from U.S. EPA ProUCL software. ProUCL was used initially for data review and screening. Final calculations were generated using S-Plus software to incorporate statistical weights that adjusted for the uneven sampling of wells. In this manner, the resulting upper tolerance limit (UTL) value is spatially representative of the entire area sampled. Once the BSL concentrations were determined, the locations associated with the values were reviewed, as well as the locations of the maximum constituent concentrations.
May 2011	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2010, Battelle Pacific Northwest Laboratories	The objectives of the study are to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed and to establish the current conditions of water quality and hydrological parameters so the effects of any ongoing or future events associated with the effluent holding pond and related operations could be evaluated.	Precipitation during 2010 totaled 18.07 in., approximately 17% above the long-term average of 15.5 in. Groundwater levels in most of the monitored wells during 2010 were higher than the 2009 measurements for both June and September monitoring events. Statistical analyses of conductivity, sulfate, and boron data identified six site-level and three drainage-level trends where water quality had changed from previous years. A statistically significant increasing drainage-level trend was found for boron at South Fork Cow Creek. At Pony Creek, increasing trends were found for both boron and sulfate. No drainage-level trends were discovered at Cow Creek. A continuous monitoring probe that measured depth to water, temperature, and conductivity was installed in well PW 736 in December 2010. Initial data from this system show fluctuations in the parameters that appear to be related to precipitation events such as the heavy rains in May 2011. Bromide was formally added as a monitoring constituent in 2010 in response to PPL Montana LLC's recent addition of bromide to the flue gas scrubber solution. Initial bromide results do not reveal any obvious trends when background levels and measurement variability are considered.

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May 2011 (continued)			No major changes in groundwater flow patterns were indicated in Cow Creek or South Fork Cow Creek. For Cow Creek and South Fork Cow Creek, these findings do not indicate any definitive impacts on groundwater quality from the operations of the effluent holding pond.
September 30, 2011	Interpretive Summary of April 2011 Geophysics Survey. Technical Memorandum from Hydrometrics to PPLM	A EMI survey was completed to identify groundwater flow paths that may be contributing to variable groundwater quality trends observed at select wells in the South Fork Cow Creek network (e.g. 1019AM and 1023AM). The configuration of the survey lines was chosen to detect potential flow paths that may exist between the 3&4 EHP and SFCC and/or groundwater flow that may originate from further upgradient in the SFCC drainage.	A review of EM34-3 survey data collected in April 2011 by UMS indicates that high conductivity anomalies were recorded south of the 3&4 EHP Area, between the ponds and SFCC. Some of the anomalies were mapped at locations where groundwater flow paths are known to exist or are likely to exist based on prior knowledge of the site. High conductivity anomalies were also recorded at locations where groundwater (possibly impacted by process pond water) has not been monitored. These anomalies may represent gaps in the current monitoring well network in the 3&4 EHP Area of the Colstrip SES. Based on these data, it is recommended that five monitoring wells be installed at select geophysical anomalies. Depending on conditions encountered in the field at the initial five wells, up to six supplementary monitoring wells may be drilled.
November 21, 2011	Installation and Startup of Capture Wells 1128D and 1129D North of Units 3&4 Effluent Holding Pond, 602S Area Technical Memorandum from Hydrometrics to PPLM	Memo describes well installation/conversion methodology, groundwater quality and flow characteristics of two wells located below the 3&4 EHP Main Dam.	New capture wells 1128D and 1129D target groundwater that is impacted by process water. Although yield at these wells is not as great as was originally estimated, the addition of 1128D and 1129D to the existing capture well network north of the 3&4 EHP increases groundwater collection, reduces pump back distances, and limits mixing of impacted water with native groundwater farther from the ponds.
December 14, 2011	PSW-10- Well Installation. Technical Memorandum from Hydrometrics to PPLM	The purpose of the well is to provide a reliable source of livestock drinking water. Report describes the completion, development, and groundwater quality analysis of private stock well PSW-10.	Based on yield estimates made during development and laboratory analytical results, PSW-10 provides water of sufficient yield and quality for livestock watering. Recommend PSW-10 be monitored at least annually to evaluate any changes in groundwater quality that may occur.
December 2011	Plant Diversity and Boron Studies on the Stage 1 Ash Disposal Pond Cap and Areas near the Effluent Holding Ponds, Colstrip, Montana 2011. Reclamation Research Group	Study of plant species richness and boron levels in vegetation at the Saddle Dam seep, South Seep, Southeast Dam and Reference Area 5.	The Saddle Dam area has a clearly defined zone of impact as indicated by the plant community and chemical analysis of soils. Impact expression ranged from almost all vegetation eradicated in the zone referred to as the High Impact area to decreasing impact down gradient from this site. The extent of the High Impact area is very small, <0.1 acre. Vegetation boron levels remain high in the High Impact zone. At the South Seep much of the impacted area was a monoculture of Western wheatgrass with yellow sweetclover invading the community in 2011. The highest level of boron in plant tissue at the South Seep was in the central portion of the impacted area. The South East Dam area was moderately impacted by boron from the EHP. Western wheatgrass has not assumed a dominant place in the community indicating that the soil profile has not been impacted with boron within the root zone. This site does not presently show signs of being impacted by elevated boron. Yellow sweetclover was very dense at this site. Ponderosa pine needle boron levels are elevated in the older needles of the Southeast Dam area.
January 9, 2012	Results of Supplementary Drilling and Testing at Geophysical Anomalies North of the 3&4 EHP. Technical Memorandum from Hydrometrics to PPLM	Results of supplemental subsurface investigation to evaluate potential process water impacts at geophysics anomalies in the area north of the 3&4 EHP.	Four boreholes were drilled in June 2011. Monitoring wells 1130D, 1131D, and 1132D were completed at three of the drilling locations, the fourth borehole was plugged and abandoned. Five test pits were excavated on September 15, 2011. There appear to be three discrete water-bearing zones in the 560A/1051A Area and adjacent strata to the northwest: 1.) alluvium and near surface bedrock with consistent groundwater elevations; 2.) shallow, thin, sandstone/siltstone bedrock deposits with groundwater potential that is lower than alluvial water levels; and 3.) a deeper, thicker, sandstone unit. Based on values of common process water indicator parameters, groundwater quality at wells 1130D and 1131D is consistent with groundwater that is currently being captured in alluvium and shallow bedrock south of the 1079A-Trench in the 560A/1051AArea. Both wells are completed in a shallow coal interval. Well 1132D is completed in a deeper sandstone horizon and shows water quality with no evidence of impacts.

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Jan. 9, 2012 (continued)			Recommendations for further work in this area include: • Perform long-term pump test at 1121D to evaluate for use as a capture well. • Convert 1127D for capture. • Install additional monitoring wells between 1127D and wells 1100D and 1101D. • Ongoing monitoring in the area, with the addition of isotope studies at 1120C, 1123A, 1130D and 1131D.
January 16, 2012	Results of Drilling and Testing at Geophysics Anomalies Between the Units 3&4 Effluent Holding Ponds and South Fork Cow Creek. Technical Memorandum from Hydrometrics to PPLM	Findings of drilling and groundwater evaluation focused on geophysical anomalies identified in April 2011 survey.	Monitoring wells 1133D through 1139D were installed at select geophysical anomalies. Based on laboratory analytical results from the seven new wells drilled at geophysical anomalies, well 1136A is the only well with groundwater quality indicative of process water impacts. Results from the other six wells are not indicative of process water influences. At present, well 1136A is located the farthest upgradient in the SFCC drainage of all monitoring wells with impacted groundwater. Because upgradient monitoring well 1022A is not impacted by process water, the suspected impacted flow path possibly converges with the alluvium between 1022A and 1136A. Up to five additional monitoring wells in the alluvium or shallow bedrock between the 3&4 EHP and the SFCC are recommended.
May 2012	Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2011, Battelle Pacific Northwest Laboratories	The objectives of the study are to determine whether there were changes in water quality downgradient of the EHP on Genie Property Land since the 1985-1986 baseline study was completed and to establish the current conditions of water quality and hydrological parameters so the effects of any ongoing or future events associated with the effluent holding pond and related operations could be evaluated.	Groundwater levels measured in the alluvial wells in 2011 averaged about 1.3 feet higher in both June and September than the levels measured in June and September 2010. The groundwater levels increased because of increased precipitation in 2011. Ten inches of rain fell during May 2011. The 2011 groundwater levels do not indicate any major changes in groundwater flow patterns for Cow Creek and South Fork Cow Creek. Statistical analyses of conductivity, sulfate, and boron data identified four site-level and two drainage level trends where water quality had changed from previous years. Statistically significant increasing drainage-level trends were found for boron and sulfate at South Fork Cow Creek. No drainage-level trends were identified at Pony Creek or Cow Creek. No site trends were detected in the Cow Creek drainage. For Cow Creek and South Fork Cow Creek, these findings do not indicate any definitive impacts on groundwater quality from the operations of the effluent holding pond.
June 2012	Evaluation of 2011 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System Colstrip Steam Electric Station Colstrip, Montana, Hydrometrics, Inc.	Annual Water Resources Report	The following work was conducted in 2011. • Wells 1128D and 1129D were installed and converted to collection wells north of the Units 3&4 EHP. • Monitoring wells 1130D, 1131D, and 1132D were installed east of the Units 3&4 EHP Saddle Dam. • Groundwater capture was initiated at well 1087D; this well was converted near the end of 2010 but pumping did not begin until 2011. • Monitoring wells 1133D, 1134D, 1135D, 1136A, 1137M, 1138D, and 1139M were installed south of the Units 3&4 EHP in the South Fork Cow Creek (SFCC) Drainage. • Several tests pits were excavated to evaluate shallow groundwater in the Cow Creek Drainage north of the Units 3&4 EHP. • PPLM installed stock well PSW-10 in the Cow Creek Drainage, approximately three miles east of the plant site. The new well will provide water to cattle on land PPLM leases for grazing. Water quality at the well is suitable for stock watering and does not exhibit process water impacts. Groundwater capture/containment was conducted at 85 sites in 2011 in the Units 3&4 EHP area. Of these 85 sites, 76 are capture wells, seven are interception trenches and two are dam sumps. Twenty of these capture wells are located in SFCC. Water at sites CC3 and CC4 was sampled, the other sites were dry. Water quality was within historical ranges observed at these sites.

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June 2012 (continued)			During 2011, the paste process continued to operate and paste was deposited in the old clearwell to help reduce seepage from the pond. In 2011, the excess water inventory was reduced by an estimated 83.2 million gallons. Since 2006, water inventory has been reduced by 1.127 billion gallons. Collection of impacted groundwater initiated downgradient of the 3&4 EHP Main Dam in 1989 was continued in 2011. Additional groundwater investigation and efforts to mitigate water quality impacts directly north of the Units 3&4 EHP continued in 2011. As noted, capture began in March 2011 at well 1087D. Wells 1128D and 1129D were installed, tested, sampled, and converted to capture wells in this area in 2011. Water quality trends in the area can be found in the annual report. Groundwater collection systems were originally installed in the 3&4 EHP Saddle Dam Area to address impacts from a dam leak that occurred in December 1999. These capture systems have continued to operate and have been expanded eastward to improve capture of seepage from this area. Water quality trends in the area can be found in the annual report. The 560A area has been the subject of intensive groundwater investigation and mitigation efforts in recent years. Operational monitoring at the capture wells and nearby monitoring wells indicates that capture system pumping has resulted in sustained water level drawdown in this area since pumping began. Monitoring wells 1130D, 1131D, and 1132D were installed in shallow bedrock north of the 560A Area in 2011. Water quality trends in the area can be found in the annual report. A collection system consisting of wells 556D, 609D, 610D, and 621D has been in operation in the north Saddle Dam Area for approximately 10 years. Water levels in these wells have been lowered by between 30 to 35 feet since collection was started. On the west side of the 3&4 EHP, well 656R continued to capture impacted groundwater. This well was converted for groundwater capture in 2006 to replace capture at wells 640P and 641P, which are now used to monitor water levels near the capture wells. This system (1031R Area) was expanded in 2008 to include capture at 1031R, 1034R, and 1037R. Capture rates have diminished greatly since the system was started; suggesting the volume of impacted groundwater in this area is being reduced. The overall volume of water captured at the SP-15 interception trenches has decreased annually since startup of the systems. This reduction is likely due to increased groundwater capture at upgradient capture wells adjacent to the slurry wall (well 1031R Area), the reduction in source water outside the 3&4 EHP, and revised pond management practices. A break in the flyash slurry pipeline occurred in December 2010. PPLM responded by containing the spill and placing impacted water in Drain Pit 5. Changes in water quality observed at WA-145 and WA-222, located downgradient of Drain Pit 5, prompted the installation of pumps in these wells in 2011. In addition, PPLM installed a synthetic liner in Drain Pit 5 in 2011. Mitigation efforts for the SFCC and West Seeps continued throughout 2011. In 2011, capture volumes were similar to those in 2010, likely the result of high precipitation that occurred during the year. Water levels of the South Fork Cow Creek collection wells and associated observation wells indicate effective capture of groundwater as the levels have been lowered by between two to 24 feet during pumping.

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June 2012 (continued)			The alluvium at the downstream capture wells is essentially dry as observed at wells 665A, 666A, 667A, 668A, 669A, 670A, 671A, 682A, 685A, 689A and 690A. In 2000, the Drain Pit #3 Interception Trench system was installed to collect potential impacts from a spill in the pipeline/drain pond. Water quality downgradient at PSW-2 and DP3-639D, located downgradient of the DP3 Trench and PSW-2, have shown consistent water quality over the period of record. Water quality changes observed at wells in this area include: • PSW-2 - water quality declined; and • DP-3IT – boron concentrations increased in the spring sample. Drain Pit 3 was lined with synthetic liner in 2011 after results of an investigation conducted in 2010 indicated that water from the pond may have been seeping to the local shallow groundwater system that is captured by the DP3-IT.
September 2012	PPL Montana, LLC 2012 Pond Capacity Survey	Water level and depth were measured on STEP Cell E and the Units 3&4 C Cell. Data were used to estimate remaining pond capacities and to develop rating curves for each cell.	A remaining service life for 3&4 EHP Cell E was estimated to be about 2.4 years. Estimates were based on 95% operating capacity, 73 tons per hours of paste disposal, and a dry density of 81 pounds per cubic foot.
January 30, 2013	Pumping Tests at 3&4 EHP Underdrain and 1003R, Technical Memorandum. Hydrometrics to PPLM	Pumping tests were conducted on the 3&4 EHP Underdrain and on well 1003R. The underdrain is a sump at the junction of perforated "lateral" pipes installed above the bentonite lining and below the ash at elevations below 3200 feet. Well 1003R is installed in Rosebud clinker adjacent to the inboard side of the slurry wall on the south side of the pond.	Two pumping tests were conducted on the 3&4 EHP Underdrain. On April 19, 2012 the underdrain was pumped at a rate of 121 gpm for 123 minutes. Initial water elevations in the underdrain were about 3,240 feet above MSL. During pumping about 42.3 feet of drawdown were observed, dropping the water level to an elevation of about 3,200, or the upper limits of the underdrain. Water levels equilibrated at this level. It was unclear if drawdown stopped because the pumping rate was insufficient to dewater the underdrain piping or because of the large amount of storage potentially within the piping itself. A second test was conducted January 16, 2013. A higher capacity pump, set deeper in the underdrain, was used for the second test and the underdrain was pumped at an initial rate of 375 gpm but dropped to 187 gpm as water levels dropped. Initial water level elevations were about 3237 feet. Pumping resulted in 47.2 feet of drawdown, lowering the water level to about 3190 foot elevation, or 10 feet below the upper limits of the drain laterals. This elevation was also below water levels in Cell C (~3262 ft.), Cell G (~3,237 ft.), and the Old Clearwell (~3,233 ft.) Results of the pumping suggest dewatering of the underdrain may be effective. Well 1003R was pumped on January 17, 2013 at a rate of 440 gpm for 5208 minutes. The generator operating the pump ran out of fuel at this time but was restarted about six hours later. The test continued for a total of almost six days. Water levels were monitored in the pumping wells and monitoring wells 674R and 1085R, both completed in clinker inside the slurry wall. During the test, about 6.9 feet of drawdown were observed at 1003R and 0.14 feet at well 674R. Drawdown was not observed at well 1085R. The pumping indicates that a large radius of influence can be expected from pumping wells completed in the clinker, minimizing the number of wells potentially needed to dewater the clinker inside the pond. Dewatering the clinker (estimated between 63 and 74 million gallons without storage losses from adjacent saturated flyash or paste) would be feasible, particularly after all cells are lined.
March 5, 2013	Interim Report – South Fork Cow Creek Diversion Sediment Removal. Technical Memorandum from Hydrometrics to PPLM	Report describing sediment removal activities at the SFCC Diversion pond south of the 3&4 EHP. Tasks consisted of sampling of the sediments above the dam, sediment removal and disposal and removal of piping and other associated appurtenances.	Approximately 320 cubic yards of salt-laden soil/sediment was removed from upstream of the diversion. Material removed included mostly unconsolidated fine-grained alluvium/colluvium but also some underlying bedrock. A composite sample taken from residual sediments and exposed bedrock after target soils were removed had concentrations of dissolved constituents similar to those of the removed sediments. Free water was observed issuing from Sub-area 3 once the excavation was complete. Flowing water collected from the area at its point of emergence had a field SC of 8,135umhos/cm. Hydrometrics recommends observing this area to determine if the flow is release from storage or part of a larger zone of perched groundwater. Samples should be collected if flowing water is present. Characterization of the

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March 5, 2013 (continued)			sample would be used to evaluate if it is part of a persistent shallow subsurface flow path of impacted water or if it is a naturally-occurring feature. If necessary, capture system options will be evaluated and implemented for water emerging from Sub-area 3. The existing culvert in the diversion dam was lowered to allow surface water to run freely down the drainage; however, observations made to date indicate that no surface water has passed beyond the SFCC Diversion Dam during early spring runoff. The invert of the culvert will be plugged until the source of flowing water at Sub-area 3 is characterized, and if necessary, until a capture system is in place.
March 18, 2013	Interim Report – Investigation and Capture System Construction North of 1079A-Trench	Update status of activities conducted to investigate the possibility of a flow path between shallow bedrock north of the 1079A-Trench and alluvium at well 559A.	Task 1 – Three monitoring wells (1146D, 1147D, and 1148D) were installed. Each of the three new wells was advanced to shallow bedrock. Total depths ranged from 63 to 82 feet bgs. Task 2 –Groundwater samples were collected at each of the new wells and analyzed for a list of parameters commonly used by PPLM to evaluate water quality and identify possible process water impacts. Based on the results, wells 1146D and 1147D are not impacted by process water, but water quality at well 1148D is suggestive of process water impacts. Task 3 – Groundwater samples were collected and analyzed for hydrogen and oxygen isotopes at existing wells: 1073A-Trench, 1078D, 1120C, 1123A, 1130D, and 1131D. Task 4 – Conversion of well 1127D to a capture well has been initiated. Task 5 – Evaluation of Well 1121D – Although 1121D is apparently impacted by process water, conversion was not imminent due to low well yield. Impacted groundwater at well 1148D is consistent with the hydrostratigraphic interval monitored by well 1121D; but 1148D has higher yield. Well 1148D is currently under conversion and will be started simultaneously with 1127D. A complete startup evaluation will be conducted, including observation of water levels in well 1121D.
April 2013	Monitoring Well Installation and Investigation in the 1068A and Drain Pit #5 Areas, Hydrometrics, Inc.	Final report on well installation, sampling, and testing that targeted shallow groundwater downgradient of capture well 1068A and Drain Pit #5.	An evaluation of groundwater in shallow bedrock west of capture well 1068A and north/northeast of Drain Pit #5 was conducted by installing, testing, and sampling six new wells. Each of the six wells drilled during this investigation were found to be un-impacted by process water. Pursuant to this finding, it is recommended that wells 1140D, 1141D, 1142D, 1143D, 1144D, and 1145D should be sampled and monitored at PPLM's typical operational frequency. No additional analysis was recommended at these wells unless marked changes in water quality occur.
April 17, 2013	Evaluation of 2012 Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System Colstrip Steam Electric Station Colstrip, Montana, Hydrometrics, Inc.	Annual Water Resources Report	Work activities conducted in the 3&4 EHP in 2012 included: • Monitoring wells 1140D, 1141D, 1142D, 1143D, and 1144D were installed near Drain Pit# 5. • Monitoring wells 1146D, 1147D and 1148D were installed northeast of the Units 3&4 Saddle Dam. • Monitoring wells 1127D and 1148D were converted to groundwater collection wells • Monitoring wells 1149M, 1150A, 1151M, and 1152D were installed in the South Fork Cow Creek. • Unconsolidated sediments were sampled and removed from the SFCC Diversion. • 638C was abandoned during dam construction. Groundwater capture/containment was conducted at 85 sites in 2012 in the Units 3&4 EHP area. Of these 85 sites, 76 are capture wells, seven are interception trenches and two are dam sumps. Surface water sites CC3 and CC4 were sampled, the other sites were dry. Water quality was within historical ranges observed at these sites.

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April 17, 2013 (continued)			Observed changes in water quality North of the Units 3&4 Main Dam were: • 552D, 619D, 644D, 645D (capture wells) – bromide concentrations of greater than 10 mg/L were observed at these wells. • 607A – water quality declined, but boron concentrations decreased. • 604A, 605A-2 (collection wells) and 620D-P - bromide concentrations greater than 10 were observed at these wells. • 613D (collection well) – sulfate and chlorine concentrations increased; bromide concentrations of greater than 10 mg/L were observed. • 623D and 624D - concentrations of all indicator parameters increased in 2012 when compared to the previous three year average. • 625A and 626S – water quality improved to levels observed when wells were installed. • 1081D (collection well) – bromide concentrations reported for this well were greater than 10 mg/L • 1082D – water quality has declined since installation in 2009. Groundwater capture is occurring to the east and west of this low yield well. • 1084A (collection well) – water quality declined in 2012. • 1087D (collection well) – boron concentrations increased. • 1091D – water quality continued to improve. • 1115D (collection well) – bromide concentrations greater than 10 mg/L were reported. • 1116D – bromide concentrations greater than 10mg/L were reported. • 1119D – water quality has shown an improvement since the well was installed. • EAP-514 – boron concentrations declined slightly in 2012. • 1128D (collection well) – bromide concentrations greater than 10 mg/L were observed in 2012. Groundwater collection systems were originally installed in the Units 3&4 EHP Saddle Dam Area to address impacts from a dam leak that occurred in December 1999 were operational throughout 2012. Groundwater quality changes or trends observed at wells in the Saddle Dam Area during 2012 monitoring are as follows: • Wells 565D, 566D and 576D showed declining water quality; • 646D (collection well) – water quality improved; • 648D (collection well) – boron concentrations increased in the fall sample; and • Water quality improved at wells 646D, 662D and spring 14. Capture systems continued to operate in the 560A in 2012. Water levels have dropped below the total depth of completion at wells 1051A, 1062D, and 1112D since pumping began. Groundwater quality trends observed in the 560A area during 2012 are noted below. • 1095D (collection well) – water quality declined. • 1109D, 1113D, 1093D, 1097D, 1098D, 1099D, 1100D, 1101D, 1102D, 1127D (collection wells) – water quality improved at all of these capture wells in 2012. • 560A Trench – overall water quality has shown a gradual improving trend since installation. • 1051A (Trench) – this collection trench has been dry, or contained insufficient water to collect a sample, since 2010. Groundwater capture on the west side of the 3&4 EHP continued through 2012 at the well 656R system. Note that capture rates have diminished greatly since the system was started; suggesting the volume of impacted groundwater in this area is being reduced. Interception trenches SP-15 South and SP-15 North were installed in 2002 to collect impacted groundwater

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DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
April 17, 2013 (continued)			in the area west of the Units 3&4 EHP. The overall volume of water captured at the SP-15 interception trenches has decreased annually since startup of the systems. This reduction is likely due to increased groundwater capture at upgradient capture wells adjacent to the slurry wall (well 1031R Area) and revised pond management practices. A break in the fly ash slurry pipeline occurred in December 2010. PPLM responded by containing the spill and placing impacted water in Drain Pit 5. Changes in water quality observed at WA-145 and WA-222, located downgradient of Drain Pit 5 prompted the installation of pumps in these wells in 2011; in addition, PPLM installed a synthetic liner in Drain Pit 5 in 2011. Collection pumps were removed from WA-145 and WA-222. Additional groundwater investigation was conducted downgradient of both Drain Pit #5 and capture well 1068A in 2012. The investigation included installing, sampling, and aquifer testing six shallow bedrock wells (1140D, 1141D, 1142D, 1143D, 1144D, and 1145D). None of the wells appeared to be impacted by process water. Water quality trends, or changes, observed in the Units 3&4 EHP west side area in 2012 included the following. • EAP-515 – concentrations of chemical constituents, except boron, have shown an increasing trend for several years, a trend that continued in 2012. • 640P and 641P– water quality declined; and bromide concentrations greater than 10 mg/L were observed. • 642P, 1035R, and1036R – water quality continues to exhibit apparent impacts at these wells; however, concentrations of chemical constituents have declined significantly since initiation of capture at 1031R, 1034R and 1037R. • 656R, 1031R, 1034R, and 1037R (collection wells) – water quality has improved since 2007. Bromide concentrations at 656R and 1034R were greater than 10 mg/L. Downgradient water quality has also shown improvement. • 1068A (collection well) – water quality improved. • 1071D – overall water quality declined. Groundwater is being captured downgradient of this well.SP-15 South (interception trench) – water quality improved at this trench. Capture systems operated throughout 2012 in the SFCC, West Seep, and south of the 3&4 EHP.
May 2013	2012 Hydrologic Water Quality Study of Cow and Pony Creek Drainages, Rosebud County, Montana. Pacific Northwest National Laboratory (operated by Battelle)	Study objectives are 1) to determine whether there were changes in water quality and hydrological parameters downgradient of the 3&4 EHP on Genie Land Company property since the 1985–1986 baseline study was completed and 2) establish the current characteristics and conditions of water quality and hydrological parameters so that effects of any ongoing or future events associated with the EHP can be evaluated.	Continuous monitoring probe measurements in well PW 736 show a sustained decrease in specific conductance since the probe was installed in December 2010. The 2012 probe data show fluctuations in temperature and water levels that appear to be related to precipitation events and aquifer recharge. Groundwater levels measured in the alluvial wells in 2012 averaged about 0.8 ft. lower than the levels measured in June and September 2011. The decrease in groundwater levels in the alluvial wells was likely caused by lower precipitation in 2012 compared to the higher than average precipitation in 2011 and 2010. Overall, the 2012 groundwater levels do not indicate any major changes in groundwater flow patterns for Cow Creek and South Fork Cow Creek. Statistical analyses of SC, sulfate, and boron data identified two site-level and two drainage-level trends where water quality had changed from previous years. Statistically significant increasing drainage-level trends were found for conductivity and sulfate at South Fork Cow Creek. At the site level, Pony Creek had statistically significant increases in conductivity at Genie spring (GSP) 4 and Genie old well (GOW) 4 These findings do not indicate any definitive impacts on groundwater quality from the operations of the effluent holding pond.

TABLE 3-2
SUMMARY OF WORK CONDUCTED AND FINDINGS
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3 & 4 EFFLUENT HOLDING POND

DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
September 9, 2013	Addendum – South Fork Cow Creek Diversion Sediment Removal. Technical Memorandum from Hydrometrics to PPLM	Report of follow-up water sampling after sediment removal at the SFCC Diversion Dam.	Upon removal of approximately 320 cy of sediments, free water was observed issuing to the drainage above the diversion dam. A water quality sample was collected; results of which indicated probable process water impacts. SC, TDS) sulfate, boron, and chloride concentrations in the sample were 7,130 µmhos/cm, 7,900 mg/L, 5,290 mg/L, 6.42 mg/L, and 88 mg/L, respectively. Staff from the Colstrip-SES environmental department tracked the source of the impacted water to a leaky unused pipeline up-gradient of the SFCC Diversion Dam. Specifically, the leak originated at a valve housed below ground in a vault constructed of corrugated metal pipe (CMP). The leaks were repaired and the valves and CMP vault were removed. This addendum serves as the final report on activities conducted under the Work Plan *SOUTH FORK COW CREEK DIVERSION SEDIMENT REMOVAL.*

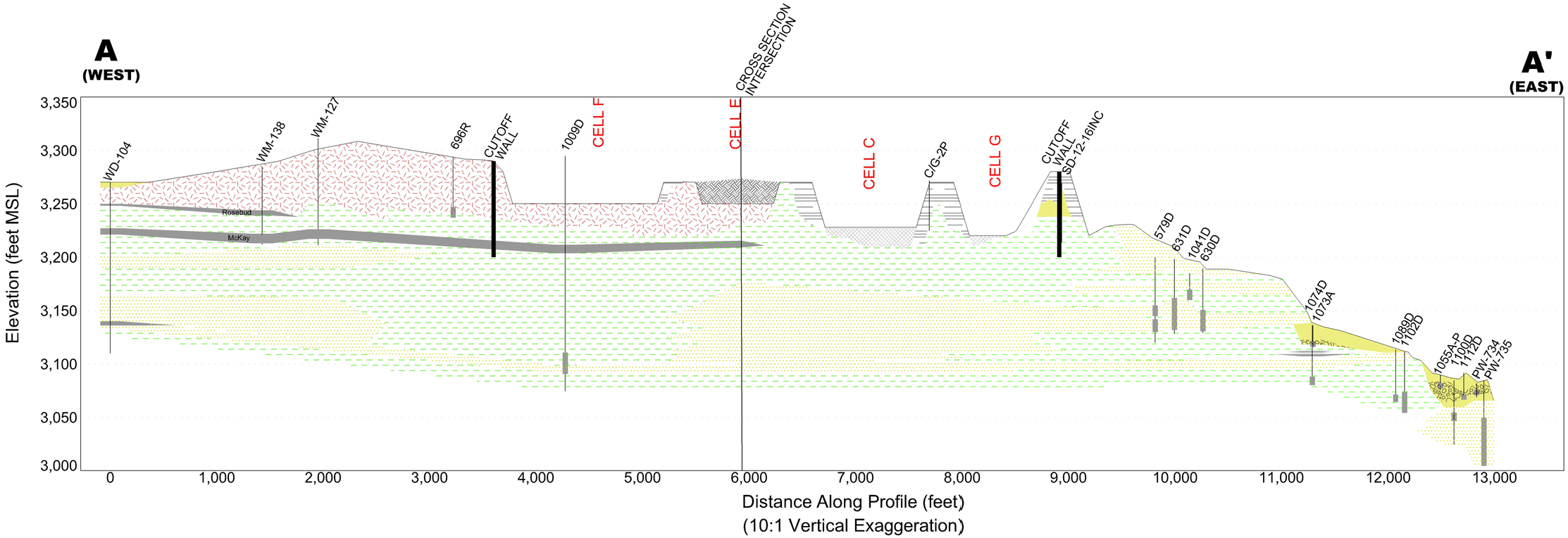
3.4.1 Site Hydrogeology

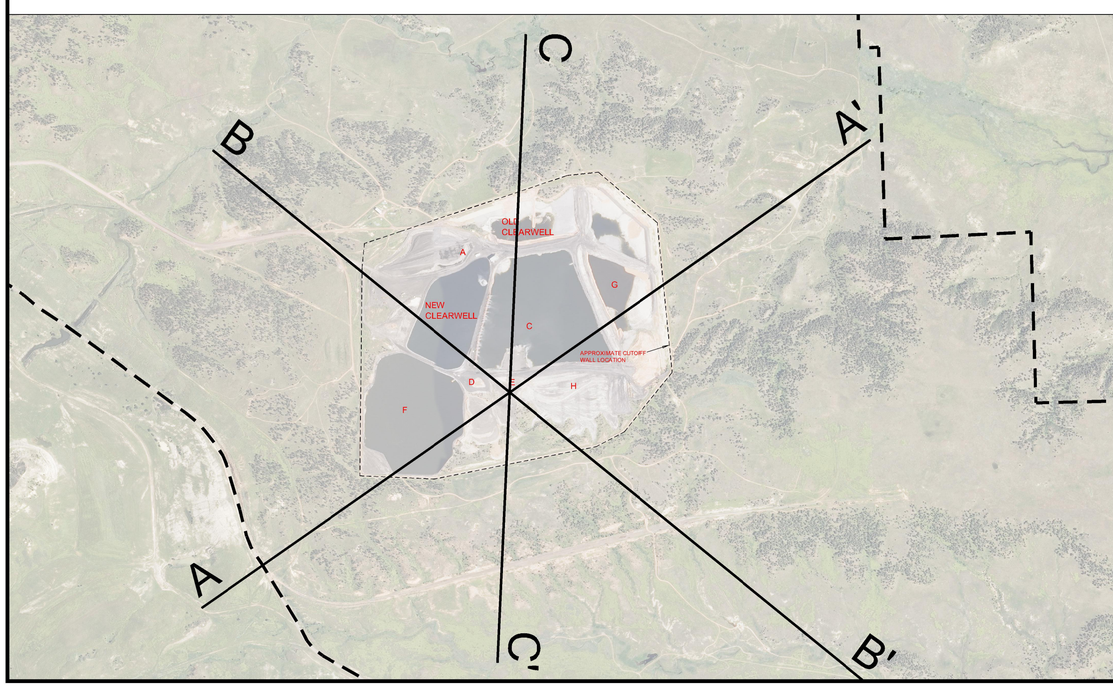
Geology in the 3&4 EHP area generally is mainly comprised of shallow overburden bedrock, Rosebud and McKay Coal, clinker, and various deeper strata of the Fort Union Formation. Colluvium blankets the slopes in many areas and may grade into alluvial deposits which inhabit many of the drainage bottoms. Spoil associated with area coal mining are also upstream of the 3&4 EHP area in upper Cow Creek and South Fork Cow Creek (SFCC). Cross sections illustrating strata of the 3&4 EHP area are presented on Figures 3-1, 3-2 and 3-3 (Section 3.4.1.1). Monitoring well, capture well, and capture trench locations are shown on Figure 3-4. A general description of these deposits in approximately descending order follows.

- Alluvium – These deposits are present in drainage bottoms in the 3&4 EHP area. Major deposits are found in Cow Creek and SFCC. Minor alluvial deposits are also present in some of the drainages tributary to Cow Creek and SFCC and the drainage below the 3&4 EHP Main Dam Valley Drain Sump.

  Alluvial deposits in the 3&4 EHP consist of various mixtures of clay, silt, sand, and gravel. Thin deposits of basal gravels, overlying the bedrock contact, are present in the larger valleys of Cow Creek and SFCC. However, basal gravel deposits are generally absent in the smaller drainages except in isolated cases. Gravel generally grades upward into poorly sorted sands and silts, as is characteristic of ephemeral channel and floodplain depositional environments. Nearer surface deposits include silty clay to clayey silt that are generally gradational with colluvium that lines the valley margins and blankets much of the valley bottoms. The result is an overall fining-upward (with respect to grain size) sequence.

  Alluvial deposits typically exhibit lenses of coarser-grained deposits embedded within finer matrices, as the coarsest materials are deposited during higher energy water flow events and finer materials are deposited by shallower, lower energy water. Periodic storm events result in short term high flows that deposit coarse gravel and





NORTH

SCALE
(In Feet)
1200 0 1200 2400 3600
(Approximate Only)

UNITS 3 & 4 EFFLUENT HOLDING POND AREA BOUNDARY

CROSS SECTION LINE

LEGEND

- COLLUVIUM/ALLUVIUM
- FLY ASH
- GRAVEL
- SANDSTONE
- COAL
- DIVIDER DIKE
- CLINKER
- SHALE
- FILL

696R — WELL DESIGNATION

MONITOR WELL

SCREENED INTERVAL

TOTAL DEPTH OF HOLE

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PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT

GEOLOGIC CROSS SECTION A-A'

DRAWING FILE NUMBER
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AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-1

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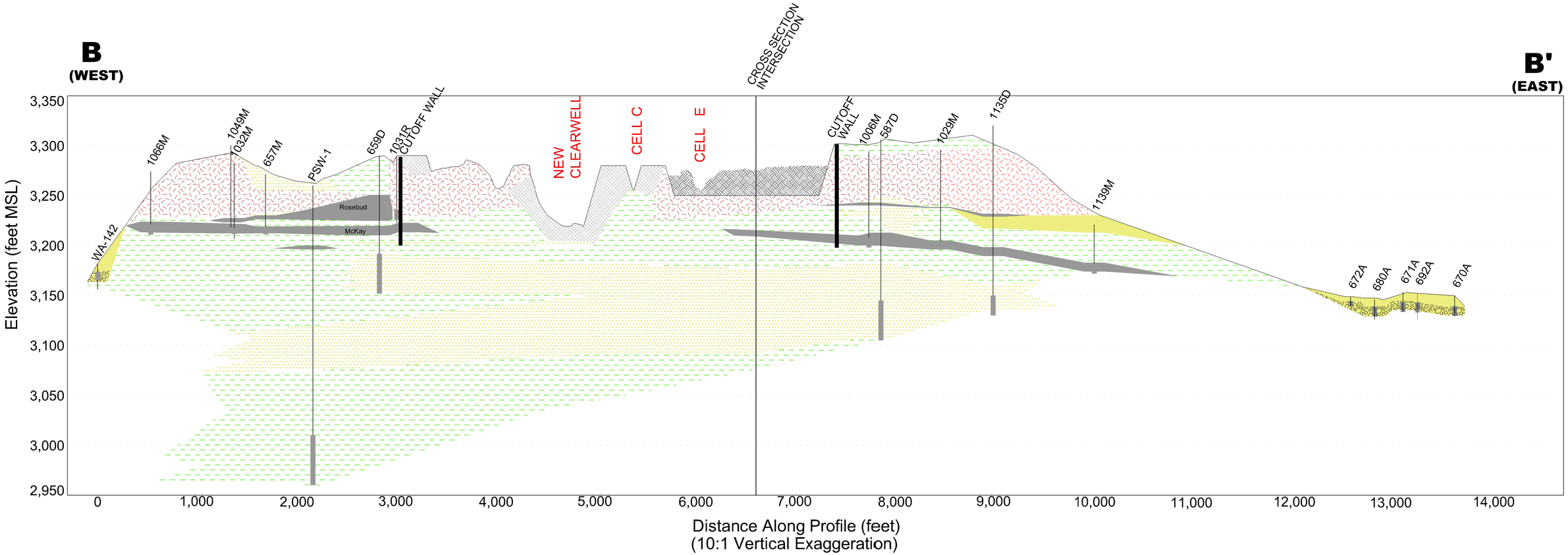

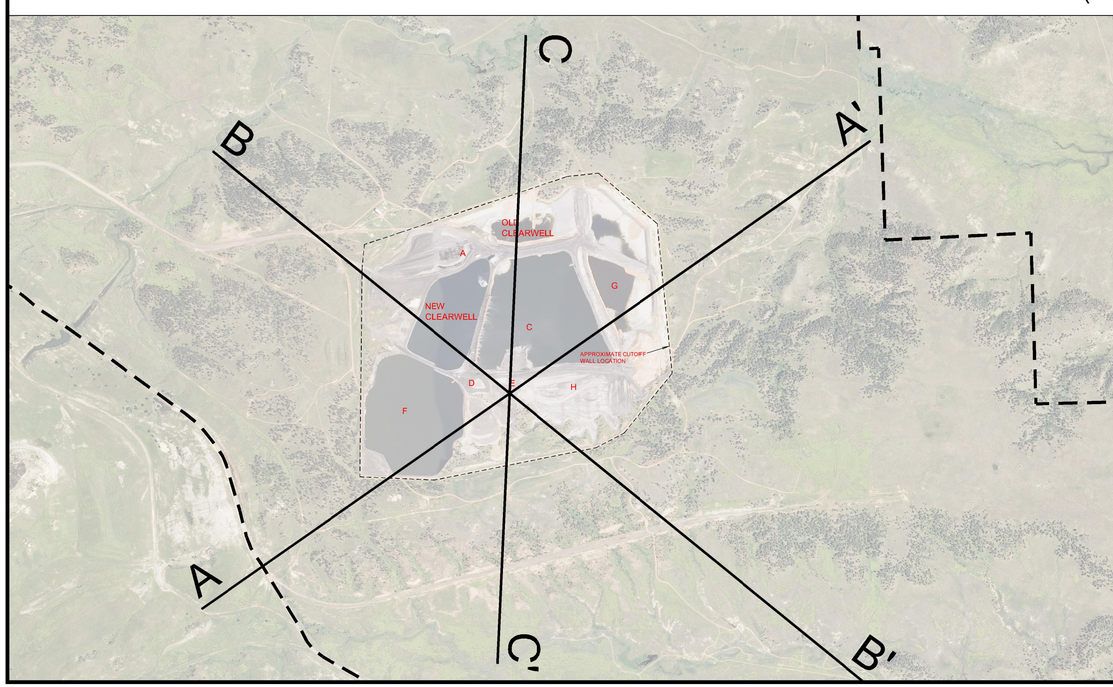

NORTH

SCALE
(In Feet)
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(Approximate Only)

UNITS 3 & 4 EFFLUENT HOLDING POND AREA BOUNDARY

CROSS SECTION LINE

LEGEND

- COLLUVIUM/ALLUVIUM
- FLY ASH
- GRAVEL
- SANDSTONE
- COAL
- DIVIDER DIKE
- CLINKER
- SHALE
- FILL

1006M — WELL DESIGNATION

MONITOR WELL

SCREENED INTERVAL

TOTAL DEPTH OF HOLE

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GEOLOGIC CROSS SECTION B-B'

DRAWING FILE NUMBER
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AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-2

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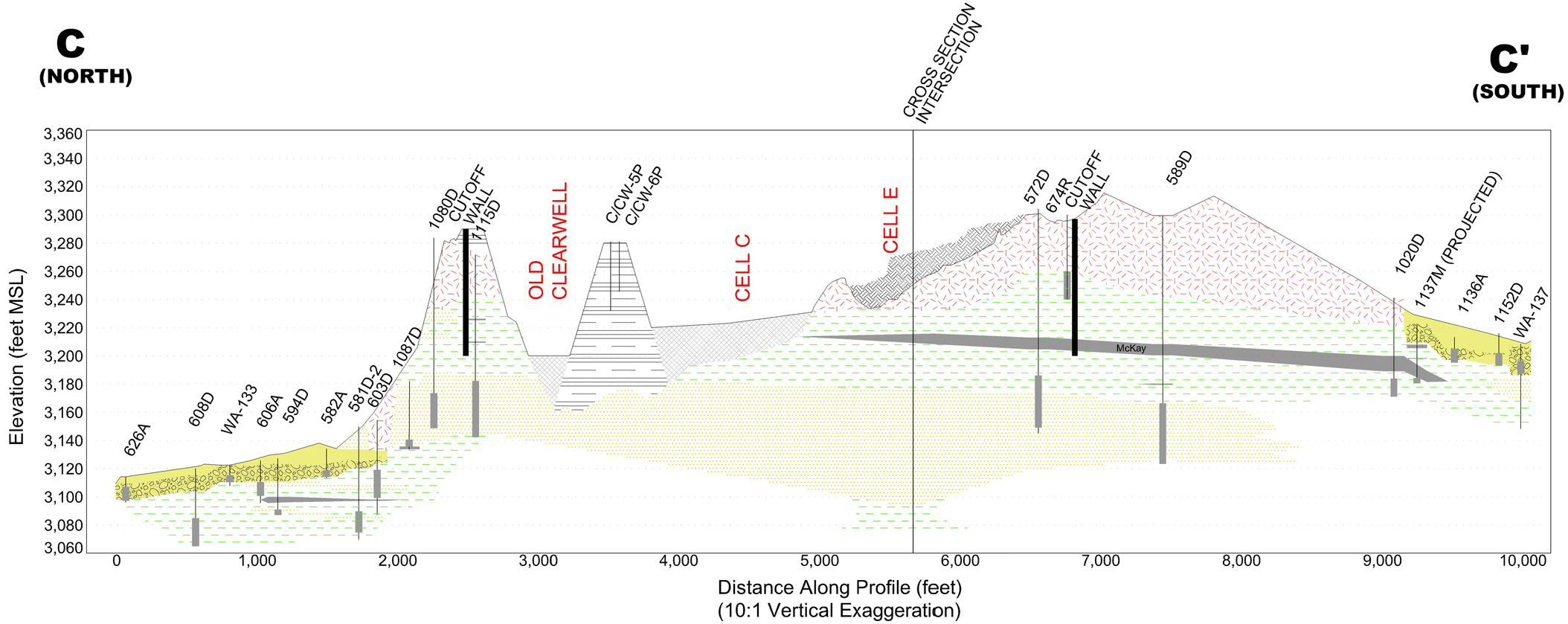

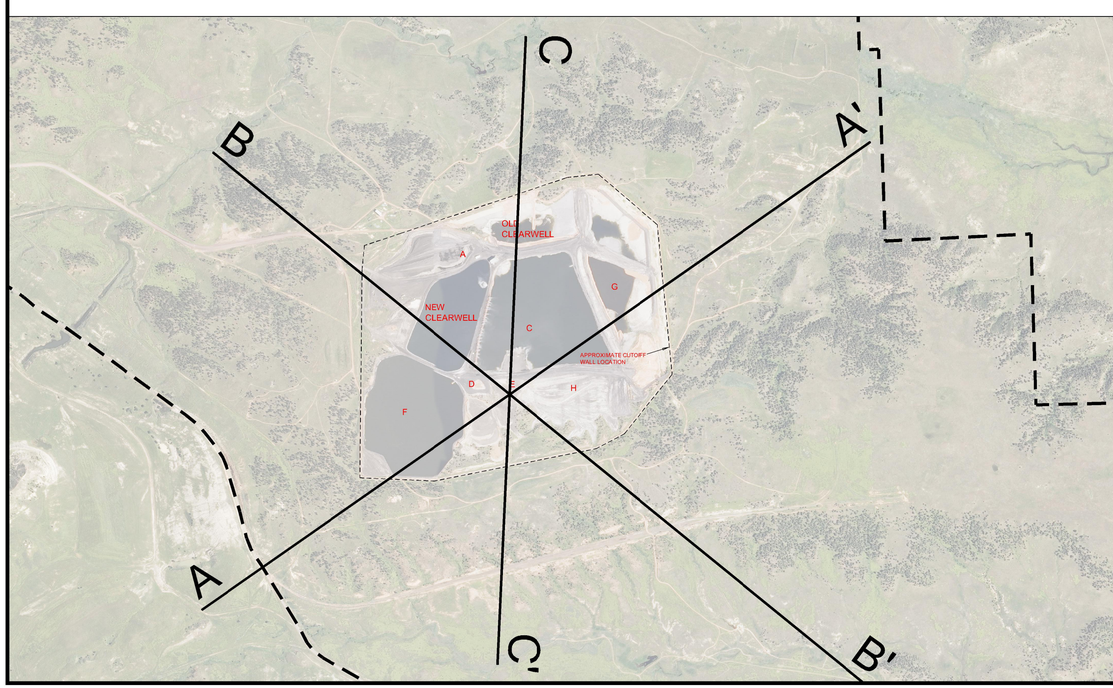

NORTH

SCALE
(In Feet)
1200 0 1200 2400 3600
(Approximate Only)

UNITS 3 & 4 EFFLUENT HOLDING POND AREA BOUNDARY

CROSS SECTION LINE

LEGEND

- COLLUVIUM/ALLUVIUM
- FLY ASH
- GRAVEL
- SANDSTONE
- COAL
- DIVIDER DIKE
- CLINKER
- SHALE
- FILL

572D — WELL DESIGNATION

MONITOR WELL

SCREENED INTERVAL

TOTAL DEPTH OF HOLE

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GEOLOGIC CROSS SECTION C-C'

DRAWING FILE NUMBER
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AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-3

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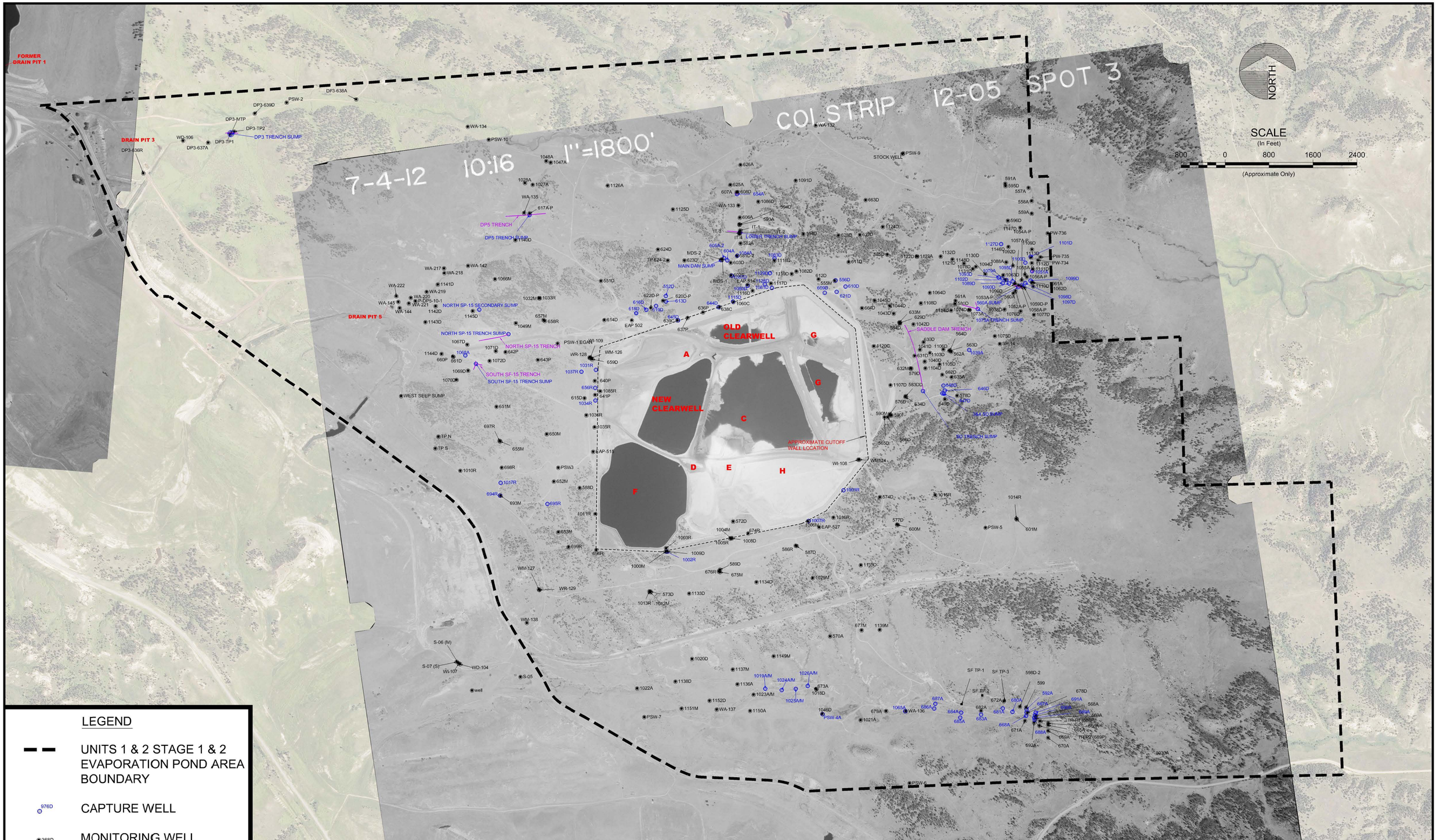

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UNITS 3 & 4
EFFLUENT HOLDING POND AREA
CAPTURE AND MONITORING WELLS

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AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-4

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sand within the channel and flooding results in deposits of silt and clay in quiescent areas. These deposits are apparent downgradient of the 3&4 Main Dam Valley Drain Sump, where multiple thin, discontinuous coarser lenses were observed at different elevations and at different locations across the drainage.

Deposition during lower energy events result in finer grain materials surrounding the coarser grained material. Migration of the valley channel during depositional times resulted in deposition of coarser grained materials in the finer groundmass.

Rock fragments observed in the coarser grained deposits are typically angular to sub-rounded and are mostly comprised of clinker. The presence of the highly erodible and easily weathered clinker is indicative of the near source deposition which occurred.

Hydraulic conductivity of the alluvium varies greatly and is a function of overall grain size, size of the interstitial spaces, grain orientation, and degree of cementation, if any. Alluvium with relatively large grain sizes, good connection between larger pore spaces, consistent grain orientation, and limited cementation exhibit higher permeability. In general basal gravels exhibit higher permeability than overlying sediments that exhibit mixing of grain sizes and lower overall grain sizes. Conversely, lower permeabilities are associated with small overall grain size, poor interconnection of pore spaces, and random grain orientation. Monitoring wells completed in the alluvium are designated with an “A”.

- Colluvium – Colluvium is a deposit of sediments which have been transported downslope by gravitational means to the point of deposition. In the 3&4 EHP, colluvium is most often a silty clay or clayey silt composition, although coarser rock fragments or deposits may be present locally. Colluvium deposited on the valley slopes tends to grade laterally into the alluvium at the valley margins. Colluvium also tends to be in gradational contact with underlying weathered bedrock when alluvium is absent. Because of the stratigraphic position near ground surface and the

general fine grain size of particles, hydraulic conductivities are typical very low and little groundwater is transmitted. Probably the most significant contribution of colluvium in the Colstrip area is storage for precipitation water, which is released at varying rates to provide recharge to adjacent alluvial deposits and/or or springs.

- Rosebud overburden – Bedrock units of the Fort Union Formation are comprised of siltstone, claystone, shale, and fine-grained sandstone that typically overlay Rosebud Coal. In the majority of the 3&4 EHP area, the Rosebud Coal has been partially or completed burned. As this happened, sediments in the Rosebud overburden were altered to form clinker (see next bullet). Wells labeled with an "S" are generally completed in this unaltered overburden directly above the Rosebud Coal or in interburden, where the Rosebud has been removed. Yield of the shallow intervals are variable and are typically related to grain size and a supply of water to provide recharge. Wells with shallow local recharge typically exhibit low yields while those connected to recharge boundaries provide higher yield.
- Clinker – Also referred to as scoria, porcelanite (when semi-vitrified), and baked shale; clinker is comprised of thermally altered and collapsed overburden (sandstone, siltstone, shale, etc.) formed by the in situ burning of previously underlying coal. The degree of thermal metamorphosis varies depending on the temperature of the burn, thickness of the overburden, vertical fracture patterns, moisture, and duration of burn. As the coal burned, its volume decreased. As this occurred, or some period of time after burning concluded, the overburden collapsed into the void left by the burned coal. The result is a moderate to highly fractured interval of metamorphosed sedimentary rock. Ash layers and/or layers of unburned coal remain at the base of the clinker. Substantial amounts of clinker occupy the hilltops south of the 3&4 EHP. A bentonite amended concrete cutoff wall was installed around the perimeter of the 3&4 EHP, through clinker deposits and into intact underlying bedrock, to inhibit horizontal flow of water from the pond. Hydraulic conductivity in the clinker may exceed 2,500 ft/day due to its coarse grain size, interconnected pore space, and parallel orientation of rock fragments and gravels. Clinker is typically well drained due to the high permeability. Wells completed in clinker are designated with the coal

that the interval correlates with. For example, if the well is completed to the base of the former Rosebud Coal interval, it is designated with an "R".

- Rosebud Coal – Cleated coal with thickness on the order of 20 to 25 feet. This coal has burned in most of the 3&4 EHP near the pond, leaving clinker and ash in its place. Rosebud Coal typically exhibits a relatively low hydraulic conductivity on the order of one to three feet per day. Wells completed in the Rosebud Coal or clinker occupying the former coal interval are designated with an "R".
- Spoil – Spoil consists of silt, clay, sandstone, coal fragments, and formerly overburden units that were removed and have been used to backfill areas where the Rosebud Coal was mined. Spoil is not present in the 3&4 EHP except in small isolated areas where test mining was conducted. Spoil is present in the headwaters of Cow Creek and SFCC, upstream of the 3&4 EHP area. Hydraulic conductivity of spoil units is highly variable. Areas with large rock or grain fragments situated near the base of backfilled pits may exhibit high permeability. More commonly, fine grained materials fill these pore spaces, resulting in lower hydraulic conductivity.
- Interburden – Typically comprised of siltstone and claystone which separate the Rosebud and McKay Coal seams. Interburden is present directly above the McKay Coal (when present) and is either in contact with clinker or the Rosebud Coal (if present). The thickness of the interburden is highly variable, ranging from about one foot northwest of the pond, 13 feet northeast of the pond, and 29 feet or more south of the pond. Hydraulic conductivity of the interburden is variable depending on lithology. The interburden typically contains a shale or claystone layer that inhibits downward, or upward, flow of groundwater.
- McKay Coal – Cleated coal with the thickness of the coal in the 3&4 EHP of about typically 7 to 10 feet thick. The McKay Coal is present around much of the perimeter of the 3&4 EHP, and under the pond in parts. However, the coal has been removed by erosion in the center of the pond and has undergone various degrees of burning in other areas. The McKay Coal is typically a complete, unaltered, unit along the southeast, south, and west sides of the pond. The McKay is highly altered along the north and northeast of the pond. The bentonite amended concrete cutoff wall was installed through the McKay Coal into tight intact bedrock on the north and east sides

of the pond. The base of the bentonite amended concrete cutoff wall is higher than the McKay Coal on the south and east sides of the pond. The McKay Coal has been eroded away in the immediate vicinity of the 3&4 EHP at elevations below about 3,200 feet. Hydraulic conductivity in the coal is typically on the order of one to three feet per day. Wells completed in the McKay Coal or burned remnants/clinker correlative with the McKay Coal are designated with an "M".

- Sub-McKay – Fort Union strata consisting of interbedded claystone, siltstone, fine-sandstones, and thin coal seams. Channel sands are not uncommon resulting in numerous lateral sedimentary facies changes. These depositional changes result in rapid variations in thickness and limit the lateral continuity of units. Sandstone is typically un-cemented or poorly cemented with calcium-carbonate. Hydraulic conductivity of the sub-McKay unit is variable and is dependent on the amount of interconnected pore space, cementation, and grain size and grain orientation.

3.4.1.1 Bedding Orientations

Cross sections shown on Figures 3-1, 3-2, and 3-3 help illustrate the orientation of stratigraphic units in the 3&4 EHP, the laterally discontinuous nature of lithology, and the variation in the presence or absence of coal.

Cross section A-A' (Figure 3-1) was constructed approximately perpendicular to local strike direction (up or down dip). As can be seen, a small unburned portion of the Rosebud Coal is present on the southwest end of the cross section, but is otherwise absent. Clinker has been formed over the remainder of the area. Both the coal and clinker have been eroded in the middle of the pond. Sub-McKay strata consist generally of laterally discontinuous deposits of siltstone/sandstone and shale.

Cross section B-B' (Figure 3-2) was constructed generally perpendicular to local strike direction. A slight high, forming a soft anticline, are centered over the northwest portion of the pond. Beds dip to the northwest on the northwest portion of the section and southeast on the southeast half of the cross section. A complete section of Rosebud Coal and McKay Coal is present at the northwest corner of the pond. However, the Rosebud is generally absent

over the remainder of the area and this interval has been replaced with clinker. Both the Rosebud and McKay stratigraphic intervals have been removed by erosion in the middle of the pond and at the extents of the cross section.

Cross Section C-C' (Figure 3-3) extends north and south through the 3&4 EHP. Alluvium is present, in contact with sub-McKay strata, at both the north and south ends. The Cow Creek alluvium is present on the north and the SFCC alluvium to the south. The Rosebud Coal is absent along the entire length of the cross section. Furthermore, it is eroded within the pond and at the north and south ends of the section. The southerly dip of the beds is illustrated in the section by the elevation decline of the McKay Coal from the pond to SFCC. The McKay Coal is absent at the north end of the cross section line.

3.4.1.2 Presence of Groundwater

Groundwater is present in the alluvium north of the 3&4 EHP Main Dam Valley Drain Sump, downgradient of the 3&4 Saddle Dam Valley Drain Sump, in Cow Creek, and in SFCC. Smaller volumes of water are present in drainages tributary to Cow Creek, including the one containing groundwater capture at the Drain Pit #3 Interception Trench and the Drain Pit #5 Interception Trench.

Clinker in the area typically contains very little, if any, water due to its high permeability and the orientation of the floor of the deposit. The natural occurrence of groundwater in clinker in the 3&4 EHP is typically isolated and is likely associated with local low points at the lower contact. Residual water may also be present from losses that occurred in, or around late 2004.

The McKay Coal contains a small amount of groundwater. Yield from monitoring wells completed in this unit are typically quite low, generally one to two gallons per minute or less.

Since the McKay Coal is eroded around its entire perimeter, it is not laterally continuous through the region.

Water is present in the sub-McKay strata at various depths. Wells completed in these units typically exhibit low yields but can vary from less than a half-gallon per minute to more than ten gallons per minute. Water quality is variable, but this unit is frequently used as a stock water supply source in the Units 3&4 EHP area.

3.4.2 Distribution of Indicator Parameters

Several indicator parameters are used to evaluate potential process water impacts to groundwater at the Plant. These include total dissolved solids (TDS), specific conductance (SC), dissolved boron, chloride, sulfate, and the ratio of calcium to magnesium concentrations. These parameters have been shown to be indicative of possible process water impacts and have been accepted as an evaluation method for water quality by PPLM and MDEQ. They are discussed in further detail below.

Draft baseline screening levels (BSLs) were calculated specifically for the 3&4 EHP for several indicator parameters (Exponent, 2011):

Specific conductance (SC)	Alluvium - 5,020 µmhos/cm Bedrock - 6,050 µmhos/cm McKay Coal – 6,870 µmhos/cm
Boron – Dissolved	Alluvium - 2 mg/L Bedrock - 2.5 mg/L McKay Coal – 10.6 mg/L
Chloride	Alluvium - 48 mg/L Bedrock - 29 mg/L McKay Coal – 36 mg/L
Sulfate	Alluvium - 3,350 mg/L Bedrock - 3,750 mg/L McKay Coal - 5,510 µmhos/cm

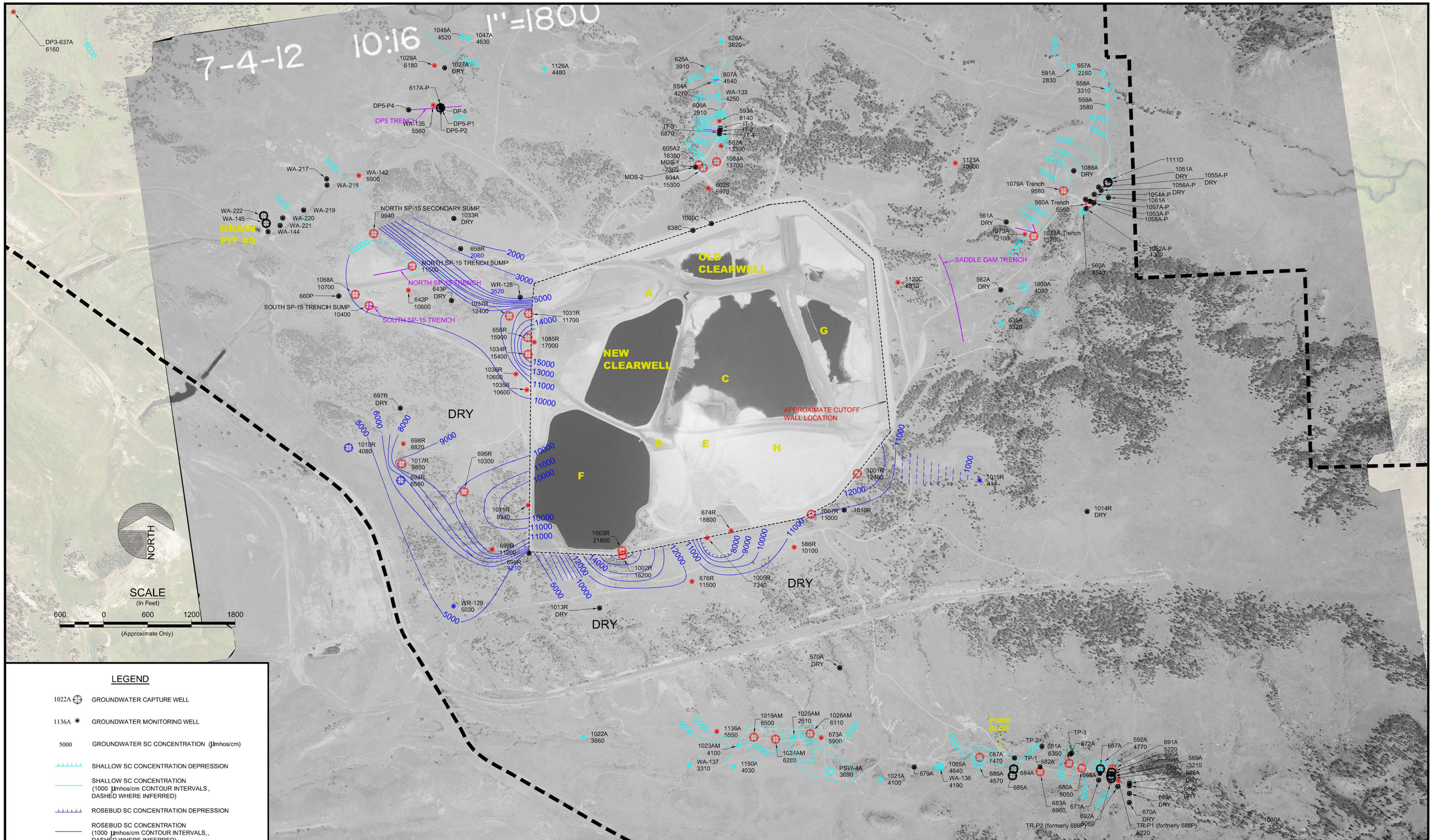
Specific conductance (SC) is a measure of waters ability to conduct an electrical current. SC shows a strong correlation to (TDS) total dissolved solids (Sterrett, 2007). Because SC is largely dictated by the ionic composition of groundwater it is a good indicator of overall water quality and is used as one of the indicators of possible process water impacts. As indicated previously, BSL's have been established for the various units. Figures 3-5 through Figure 3-13 show iso-contour maps for SC, dissolved boron, and chloride. Note also, that locations with concentrations exceeding the BSL's parameters are highlighted in red. Additional maps showing concentrations contours are contained in Appendix A.

Specific Conductance -- SC exceeding the BSL of 5,020 µmhos/cm for alluvium, is observed in the shallow stratigraphic units below the Main Dam Sump, northeast of the EHP, below the Saddle Dam, in SFCC, in Cow Creek below Drain Pit #5 and in alluvium tributary to Cow Creek below Drain Pit #3 (Figure 3-5). During fall 2012, the highest observations of SC in alluvium occurred in collection wells below the Main Dam Sump.

SC exceeding the BSL of 6,870 µmhos/cm for the Rosebud Coal/clinker was present in wells near the south and west sides of the 3&4 EHP cutoff wall. Northwest of the ponds the area of elevated SC extends about 2,000 feet from the EHP to the Northwest Secondary Sump (Figure 3-5). At this location, groundwater is moving from the Rosebud interval to the McKay Coal and alluvium. The only exceedance of the BSL for SC in the McKay Coal was observed southwest of the 3&4 EHP at well WM-127 (Figure 3-6).

The highest observed SC values in the sub-McKay units are found in the areas north and east of the 3&4 EHP, below the Main Dam, the Main Dam abutment and the Saddle Dam (Figure 3-7). The BSL for SC in bedrock is exceeded in multiple wells in these areas.

Boron – The highest concentrations of boron in the alluvium and shallow bedrock (including the Rosebud) are observed at wells completed in the Rosebud (clinker) just south of the pond and downgradient of the Main Dam. Other high concentrations of boron have been observed below the Main Dam Sump in the alluvial wells. Boron concentrations exceeding the BSL of



NOTE: SHALLOW AND COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR SC OF 5,020 AND 6,870 µMHOS/CM. VALUES ABOVE BSL ARE SHOWN IN RED

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2ND HALF 2012 SPECIFIC CONDUCTANCE IN SHALLOW AND ROSEBUD WELLS

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AUTOCAD 2000 DRAWING (DWG)
EXHIBIT
3-5

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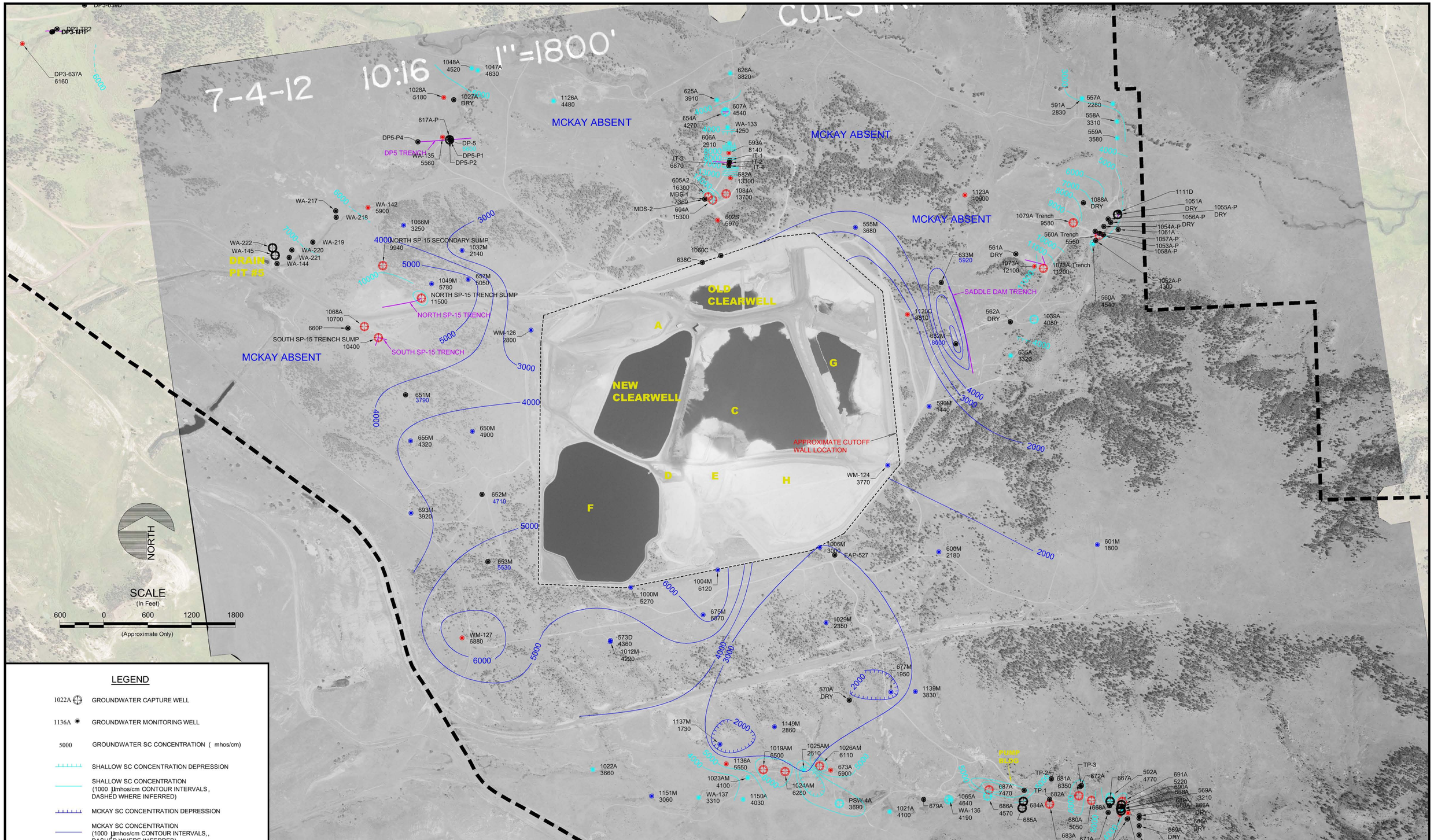

NOTE: SHALLOW AND COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR SC OF 5,020 AND 6,870 µMHOS/CM. VALUES ABOVE BSL ARE SHOWN IN RED

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2ND HALF 2012 SPECIFIC CONDUCTANCE IN SHALLOW AND MCKAY WELLS

DRAWING FILE NUMBER
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EXHIBIT
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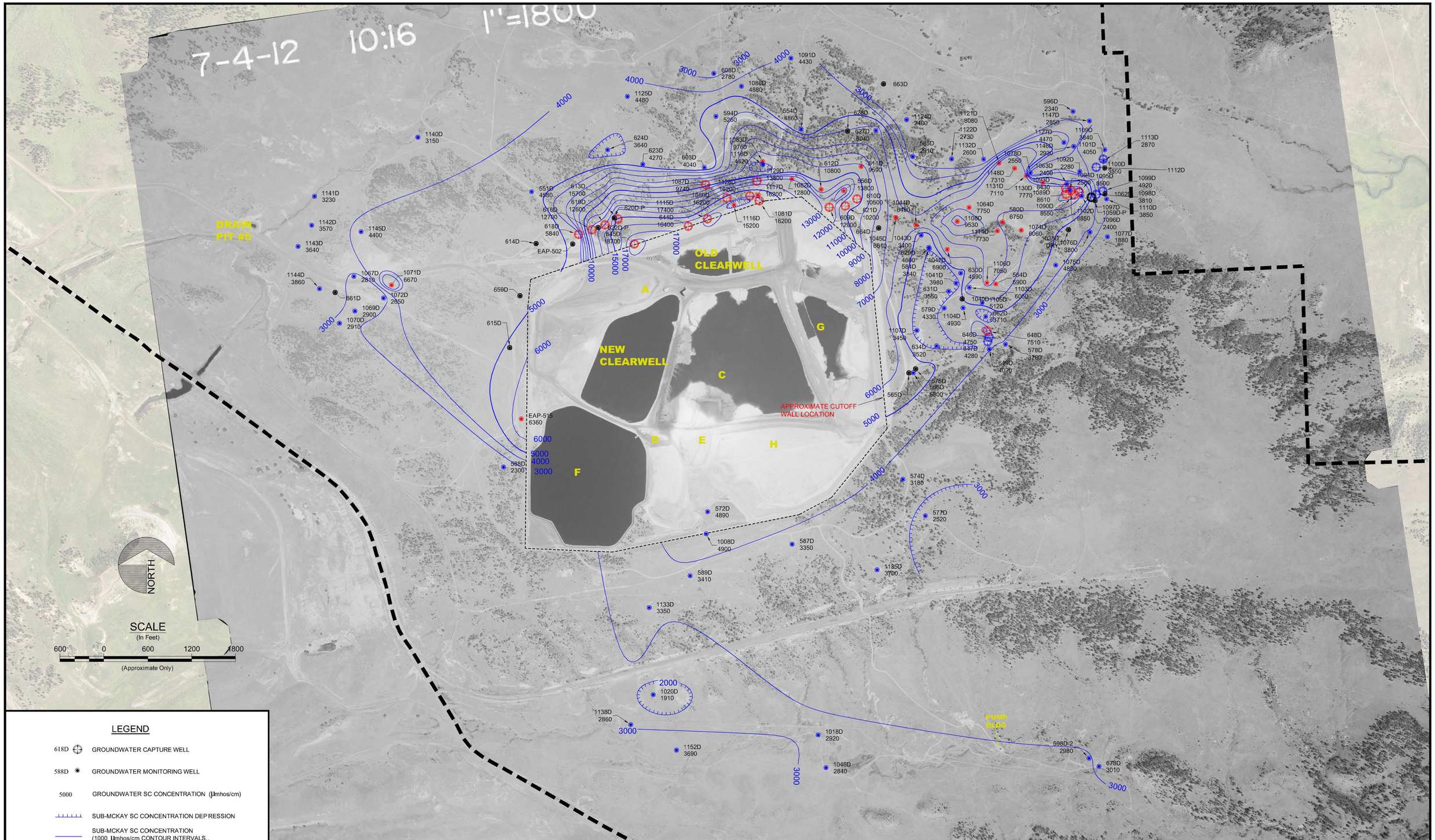

NOTE: SUB-MCKAY DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR SC OF 6050µMHOS/CM. VALUES ABOVE BSL ARE SHOWN IN RED

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PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT

2ND HALF 2012 SPECIFIC CONDUCTANCE IN SUB-MCKAY WELLS

DRAWING FILE NUMBER
1207300B005
AUTOCAD 2000 DRAWING (DWG)
EXHIBIT
3-7

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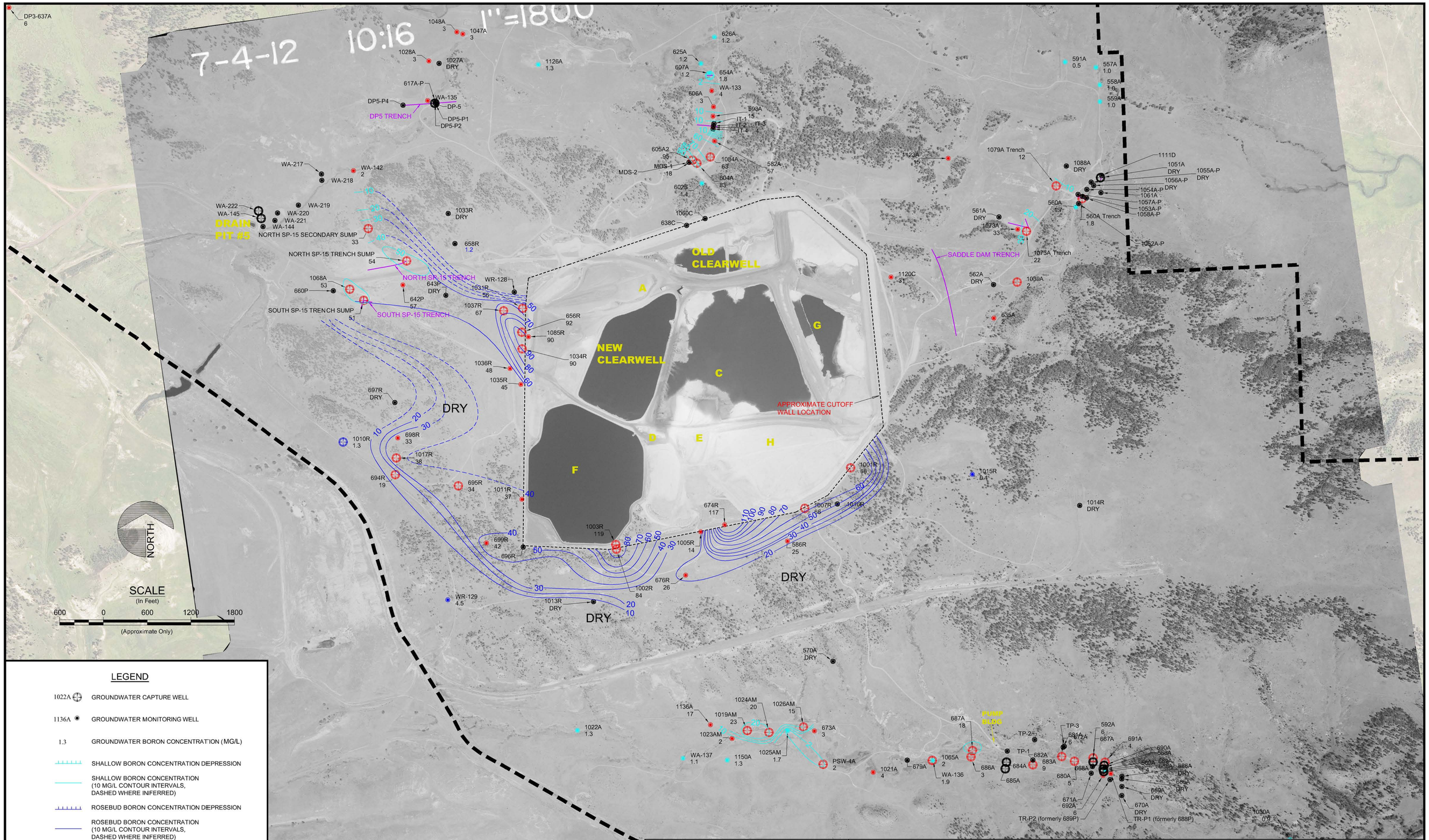
2 mg/L for the alluvium (Exponent, 2011) are present in the alluvium of Cow Creek and SFCC as well as alluvial deposits below the Main Dam, the Saddle Dam and in the Cow Creek tributary below Drain Pit #3 (Figure 3-8).

The boron BSL of 10.6 mg/L for coal is exceeded in wells completed in the Rosebud just south and to the west of the 3&4 EHP and in a clinker well (1120C) just east of the Saddle Dam.

McKay wells located west of the 3&4 EHP had concentrations of boron ranging from 1.6 mg/L to 4.9 mg/L boron in fall 2012. One McKay well, 675M, located south of the ponds, exceeded the BSL of 10.6 mg/L (Figure 3-9).

The highest concentrations of boron in sub-McKay units were observed in wells completed north, northeast and east of the 3&4 EHP, downgradient of the Main Dam, the Main Dam abutment and the Saddle Dam (Figure 3-10). The BSL was exceeded in several of these wells, with more than half of those completed as groundwater capture wells. Boron concentrations were generally less than 2 mg/L in sub-McKay groundwater south and west of the ponds, with the exception of 1145D, completed just downgradient of the SP-15 North Trench. This well had a boron concentration of 3 mg/L in fall of 2012.

Chloride – Chloride BSL's were calculated at 48 mg/L for alluvium and 29 mg/L for bedrock (Exponent, 2011). Chloride in the alluvium exceeded the BSL at alluvial wells in Cow Creek just downgradient of the Drain Pit #5 and just below Drain Pit #5. Multiple alluvial wells (mostly capture wells) in SFCC had chloride concentrations that exceeded BSL's in fall 2012. Alluvial deposits below the Main Dam and Saddle Dam also had chloride concentrations in excess of the BSL, with the highest concentration outside the cutoff wall observed just below the Main Dam Sump at collection well 606A-2 (Figure 3-11).



NOTE: SHALLOW AND COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) OF 2 AND 10.6 MG/L FOR BORON. VALUES ABOVE BSL ARE SHOWN IN RED

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2ND HALF 2012 BORON CONCENTRATIONS IN SHALLOW AND ROSEBUD WELLS

DRAWING FILE NUMBER
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AUTOCAD 2000 DRAWING (DWG)
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3-8

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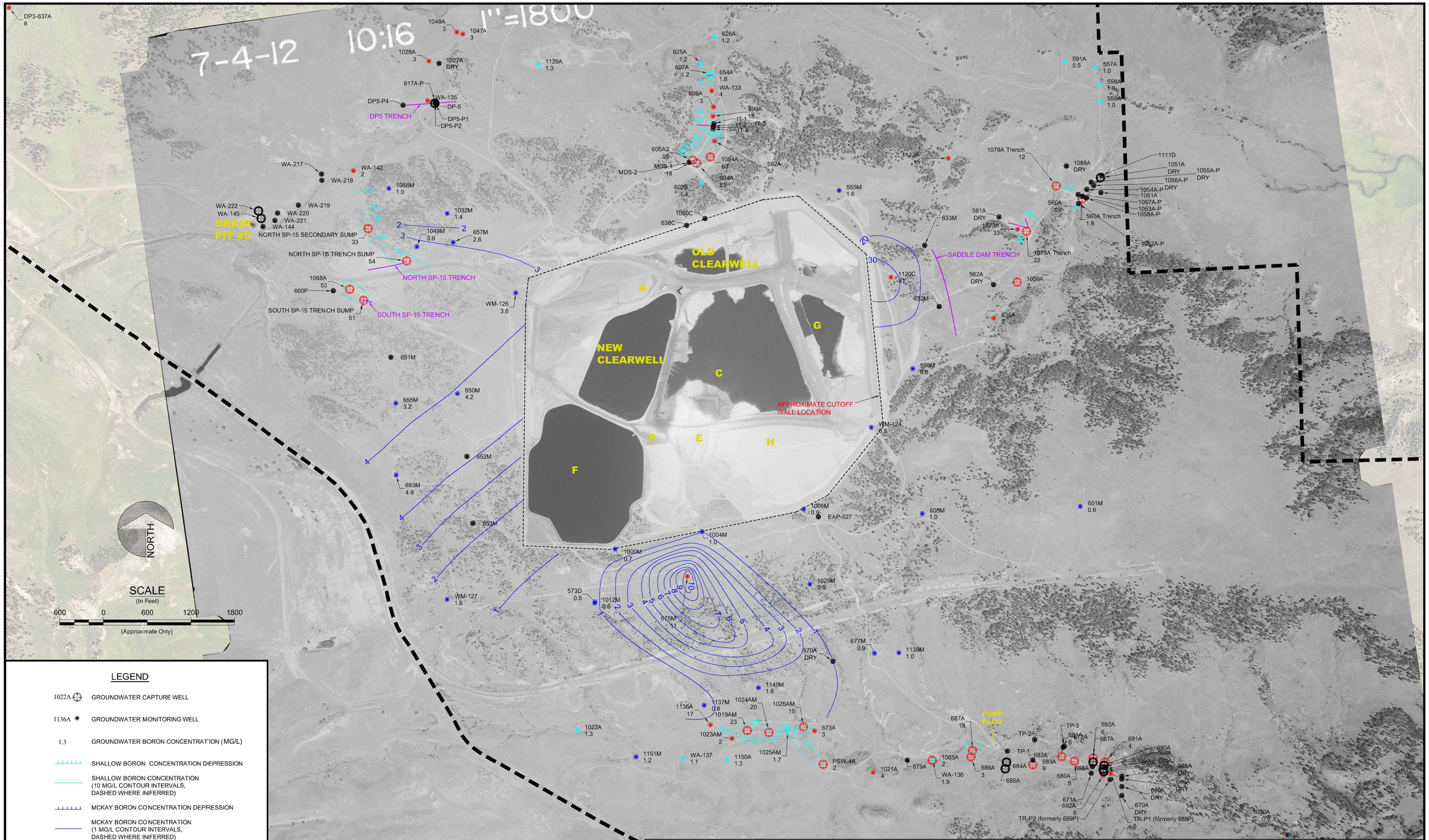

NOTE: SHALLOW AND COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) OF 2 AND 10.6 MG/L FOR BORON. VALUES ABOVE BSL ARE SHOWN IN RED

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2ND HALF 2012 BORON CONCENTRATIONS IN SHALLOW AND MCKAY WELLS

DRAWING FILE NUMBER
1207300B005
AUTOCAD 2000 DRAWING (DWG)
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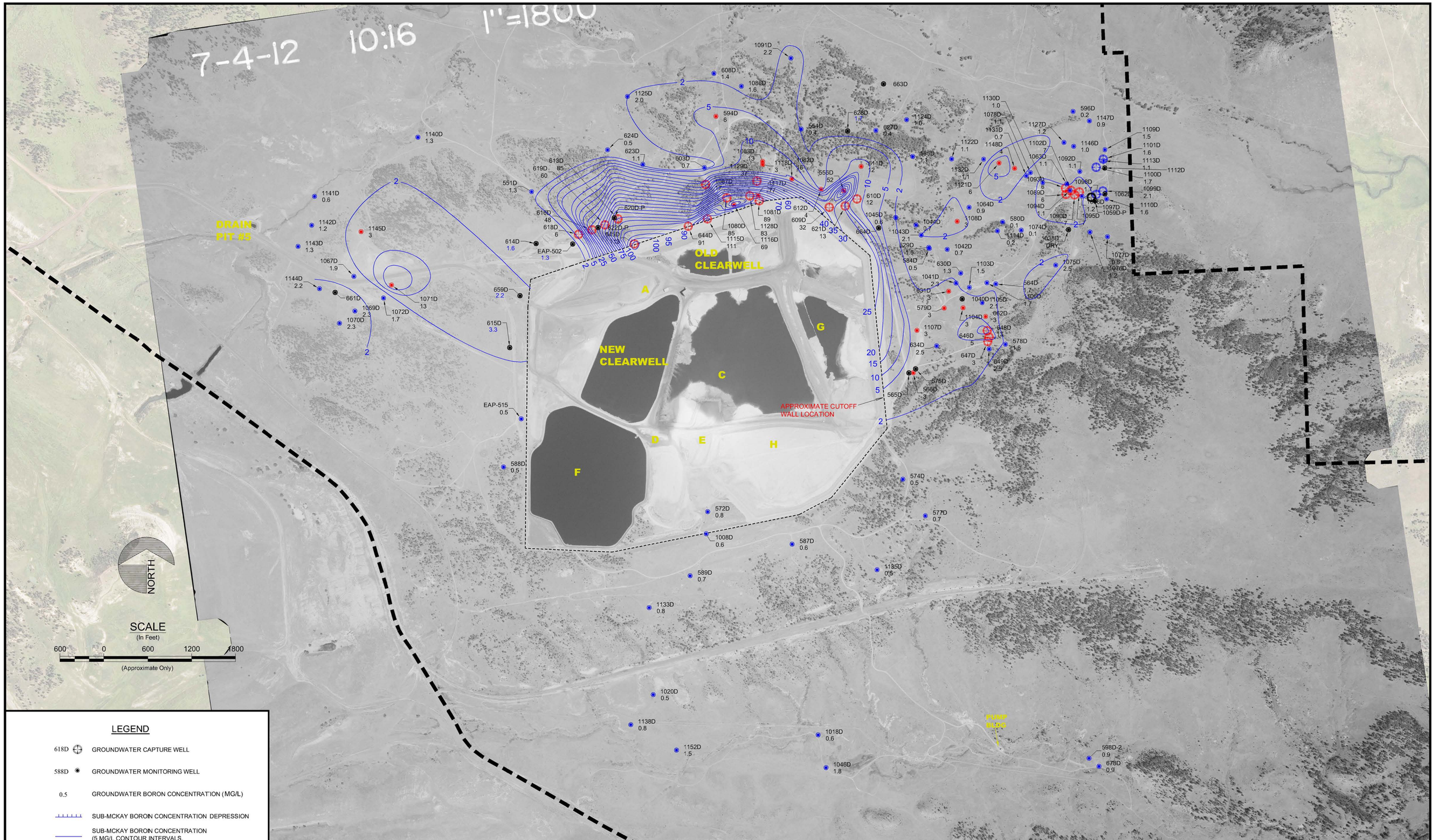

NOTE: SUBMCKAY DRAFT BACKGROUND SCREENING LEVELS (BSL) OF 2.5 MG/L FOR BORON. VALUES ABOVE BSL ARE SHOWN IN RED

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2ND HALF 2012 BORON CONCENTRATION IN SUB-MCKAY WELLS

DRAWING FILE NUMBER
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EXHIBIT
3-10

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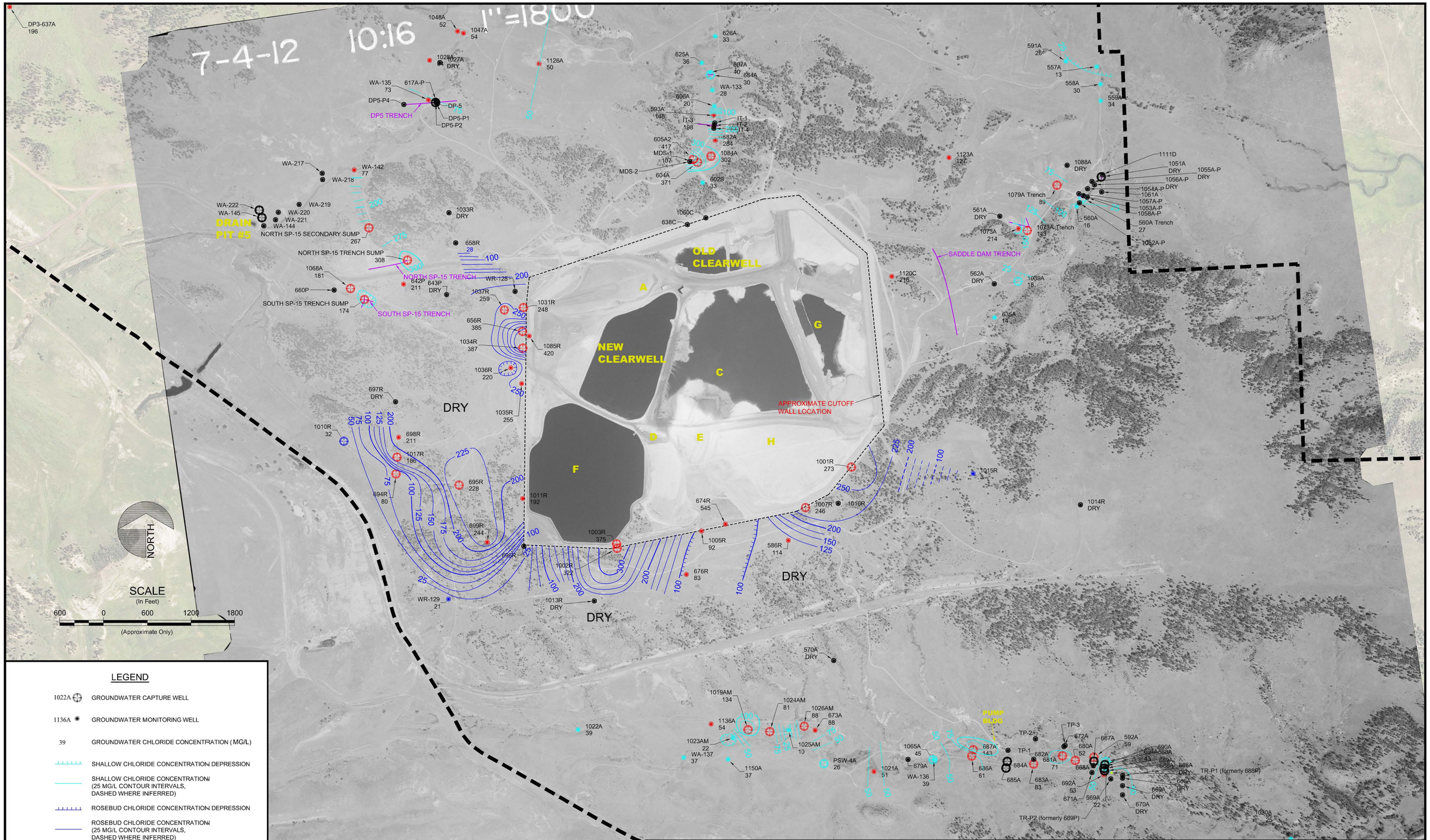

LEGEND

1022A	GROUNDWATER CAPTURE WELL
1136A	GROUNDWATER MONITORING WELL
39	GROUNDWATER CHLORIDE CONCENTRATION (MG/L)
	SHALLOW CHLORIDE CONCENTRATION DEPRESSION
	SHALLOW CHLORIDE CONCENTRATION (25 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)
	ROSEBUD CHLORIDE CONCENTRATION DEPRESSION
	ROSEBUD CHLORIDE CONCENTRATION (25 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)
	UNITS 3 & 4 EFFLUENT HOLDING POND AREA BOUNDARY
	GROUNDWATER INTERCEPTION TRENCH

NOTE: SHALLOW AND COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) OF 48 AND 36 MG/L FOR CHLORIDE. VALUES ABOVE BSL ARE SHOWN IN RED

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PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT

2ND HALF 2012 CHLORIDE CONCENTRATIONS IN SHALLOW AND ROSEBUD WELLS

DRAWING FILE NUMBER
1207300B005
AUTOCAD 2000 DRAWING (DWG)
EXHIBIT
3-11

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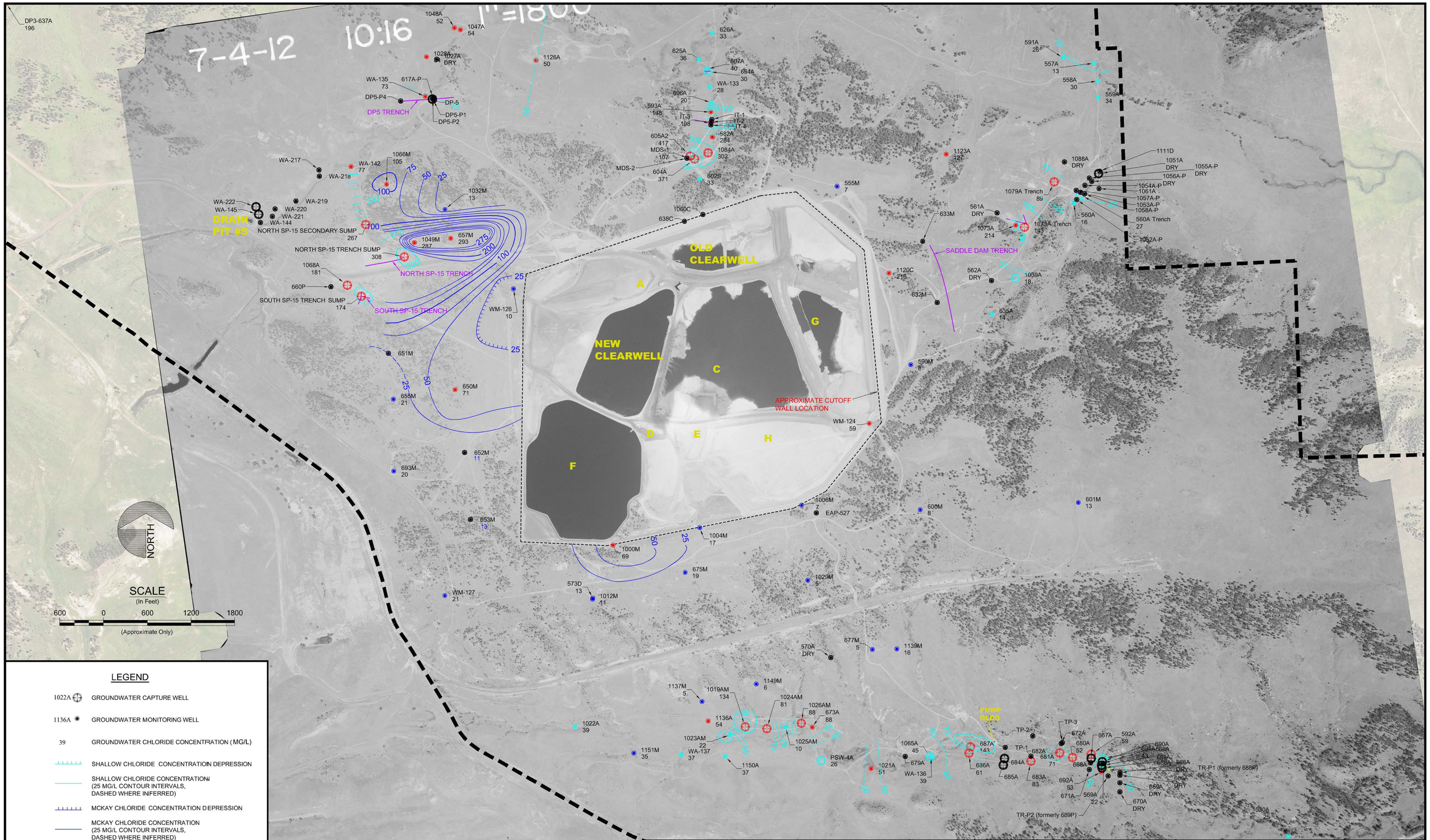
The chloride BSL of 36 mg/L for coal is exceeded in wells completed in the Rosebud just south and to the west of the 3&4 EHP and in a clinker well (1120C) just below the Saddle Dam (Figure 3-11). The highest concentration of chloride in the Rosebud outside of the bentonite amended concrete cutoff wall is observed at capture well 1034R, adjacent to the west side of the 3&4 EHP.

The highest concentration of chloride in groundwater in the McKay Coal is observed in wells 657M and 1049M located northwest of the 3&4 EHP (Figure 3-12). Other McKay wells exceeding the BSL of 36 mg/L for chloride include 1000M, next to the south cutoff wall and 650M, west of the ponds.

The highest concentrations of chloride in sub-McKay units were observed in wells completed downgradient of the Main and Saddle Dams and northwest of the pond at well 1071D (Figure 3-13). The BSL was exceeded in several of these wells, most of them completed as, or upgradient of, groundwater capture wells. Other wells with chloride above the BSL in fall of 2012 are located west of the ponds and include EAP-516, 1144D and 1145D.

Bromide -- Bromide, which has recently been incorporated as an additive at the Plant to remove mercury from flue gas, is also analyzed in water samples as a possible indicator parameter of process pond water. In the 3&4 EHP, bromide concentrations ranged from 106 mg/L in the Old Clearwell to 849 mg/L in the New Clearwell (lined Cell B). Bromide concentrations in Cell C were reported at 596 mg/L. Samples were not collected from Cell G in 2012. Baseline concentrations are not clearly defined due to problems with analytical detection limits at the laboratory during baseline data collection. Reporting limits at that time were reported to be 1 mg/L but there were commonly interferences due to elevated sulfate and detection levels during this time may have exceeded 50 mg/L. Based on analysis of existing data, a level of 9 mg/L will be used to discuss areas that show elevated levels of bromide outside of the pond. Lower concentrations are present outside the pond. However, a screening level has not been established as of yet. Bromide concentrations are contoured in Figures 3-14, 3-15, and 3-16.



LEGEND

1022A	GROUNDWATER CAPTURE WELL
1136A	GROUNDWATER MONITORING WELL
39	GROUNDWATER CHLORIDE CONCENTRATION (MG/L)
	SHALLOW CHLORIDE CONCENTRATION DEPRESSION
	SHALLOW CHLORIDE CONCENTRATION (25 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)
	MCKAY CHLORIDE CONCENTRATION DEPRESSION
	MCKAY CHLORIDE CONCENTRATION (25 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)
	UNITS 3 & 4 EFFLUENT HOLDING POND AREA BOUNDARY
	GROUNDWATER INTERCEPTION TRENCH

NOTE: SHALLOW AND COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) OF 48 AND 36 MG/L FOR CHLORIDE. VALUES ABOVE BSL ARE SHOWN IN RED

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2ND HALF 2012 CHLORIDE CONCENTRATIONS IN SHALLOW AND MCKAY WELLS

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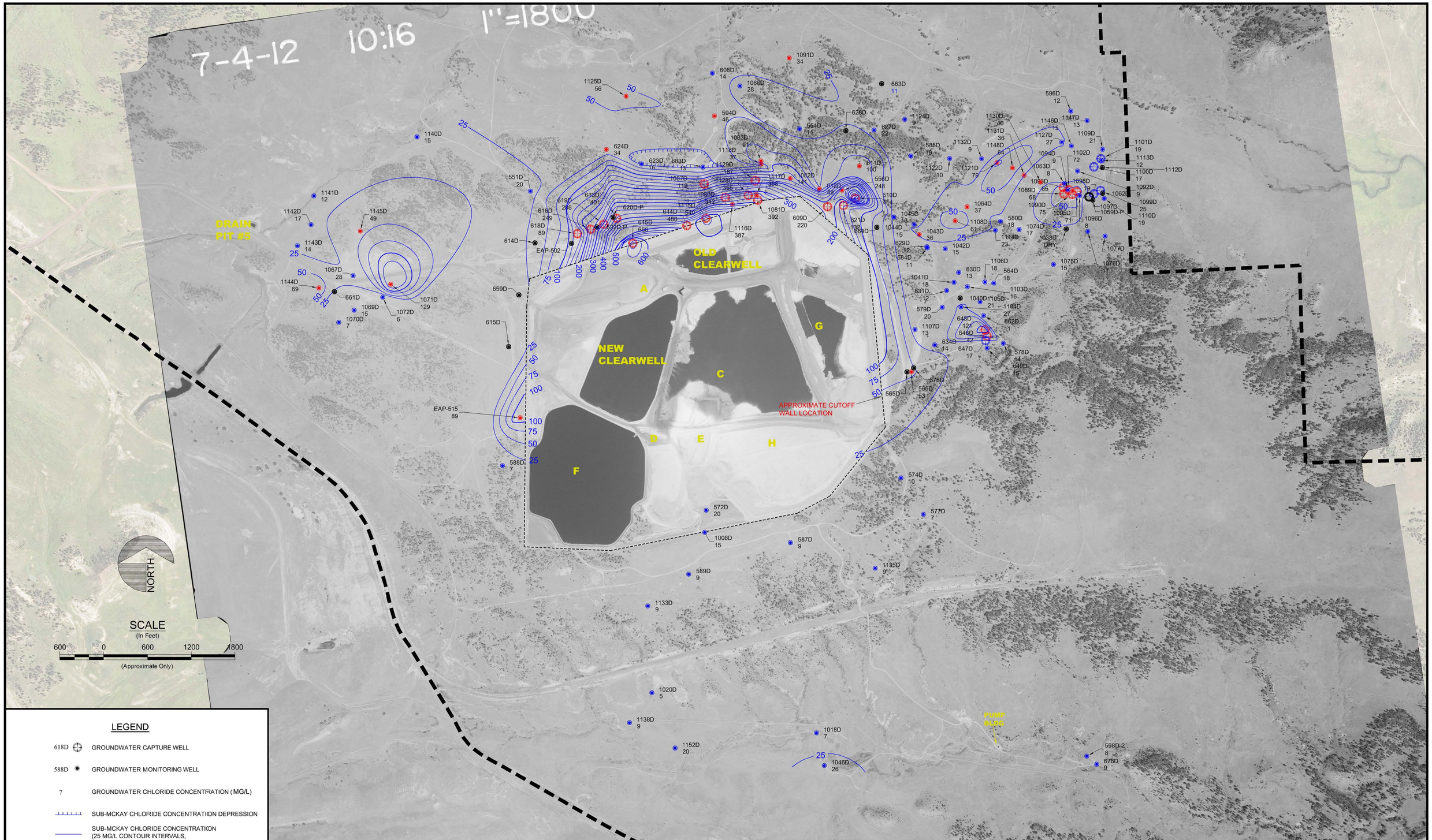

NOTE: SUBMCKAY DRAFT BACKGROUND SCREENING LEVELS (BSL) OF 29 MG/L FOR CHLORIDE. VALUES ABOVE BSL ARE SHOWN IN RED

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2ND HALF 2012 CHLORIDE CONCENTRATION IN SUB-MCKAY WELLS

DRAWING FILE NUMBER
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AUTOCAD 2000 DRAWING (DWG)
EXHIBIT
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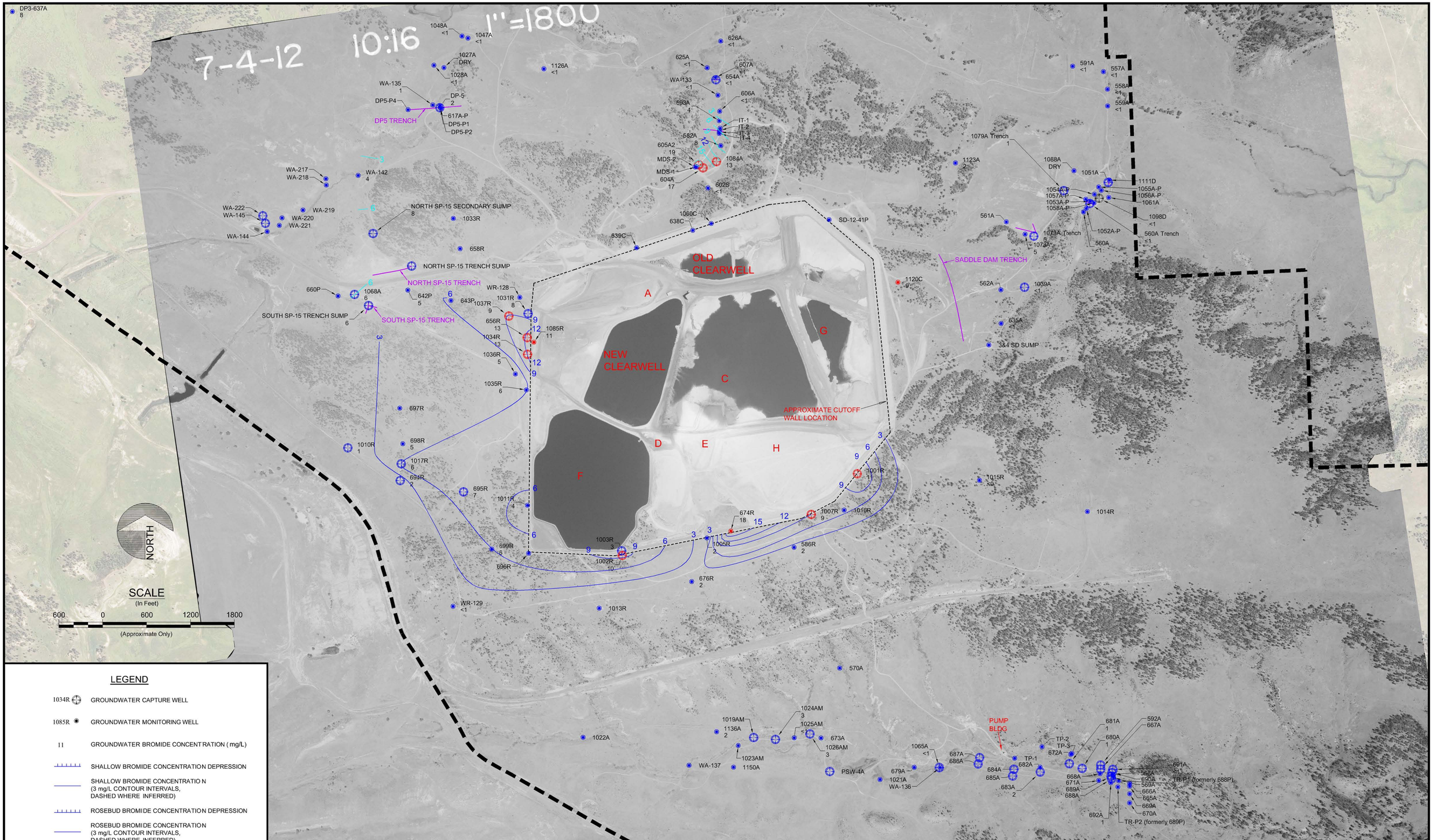

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2ND HALF 2012 BROMIDE CONCENTRATIONS IN SHALLOW AND ROSEBUD WELLS

DRAWING FILE NUMBER
1207300B006
AUTOCAD 2000 DRAWING (DWG)
EXHIBIT
3-14

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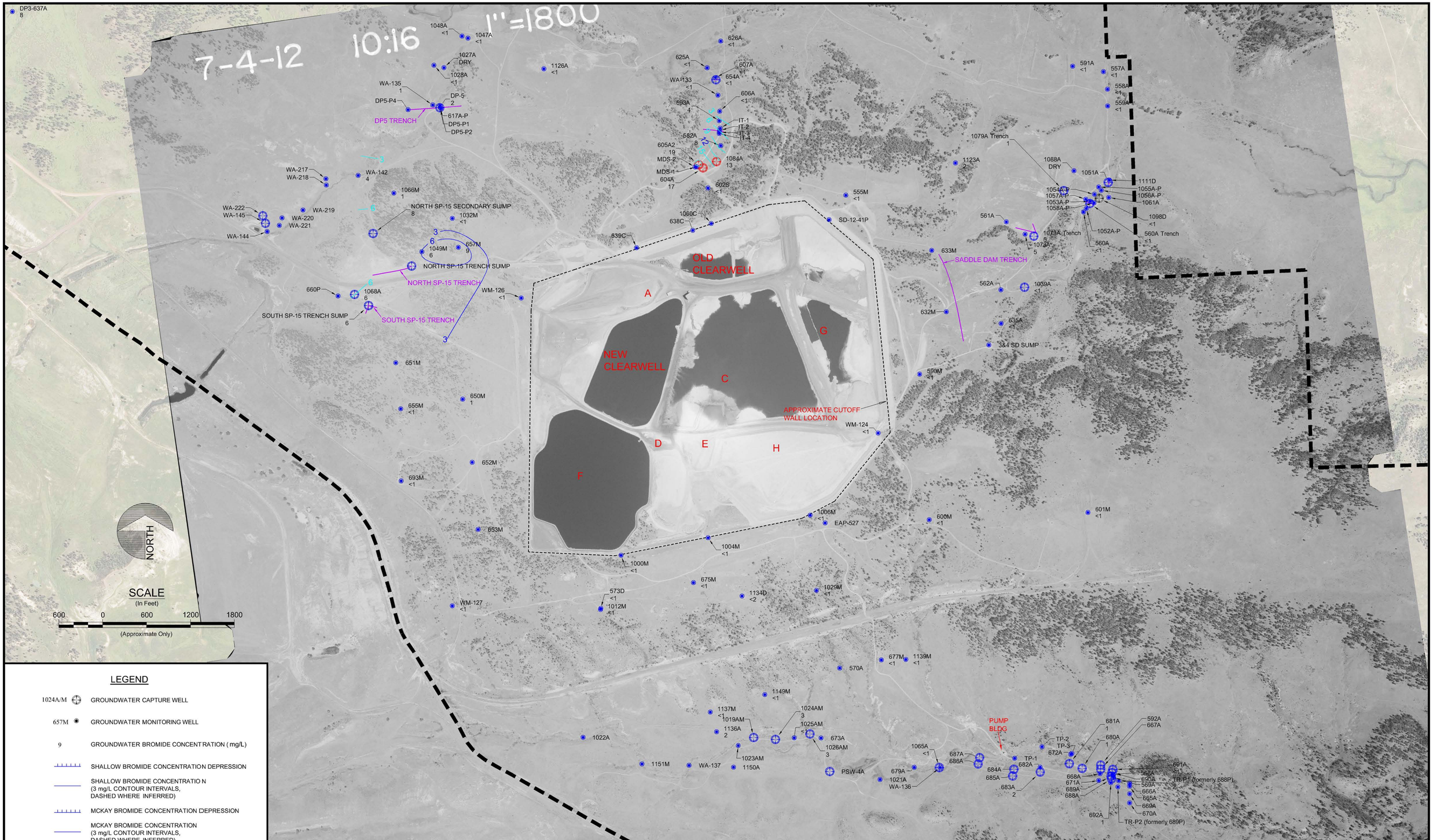

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2ND HALF 2012 BROMIDE CONCENTRATIONS IN SHALLOW AND MCKAY WELLS

DRAWING FILE NUMBER
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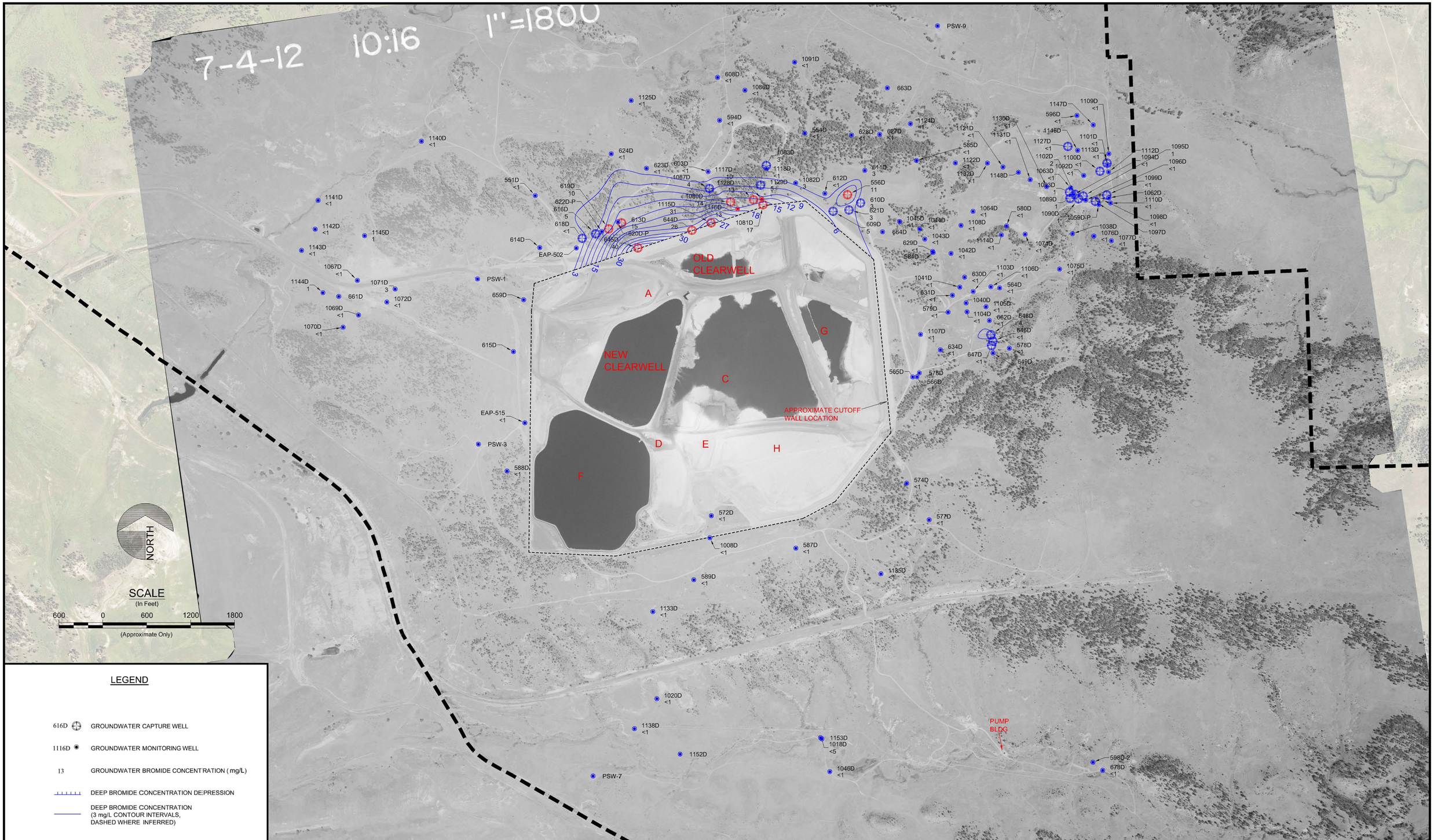

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2ND HALF 2012 BROMIDE CONCENTRATIONS IN SUB-MCKAY WELLS

DRAWING FILE NUMBER
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AUTOCAD 2000 DRAWING (DWG)
EXHIBIT
3-16

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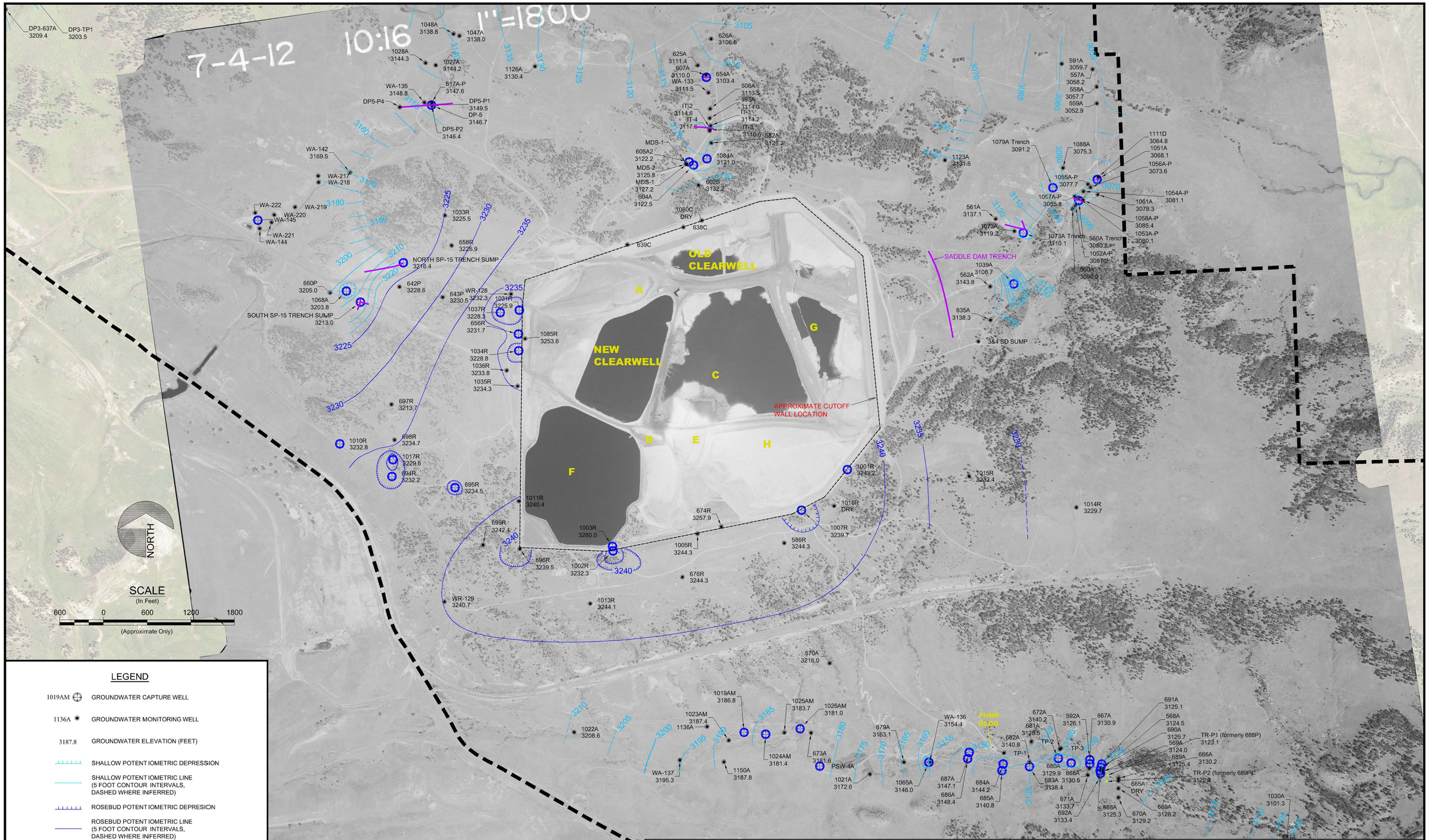
Areas with bromide concentrations exceeding 9 mg/L were as follows:

- Alluvium – Bromide concentrations of 13 to 19 mg/L were detected at the 3&4 EHP Main Dam Valley Drain Sump and well 1084A. The locations are near to or associated with the drain system incorporated into the dam design. It is not considered abnormal to see elevated levels at this location. No other areas showed bromide concentrations in the alluvium exceeding 9 mg/L.
- Rosebud Clinker – Bromide concentrations exceeded 9 mg/L around the perimeter of the ponds at capture wells 1001R, 1007R, 1002R, 656R, 1034R and 1037R. Well 1120C, had bromide concentration of 9 mg/L.
- Sub-McKay – Nine capture wells and two monitoring wells near the 3&4 EHP Main Dam, and near the north edge of the pond had bromide concentrations exceeding 9 mg/L. Well 556D, located near the northeast corner of the pond, a few hundred feet from the Saddle Dam, had concentrations of 11 mg/L. Well 556D is a low yield capture well. The highest bromide concentrations were reported at 644D and 645D, with 26 and 40 mg/L, respectively. For comparison purposes, wells 674R, 1003R, and 1085R, all completed inside the bentonite amended concrete cutoff wall, had bromide concentrations reported at 3 to 18 mg/L.

3.4.3 Groundwater Flow

Figure 3-17 is a potentiometric map of the alluvium deposits and shallow bedrock (including Rosebud Coal) monitored in areas near the 3&4 EHP; constructed using water levels measured in May 2013. Alluvial groundwater in Cow Creek and SFCC flows eastward or downstream towards Rosebud Creek. Very little groundwater is present in the alluvium directly downstream of capture in SFCC. Well 1030A was completed in SFCC alluvium about one-half mile downgradient of capture. Water quality and yield does not appear to be impacted at well 1030A by upgradient capture. Alluvium in drainages that are tributary to Cow Creek, and have been impacted by pond water, have very little groundwater flow toward the creek, due to ongoing groundwater capture. Groundwater flow in the Rosebud clinker or coal is generally away from the 3&4 EHP, but is locally influenced by



LEGEND

1019AM	GROUNDWATER CAPTURE WELL
1136A	GROUNDWATER MONITORING WELL
3187.8	GROUNDWATER ELEVATION (FEET)
	SHALLOW POTENTIOMETRIC DEPRESSION
	SHALLOW POTENTIOMETRIC LINE (5 FOOT CONTOUR INTERVALS, DASHED WHERE INFERRED)
	ROSEBUD POTENTIOMETRIC DEPRESION
	ROSEBUD POTENTIOMETRIC LINE (5 FOOT CONTOUR INTERVALS, DASHED WHERE INFERRED)
	GROUNDWATER INTERCEPTION TRENCH
	UNITS 3 & 4 EFFLUENT HOLDING POND AREA BOUNDARY

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UNITS 3 & 4 EHP ROSEBUD & ALLUVIUM HYDROSTRATIGRAPHIC UNITS POTENTIOMETRIC SURFACE MAY 2013

DRAWING FILE NUMBER
1207300B004
AUTOCAD 2000 DRAWING (DWG)
EXHIBIT
3-17

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groundwater capture systems near the south and west sides of the 3&4 EHP, although very little groundwater is present in this interval. Similar to the Rosebud, groundwater flow direction in the McKay during May 2013 (Figure 3-18) is away from the 3&4 EHP toward Cow Creek and SFCC. The McKay Coal is absent north of the 3&4 EHP and is found sparsely in the area east of the 3&4 EHP Saddle Dam and is typically either burned or partially burned.

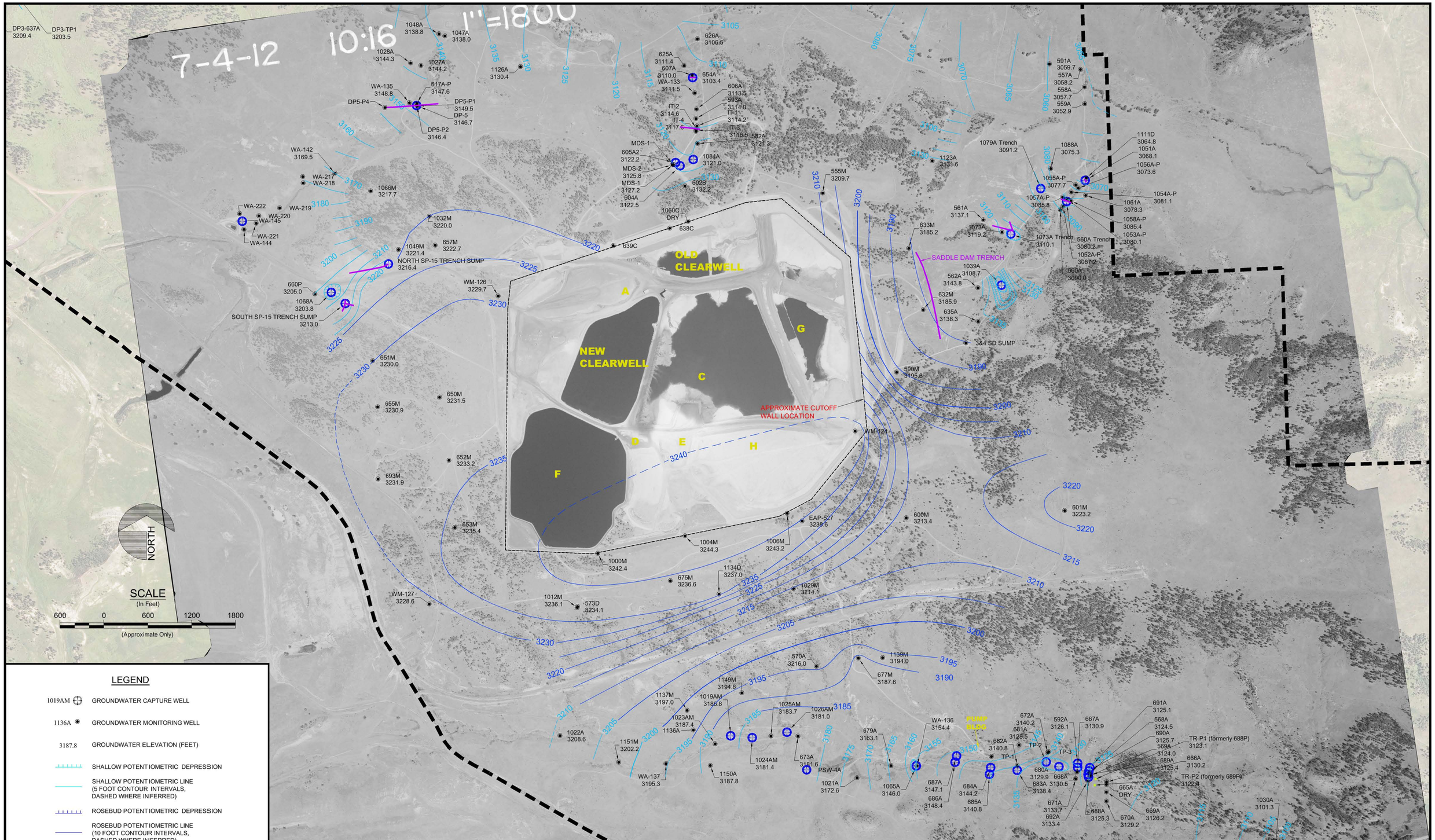
Figure 3-19 is a potentiometric map of groundwater in the sub-McKay constructed using water levels measured in May 2013. Sub-McKay groundwater generally flows to the north and east. Depressions in the groundwater table are present near capture wells, a result of groundwater removal.

3.5 DESCRIPTION OF COMPLETED AND ONGOING REMEDIAL ACTIONS

PPLM conducts extensive activities associated with groundwater in the 3&4 EHP area. These activities include routine operational groundwater monitoring, groundwater mitigation, specific groundwater or surface water investigation, operational changes, and best management practices. Mitigation and/or specific investigations are conducted in response to changes detected through operational water quality monitoring indicating process pond seepage, and/or in response to past spills or releases. These actions are discussed in the following sections. The combination of the activities described below provide a summary of current site conditions, and current or planned future activities that will be conducted to further improve groundwater conditions in the vicinity of the 3&4 EHP.

3.5.1 Operational Monitoring

PPLM conducts operational groundwater monitoring in and around the 3&4 EHP at a network of monitoring and capture wells. The monitoring program is outlined in the site monitoring plan (PPLM, September 2011, Water Resources Monitoring Plan). The monitoring plan includes lists of monitoring wells, monitoring frequency for ponds and wells, analytical parameters, and evaluation and reporting criteria. In 2012, water quality samples were collected from 347 monitoring sites during the first half of the year and 235 monitoring sites during the last half of the year. These sites included monitoring wells,



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UNITS 3 & 4 EHP MCKAY & ALLUVIUM HYDROSTRATIGRAPHIC UNITS POTENTIOMETRIC SURFACE MAY 2013

DRAWING FILE NUMBER
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AUTOCAD 2000 DRAWING (DWG)
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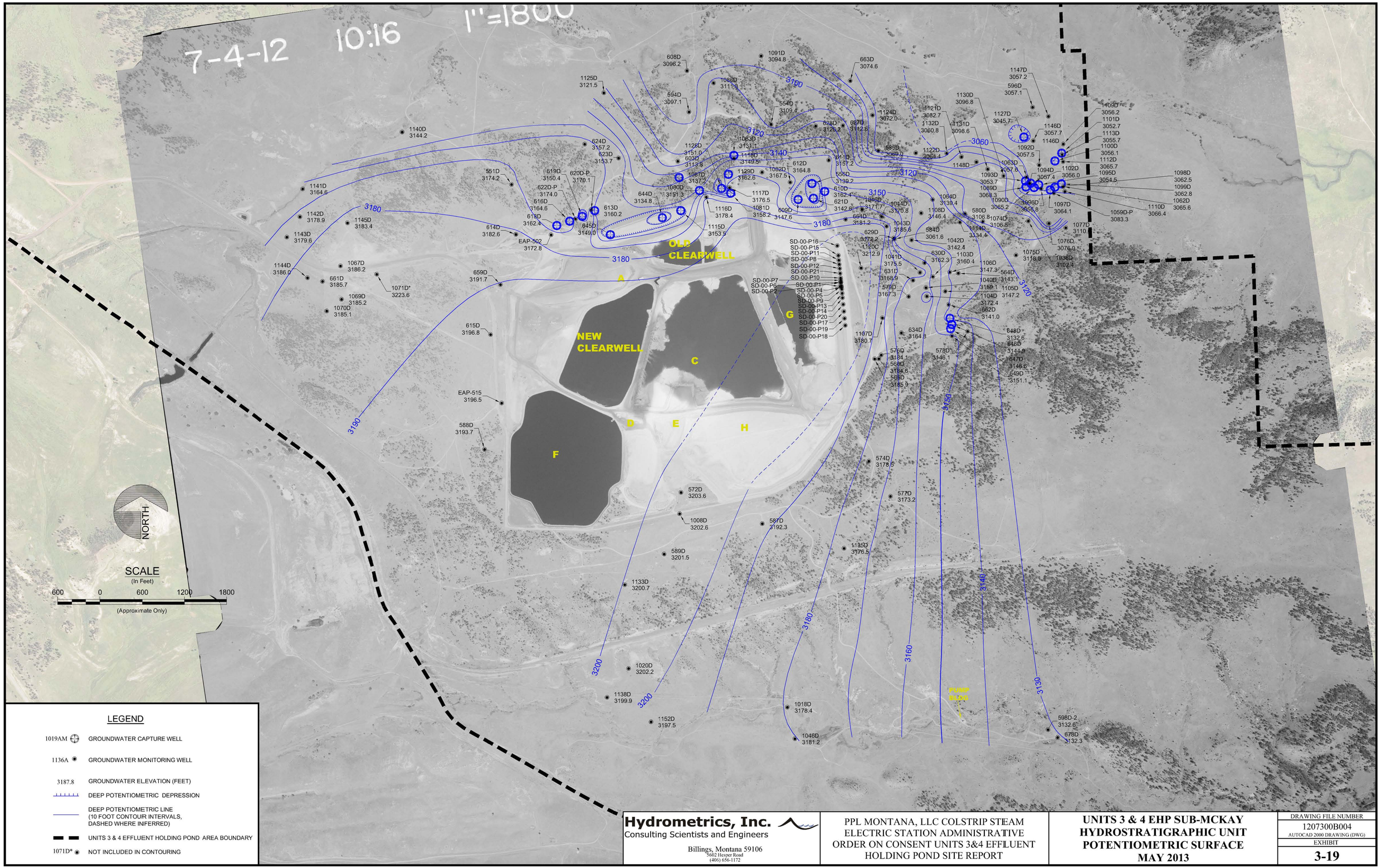

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UNITS 3 & 4 EHP SUB-MCKAY HYDROSTRATIGRAPHIC UNIT POTENTIOMETRIC SURFACE MAY 2013

DRAWING FILE NUMBER
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groundwater capture wells and trenches, one spring (SP-14), surface water in Cow Creek, 3&4 EHP cells, dam sumps, Drain Pit #3 and Drain Pit #5 and selected ponds. An updated summary of groundwater monitoring sites and analytical parameter lists are in Appendix B.

Well samples are most commonly analyzed for parameters which include SC, pH, TDS, total alkalinity as $CaCO_3$, bicarbonate, bromide, carbonate as CO_3, chloride, sulfate, and dissolved metals (boron, calcium, magnesium, potassium, selenium, and sodium), and ionic balance. Mercury is analyzed at a few select sites. Nitrate plus nitrite is also typically analyzed in newly installed wells.

PPLM samples water from cells within the 3&4 EHP typically at least once every three years. Pond samples have also been collected and analyzed for a more extensive list of parameters than that indicated in the monitoring plan. In 2012, pond water quality samples were collected from the 3&4 EHP Cell C and the Old and New Clearwells. In addition, samples were collected from the 3&4 EHP Main Dam Sump and the Saddle Dam Sump. Data are included in Table 2-2.

The monitoring plan includes six surface water sites on Cow Creek (CC-2 through CC-7) and two on SFCC (SFCC2 and SFCC3). If water is present, a sample for water quality is collected; only CC-3 and CC-4 sites had water present in 2012. Surface water samples from Cow Creek were analyzed for pH, SC, TDS, alkalinity as $CaCO_3$, sulfate, chloride, bromide, bicarbonate as $CaCO_3$, carbonate as CO_3, total boron, calcium, magnesium, potassium, selenium, and sodium.

All water quality samples are submitted to a certified commercial laboratory for analysis. Results of the analyses are validated through a quality control/quality assurance process and maintained in a project database. These validated data are provided to the MDEQ on an annual basis, following completion of the validation.

Results of operational monitoring for the previous year are summarized in annual monitoring reports (see References, Section 7). These reports are typically issued in late spring/early summer of each year. Reports are submitted to the MDEQ for review. Upon review, MDEQ and PPLM meet to discuss the findings of the monitoring program and to discuss activities that can be conducted to further evaluate a particular condition or to mitigate a condition if it is interpreted to be related to the 3&4 EHP process water operations.

PPLM Environmental Compliance Department personnel review data on a routine basis. Additional evaluation is conducted in areas showing changes in water quality. In addition to investigations conducted in response to water quality variations, PPLM also responds to operational occurrences which could potentially result in environmental impacts. Such events could include surface observations such as apparently affected vegetation, water issuing to ground surface in areas not previously observed, increases in water levels in wells that may or may not be accompanied by water quality changes, pipeline breaks, problems with drain pits such as overfilling, and other miscellaneous events.

Evaluations of these data are used to identify changes in the groundwater system. Any changes in the system are evaluated to identify those that may be caused by process pond activities. Changes which are attributed to process ponds are further evaluated through continued monitoring, site investigation, implementation of mitigation activities, changing of normal processes, or a combination of the previous.

3.6 GROUNDWATER MITIGATION ACTIVITIES

Groundwater mitigation in the 3&4 EHP area is conducted when/where process water impacts are interpreted through review of groundwater monitoring data. Mitigation activities include capturing potentially impacted groundwater and routing it to the 3&4 EHP, source reduction by paste deposition and pond lining, implementation of BMPs to reduce water inventory, and revegetation. Groundwater capture/containment is conducted at 87 sites in the Units 3&4 EHP area. Of these 87 sites, 78 are capture wells, seven are interception trenches

and two are dam sumps. A list of groundwater capture locations in the 3&4 EHP area and their respective dates of startup are listed in Table 3-3.

Locations of groundwater capture wells, trenches, and sumps are shown on Figure 3-20. Capture systems in the Units 3&4 EHP area target groundwater in multiple hydrostratigraphic intervals including alluvium, Rosebud Coal (mostly remnants of burned coal and clinker formed by burning coal), shallow interburden bedrock, McKay Coal (only in SFCC where the coal is in direct contact with alluvium), and some sub-McKay bedrock (mostly north and east of the 3&4 EHP where the McKay Coal is absent). Groundwater capture locations are present on all sides of the 3&4 EHP; but it can be seen from Figure 3-20 that they are not evenly distributed.

Capture system sites tend to be clustered because preferential groundwater flow pathways limit dispersal of impacted groundwater and because PPLM aggressively pursues remediation of groundwater in impacted areas by installing a dense capture well network.

Groundwater capture wells are routinely monitored for flow, hours operated, water level, and specific conductance. Capture system monitoring is conducted to document depth to water in pumping wells, approximate pumping rates, adjust and maximize drawdown in the wells, and to identify problems with well function. Maintenance requests are made when problems are discovered and the necessary repairs are made. Data collected from the capture systems are documented in a project field book and maintained in an electronic filing system.

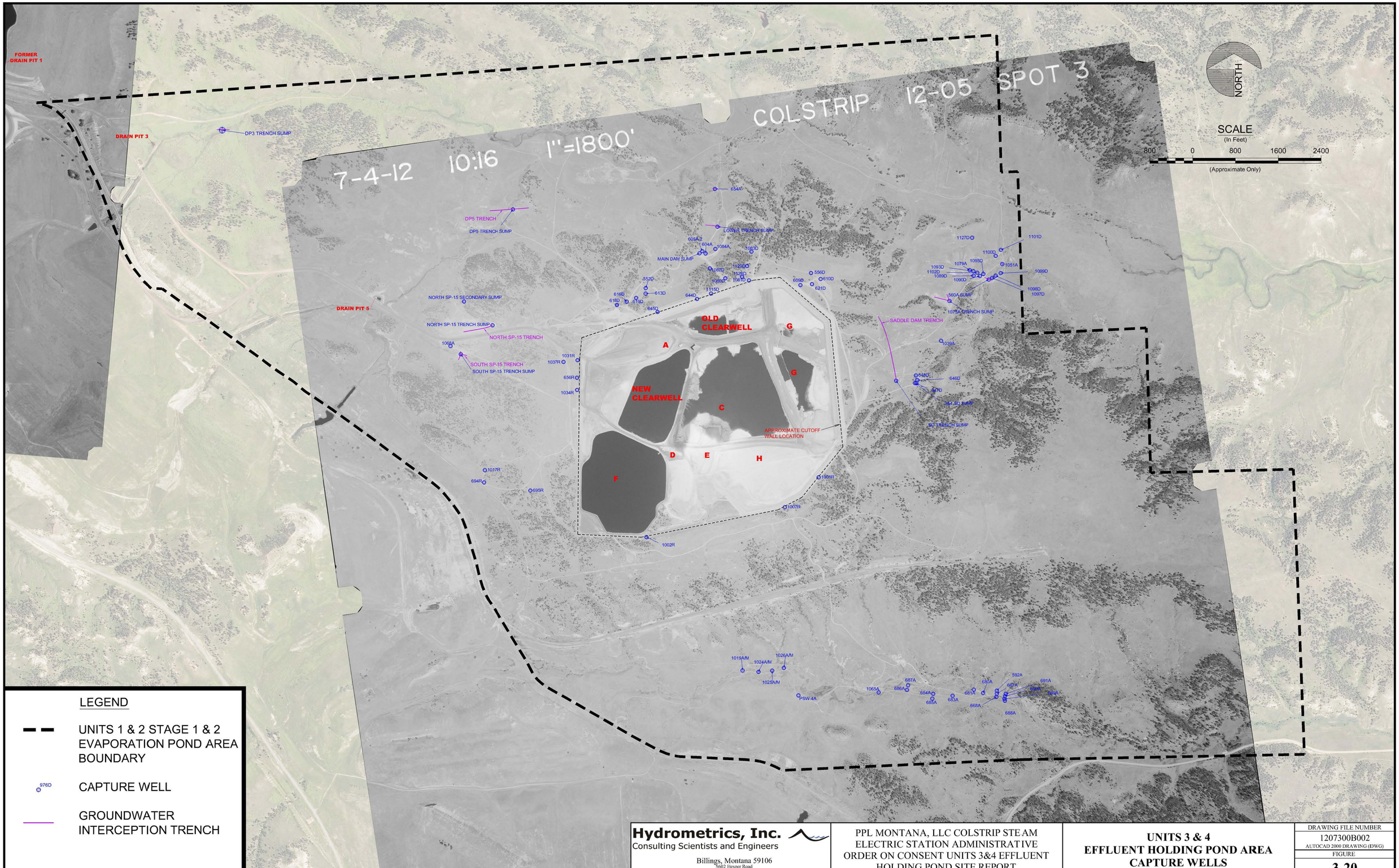
In June 2013, the total calculated average rate of water being collected at all capture systems in the 3&4 EHP area was estimated at 262 gpm. Note that the volume of water captured is overestimated. Scaling problems have made it necessary to operate the majority of systems without flow meters. Pumping rates are measured at the well head through a sampling port. This method results in overestimation of actual pumping rates in pressurized systems since flow at the wells is measured at zero head but actual pipeline pressures vary depending on scaling within the pipe, flow through the pipe, pipe size, pipeline length, and the amount of

TABLE 3-3
AREA CAPTURE LOCATIONS AND START DATES
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3&4 EFFLUENT HOLDING POND

Site ID	Start Date
Units 3 & 4 EHP Main Dam Sump/Interception Trench/Dam Abutment Areas	
3&4 Main Dam Lower Interceptor Trench	12/15/89
3&4 Main Dam Sump Drain Trench	07/26/01
604A	10/31/98
605A-2	3/11/99
1084A	10/22/09
1087D	3/11/11
654A	6/28/02
552D	11/19/98
613D	3/11/99
616D	3/11/98
618D	11/7/04
619D	3/11/99
644D	1/1/04
645D	1/1/04
1080D	9/14/10
1081D	9/14/10
1083D	9/14/10
1115D	9/14/10
1128D	08/17/11
1129D	08/17/11
Units 3 & 4 EHP Saddle Dam Area	
556D	12/17/98
609D	11/14/99
610D	11/14/98
621D	2/17/99
560A Trench Sump	3/20/08
1039A	3/20/08
1051A Trench	5/28/08
1073A Trench	7/15/10
1079A Trench	1/23/09
1089D	6/24/09
1090D	6/24/09
1093D	4/13/10
1095D	4/14/10
1097D	4/14/10
1098D	4/14/10
1099D	4/13/10
1100D	4/13/10
1101D	4/13/10
1102D	4/14/10
646D	12/19/01
647D	12/19/01
648D	11/7/04
1127D	01/29/13
1148D	01/29/13
Units 3 & 4 EHP South Side	
1001R	12/12/05
1002R	9/1/05
1007R	10/12/05
1016R	10/12/05

TABLE 3-3
AREA CAPTURE LOCATIONS AND START DATES
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3&4 EFFLUENT HOLDING POND

Site ID	Start Date
South Fork Cow Creek	
592A	12/28/04
667A	12/28/04
668A	12/28/04
680A	12/28/04
681A	12/28/04
683A	3/1/05
684A	3/2/05
685A	3/2/05
686A	4/12/05
687A	4/12/05
688A	1/25/05
689A	1/25/05
690A	1/25/05
691A	1/25/05
1019AM	11/30/05
1024AM	11/30/05
1025AM	11/30/05
1026AM	11/30/05
1065A	8/5/09
PSW-4A	10/18/07
1136A	9/17/13
1153A	9/17/13
Units 3 & 4 EHP West Side	
656R	7/11/06
1031R	4/24/08
1034R	4/10/08
1037R	4/18/08
North SP-15 Int. Trench	12/10/02
North SP-15 Secondary Sump	5/19/06
South SP-15	9/15/02
1068A	6/16/09
694R	9/1/05
695R	10/12/05
1017R	8/29/05
Units 3& 4 EHP Area Drain Pit #5 Interception Trench	
Drain Pit #5 Interception Trench	2000
Units 3& 4 EHP Area Drain Pit #3 Interception Trench	
Drain Pit #3 Interception Trench	7/30/00



Hydrometrics, Inc.
Consulting Scientists and Engineers
Billings, Montana 59106
3602 Hesper Road
(406) 656-1172

PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT

UNITS 3 & 4
EFFLUENT HOLDING POND AREA
CAPTURE WELLS

DRAWING FILE NUMBER
1207300B002
AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-20

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hydraulic head that must be overcome to reach the discharge point. For example, where flow was measured by instrumentation at the Saddle Dam Sump and compared to rates calculated as described above, the measured rate was half of the calculated pumping rate.

3.6.1 Effectiveness Assessment of Remedial Action

As mentioned previously, SC shows a strong correlation to TDS (Sterrett, 2007). Because SC is largely dictated by the ionic composition of groundwater it is a good indicator of overall water quality and is used as one of the indicators of possible process water impacts. Since SC trends provide a good indication of overall water quality, it is possible to evaluate capture systems by looking at changes in SC in groundwater at the wells. A comparison is made of highest recorded SC measurements in capture wells to the average SC over the most recent six month period. This comparison provides a current snapshot of overall capture system effectiveness. Calculated reductions in SC at individual 3&4 EHP capture locations ranged from 4 to 58 percent. The lowest reductions in SC (4 to 5 percent) were observed at wells 1084A and 1148D. Well 1084A is located downgradient of the 3&4 EHP Main Dam. Minimal changes in SC at 1084A reflect its proximity to the source and suggest that little source reduction has occurred. Well 1148D was recently started on January 29, 2013 and has not had sufficient pumping time to induce changes in water quality.

The greatest reduction in SC (58 percent) was calculated at wells 694R and 1016R. Both of these wells are installed in Rosebud clinker near the perimeter of the 3&4 EHP. The highest SC measurement at well 694R was 14,990 µmhos/cm, compared to the most recent six month average SC of 6,332 µmhos/cm. Well 1016R was operated as a capture well from October 2005 to August 2006; during which time, the well all but dried up and water quality improved sharply. To date, well 1016R is typically dry. The most recent SC measurement made at the well was 6,050 µmhos/cm. The previous high SC measurement was 14,500 µmhos/cm. The lower SC measurements are attributable to significant source reduction including paste placement, pond lining, and water volume reduction. The average reduction in SC for all capture systems in the 3&4 EHP is 23 percent.

As noted above, capture systems tend to be completed in groups or at least in common areas around the 3&4 EHP. Grouping is reflected in Table 3-3 and includes the following seven areas:

- 3&4 EHP Main Dam Sump/Interception Trench/Dam Abutment Areas;
- Saddle Dam and 560A/1051A Areas;
- EHP South and Southwest Side;
- SFCC Area;
- EHP West and Northwest Side;
- Drain Pit #5 Interception Trench Area; and
- Drain Pit #3 Interception Trench Area.

Effectiveness of remedial actions in each of the seven areas is discussed in the following sections. Figures 3-21 through 3-30 contain graphs for select capture wells and nearby monitoring wells.

3.6.2 3&4 EHP Main Dam Sump/Interception Trench/Dam Abutment Areas

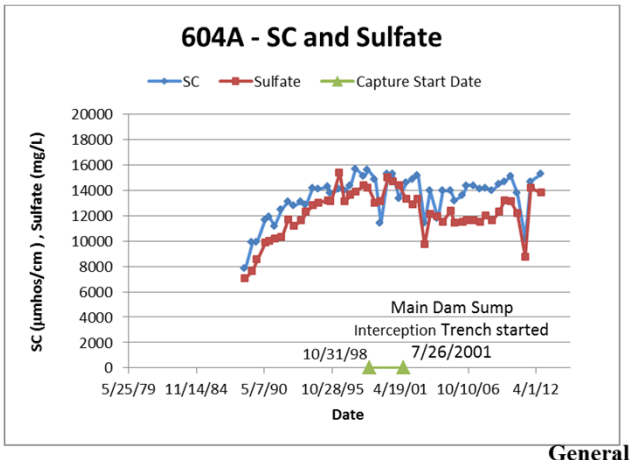
For the sake of the following discussion, this area includes all capture wells north of the 3&4 EHP. Capture systems in this area are targeting the alluvium of the ephemeral drainage north of the 3&4 EHP Main Dam and/or impacted groundwater in first bedrock below the bentonite amended concrete cutoff wall on the north edge of the ponds. The 3&4 EHP Main Dam Lower Interception Trench is the most prominent alluvial capture system in this area. However, this trench is supplemented by a drain trench that was installed in July 2001 directly upstream of the 3&4 EHP Main Dam Sump. Additionally, capture in the alluvium in this area is supplemented with three alluvial capture wells (604A, 605A-2, and 1084A) and a modified well/Trench 654A. Several bedrock capture wells flank the 3&4 EHP Main Dam to the east and west.

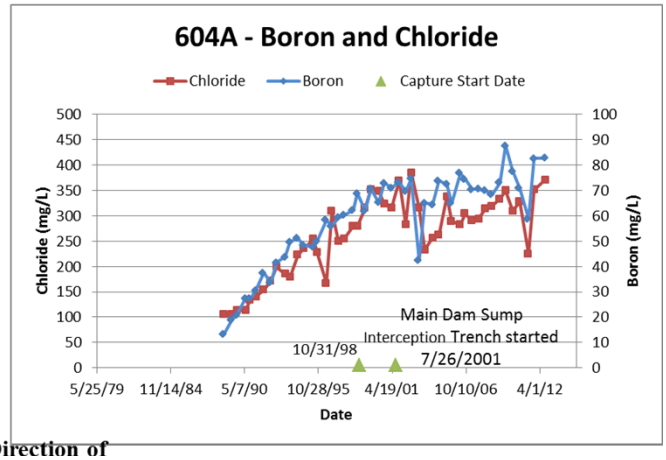
Mitigation actions were started in this area in 1989 and are ongoing. Since mitigation actions were initiated, a reduction in SC of 23 percent has been observed at the 3&4 EHP Main Dam Lower Interception Trench. Operation of the Main Dam Lower Interception

Trench, Main Dam Sump Interception Trench and other nearby capture wells has had a positive effect on water quality at downgradient monitoring wells. Examples of this are evident in water quality trend plots of wells 593A and WA-133 (Figure 3-21); each of these downgradient monitoring wells shows a general trend of improving water quality, despite variations typical of alluvial groundwater chemistry. Note a small recharge area exists upgradient of the area to provide higher quality water to the shallow system. Alluvial capture well 654A is located the farthest downgradient of all alluvial wells north of the 3&4 EHP Main Dam. Well 654A was constructed to maximize groundwater capture by installing a short trench across a portion of the alluvium. SC decreased at well 654A from 5,430 µmhos/cm to 4,000 µmhos/cm (a 26 percent decrease) since capture began in 2002. Water quality improvements and much lower SC at the downgradient well indicate effective capture is occurring.

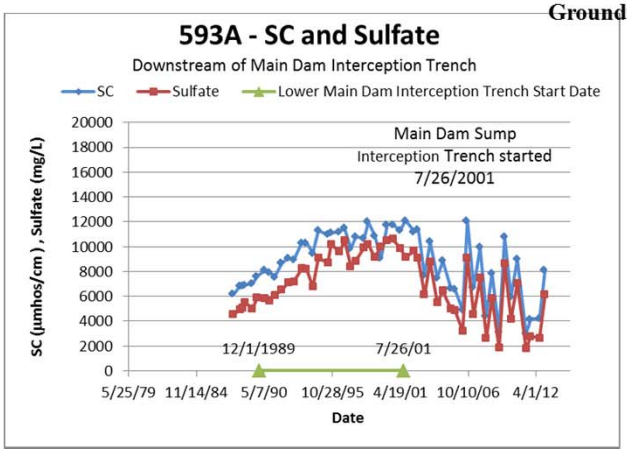
Process water impacts in bedrock groundwater tend to be the greatest at wells nearest to the 3&4 EHP Main Dam and to the 3&4 EHP's northern boundary but decline through the bedrock capture well network and with increased distance from the 3&4 EHP. Capture well 644D is located on the east abutment of the Main Dam and had a peak SC measurement of 18,370 µmhos/cm. Water quality at this well has shown a slight declining trend. Upgradient recharge to the well is within the limits of the 3&4 EHP making significant water quality improvement unlikely until final project remediation. Flow reduction through the unit can be accomplished, however, through water management practices that are currently being implemented (water volume reduction, pond lining, and paste placement around perimeter of cells and over exposed clinker). Well 644D was converted to a capture well in 2004. In the first years following its startup, average pumping from the well was 9.7 to 19.3 gpm. In 2012, the average pumping rate for this well was 6.4 gpm. Possible causes for the reduction of flow are eliminating free water from the Old Clearwell, pasting the Old Clearwell, and lining Cell B.

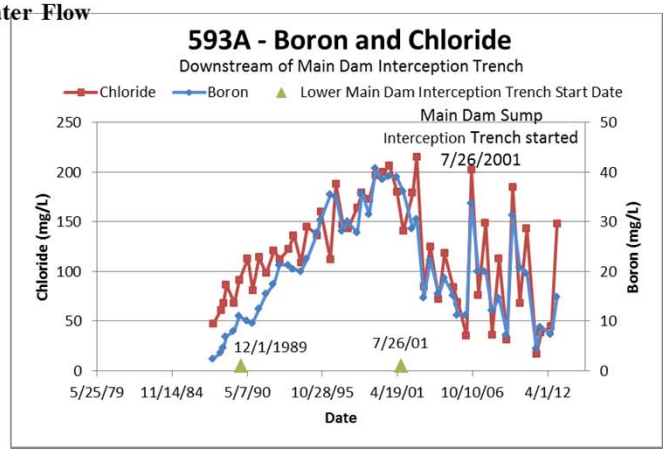
Well 552D is a notable example of a monitoring well installed prior to construction of the 3&4 EHP that began to indicate process water impacts after operation of the ponds began.

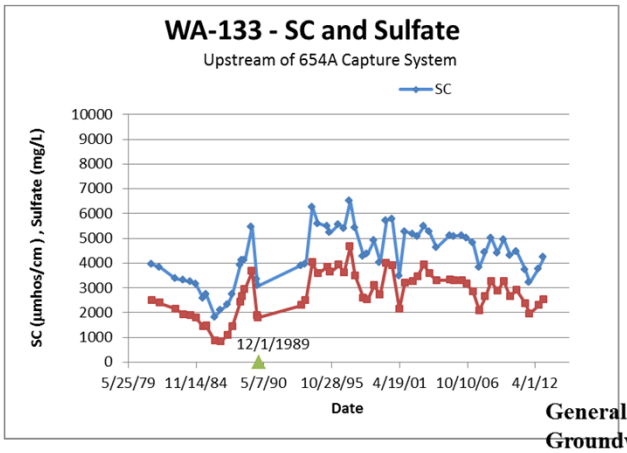


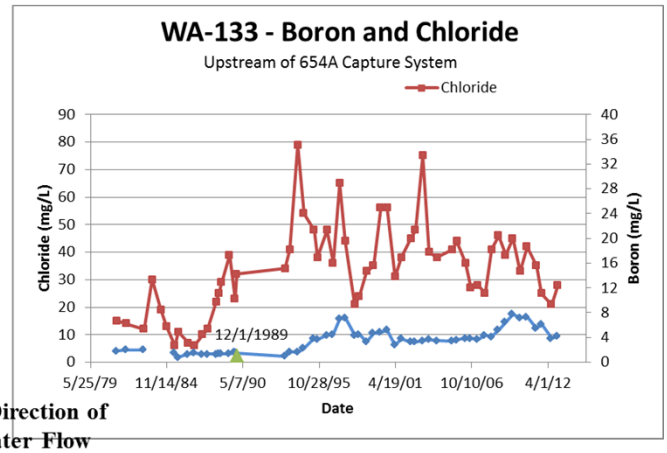


General Direction of Groundwater Flow

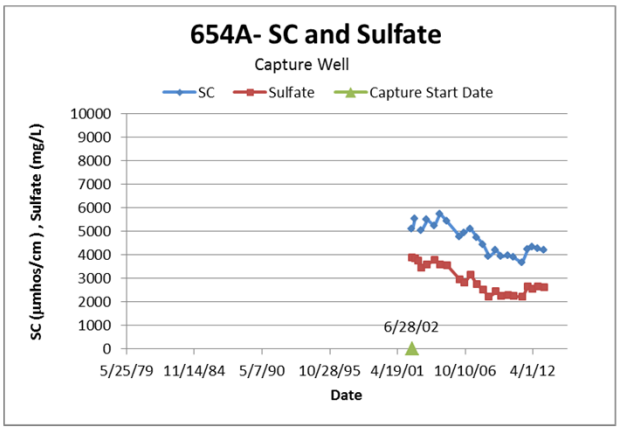


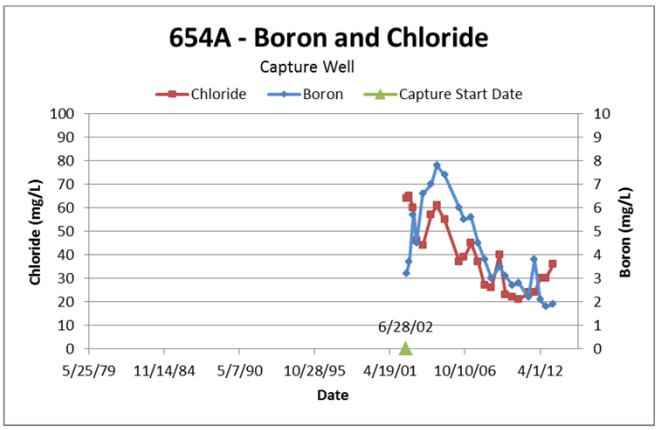






General Direction of Groundwater Flow





PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR ALLUVIAL WELLS NORTH OF THE 3&4 EHP MAIN DAM	FIGURE 3-21

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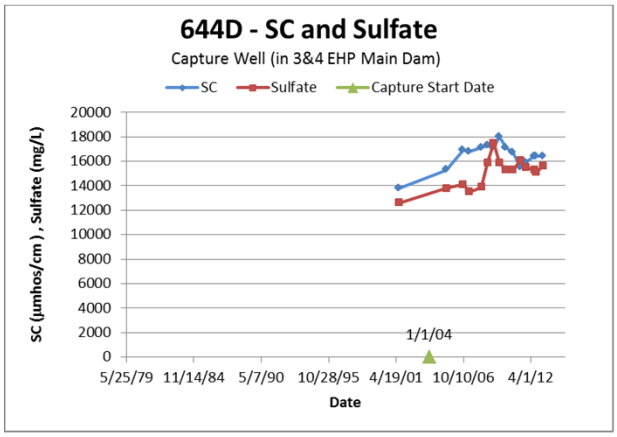
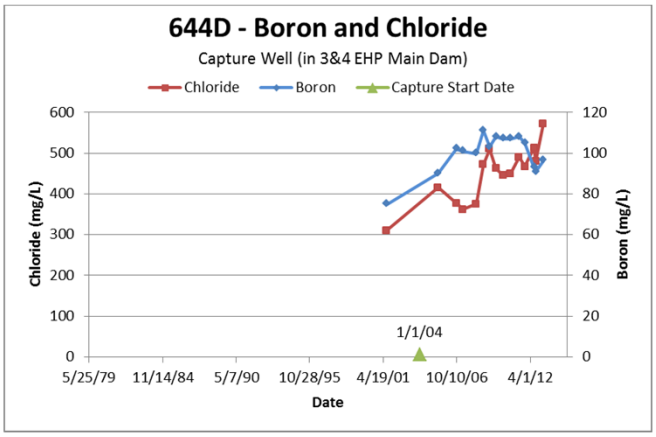
This low yield well (less than 1 gpm) has shown gradual improvements in water quality since the well was converted for capture, including a 24 percent decrease in SC. Capture well 618D, located west of well 552D, has shown gradual improvement in quality since its conversion in November 2004. Water quality graphs for select bedrock capture wells near the northern boundary of the 3&4 EHP are included in Figure 3-22A.

Bedrock wells farther downgradient, including those in the ephemeral drainage downgradient of the 3&4 EHP Main Dam, exhibit a lesser degree of process water impacts. Groundwater quality at monitoring well 602S showed a general declining trend from 1993 to 2009; but this trend was reversed after capture began at wells 1080D, 1081D, 1083D and 1115D in 2010. Continued monitoring will be conducted in this area to further evaluate groundwater conditions and capture system effectiveness. Wells 594D and 603D exhibited a similar trend in water quality decline until the late 1990s, followed by an ongoing improving trend that coincided with startup of several capture wells (e.g. 552D, 604A, 613D, 605A-2, 616D, 618D, and 619D). Well 608D is located downgradient of all capture wells in the ephemeral drainage north of the 3&4 EHP Main Dam. Water quality at well 608D has been consistent since it was completed and has not indicated process water impacts. Water quality graphs for bedrock monitoring wells north of the 3&4 EHP Main Dam are presented in Figure 3-22B.

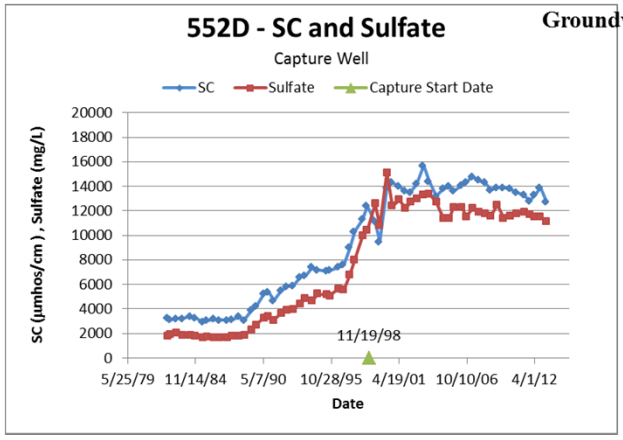
3.6.3 East of Saddle Dam and 560A/1051A Areas

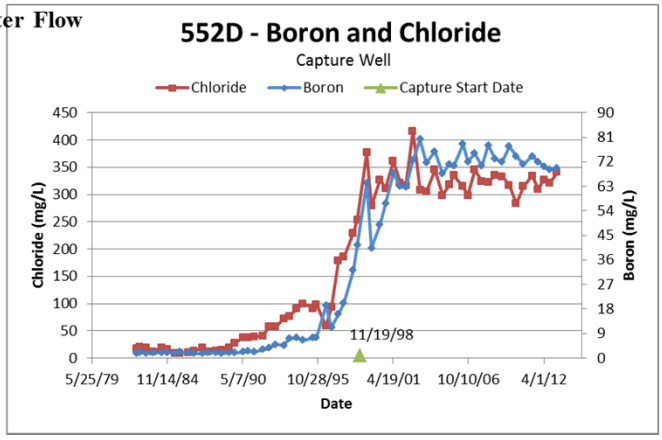
In this assessment, the area east of the 3&4 EHP Saddle Dam includes all monitoring and capture wells installed between the dam crest and the fence at PPLM's east property boundary. The area immediately west of the property boundary fence has been the focus of numerous investigations and continued mitigation efforts centered around areas interpreted to be impacted by process water near well 560A. On-going mitigation in the 560A Area includes operation of four capture interception trenches (560A, 1051A, 1073A, and 1079A Trenches) and twelve bedrock capture wells (1089D, 1090D, 1093D, 1095D, 1097D, 1098D, 1099D, 1100D, 1101D, 1102D, 1127D, and 1148D). Alluvial capture well 1039A was started concurrently with the 560A-Trench in 2008 but is located up-gradient of the 560A Area. The Saddle Dam Interception Trench (gravity drain) was constructed in early 2000

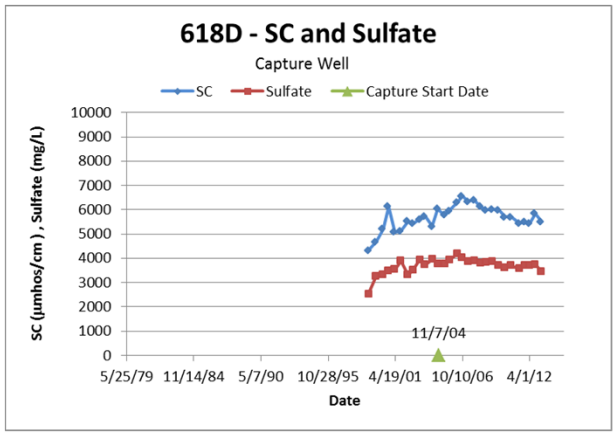


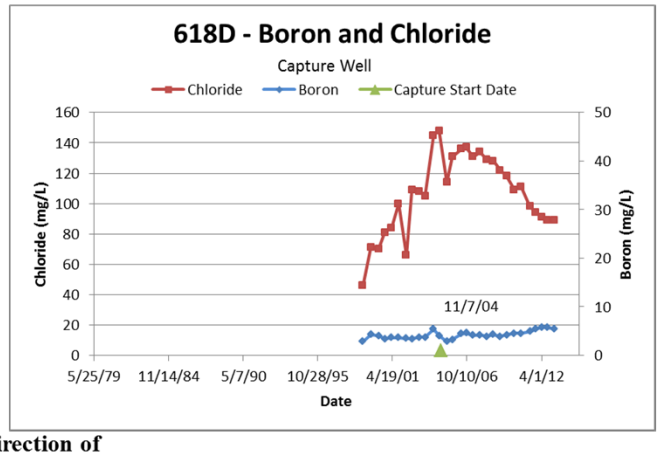


General Direction of Groundwater Flow

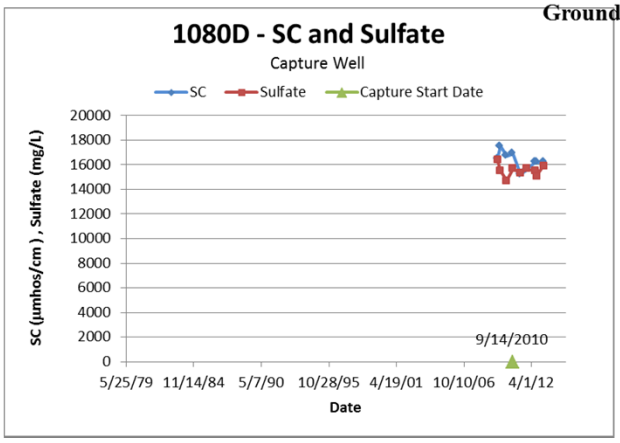


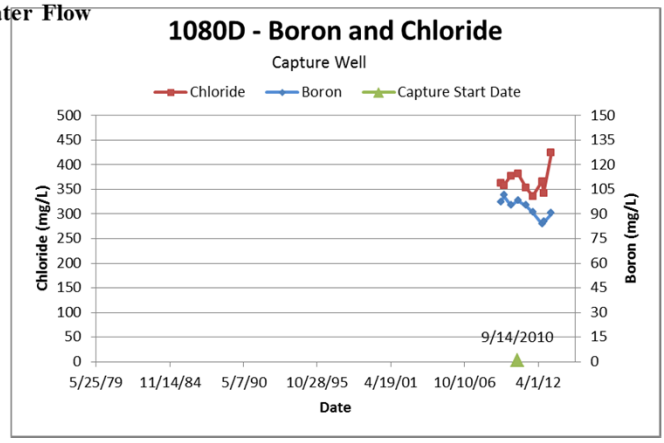






General Direction of Groundwater Flow





PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR BEDROCK WELLS NORTH/NORTHWEST OF THE 3&4 EHP	FIGURE 3-22A

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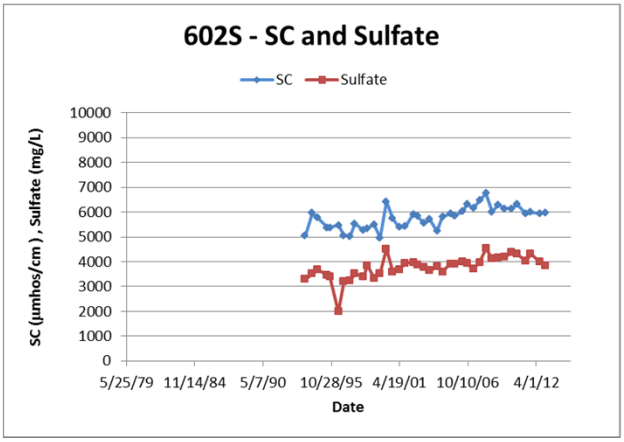
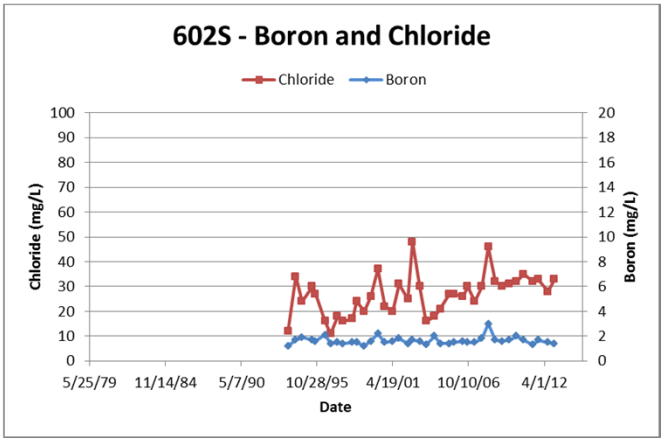
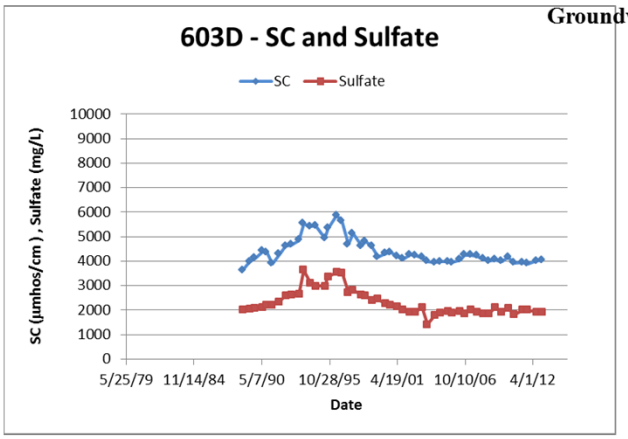
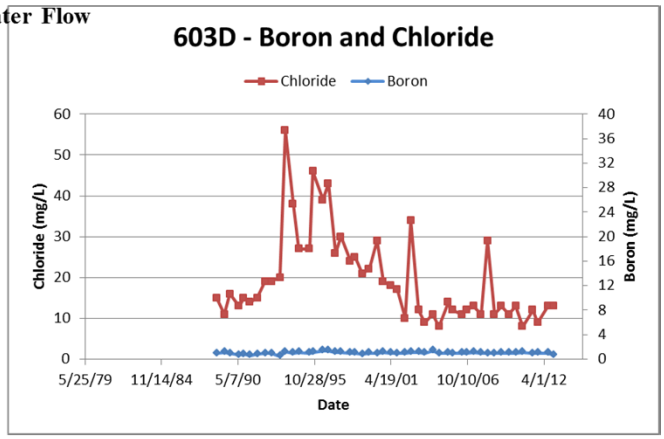
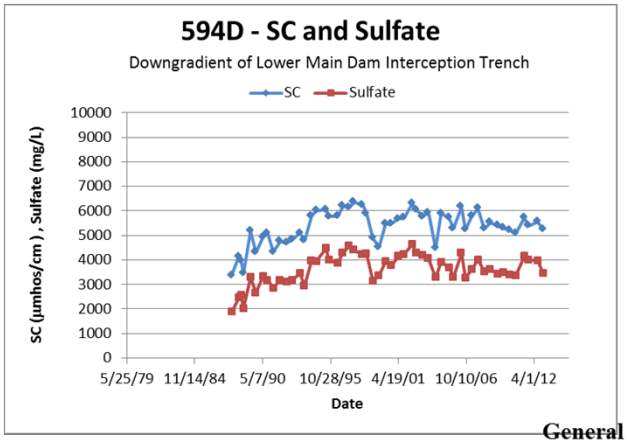


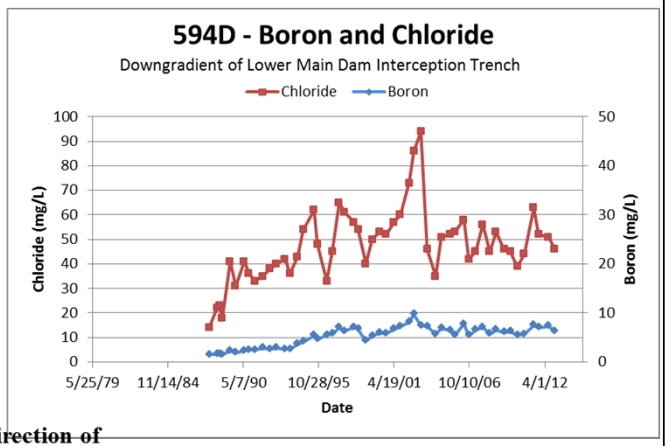


General Direction of Groundwater Flow

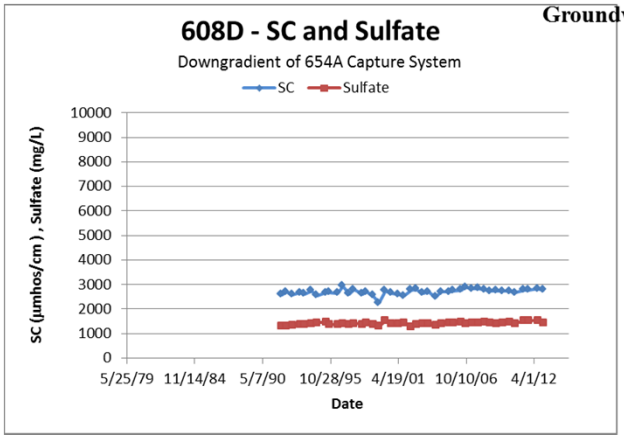


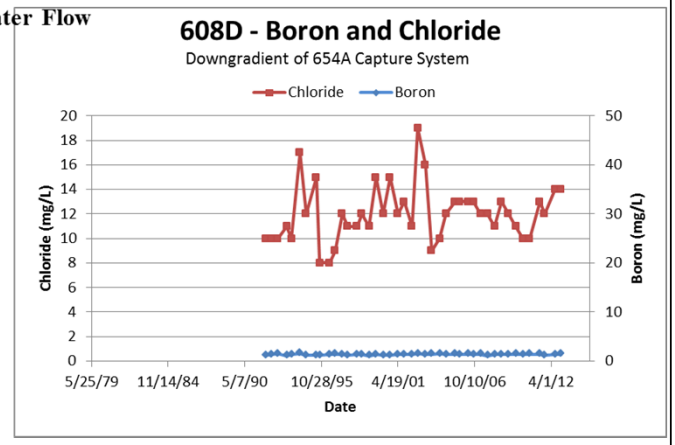






General Direction of Groundwater Flow





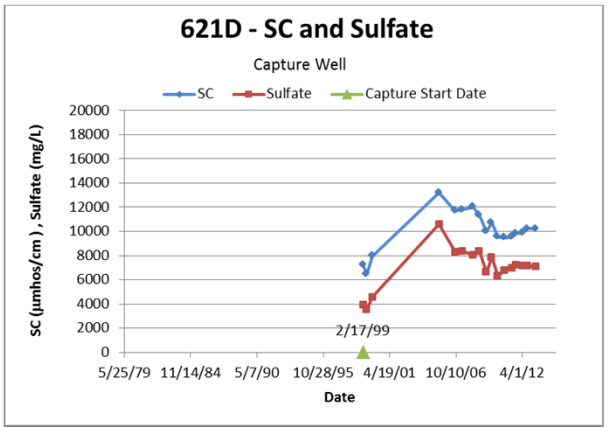
PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR BEDROCK WELLS NORTH OF THE 3&4 EHP MAIN DAM	FIGURE 3-22B

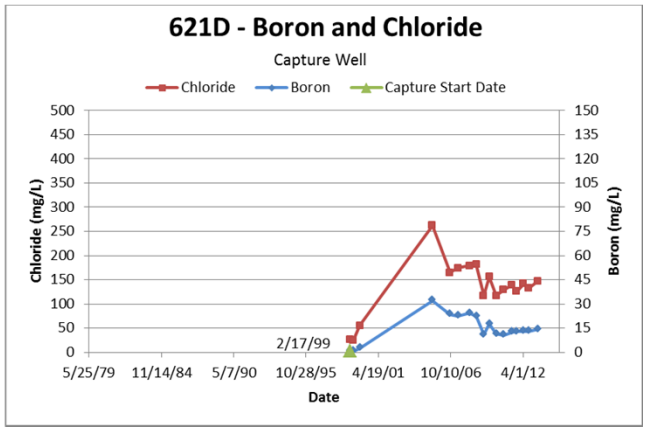
after process water was found issuing to the ground surface in December of 1999. The interception trench is still in operation and collects groundwater from shallow substrates at depths consistent with the bottom of the McKay Coal east of the Saddle Dam. Other capture locations east of the Saddle Dam include bedrock wells 556D, 609D, 610D, and 621D – located outside of the northeast corner of the 3&4 EHP – and bedrock wells 646D, 647D, and 648D – situated between the Saddle Dam and the 560A Area. A list of capture wells in the Saddle Dam area and their start dates are included in Table 3-3. Water quality graphs for select wells east of the 3&4 EHP Saddle Dam are included in Figures 3-23A through 3-23C. Graphs are presented in the general order of groundwater flow direction; likewise precedes the discussion of effectiveness of groundwater remediation in this area.

SC has decreased by an average of 17 percent at capture wells located outside of the northeast corner of the 3&4 EHP Cell G (i.e. 556D, 609D, 610D, and 621D); and values of other process water indicator parameters are following the same trend of improvement. A plot of water quality at well 621D is included in Figure 3-23A to exemplify the trend.

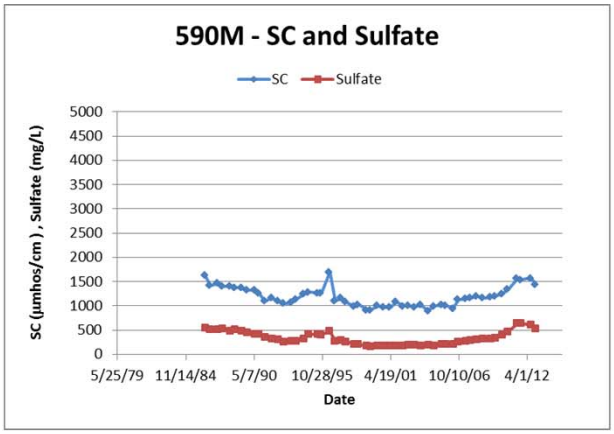
Groundwater quality in the McKay Coal interval east of the 3&4 EHP Saddle Dam is variable. For example, well 590M has exhibited no apparent process water impacts; while, an obvious trend of declining water quality is evident at well 632M, where only residual clinker from burning of the McKay remains (Figure 3-23A). The Saddle Dam Interception Trench was constructed to, or through, the base of the McKay Coal interval; so shallow groundwater upgradient of the trench has not been the target of additional mitigation measures. The McKay Coal is absent downgradient of the Saddle Dam Interception Trench.

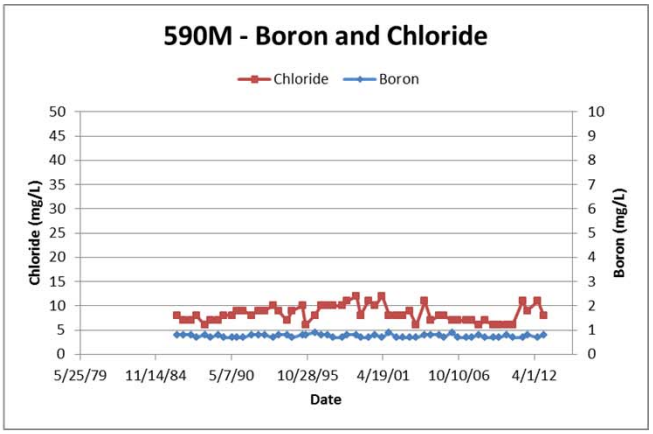
Other mitigation measures between the Saddle Dam and the 560A Area include bedrock wells 646D, 647D, and 648D. Recently measured SC values for this set of capture wells are 11 to 45 percent lower than the worst SC values recorded at these sites. Water quality graphs for these wells are presented in Figure 3-23B; and indicate distinctly different trends in process water indicator parameters. Specifically, water quality at well 646D has improved markedly since capture began; water quality at well 647D has been fairly consistent; and



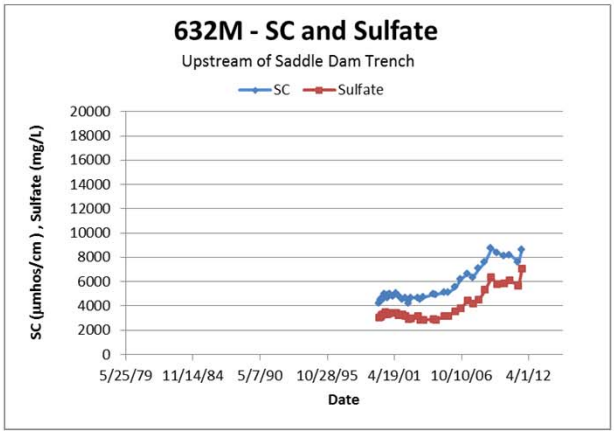


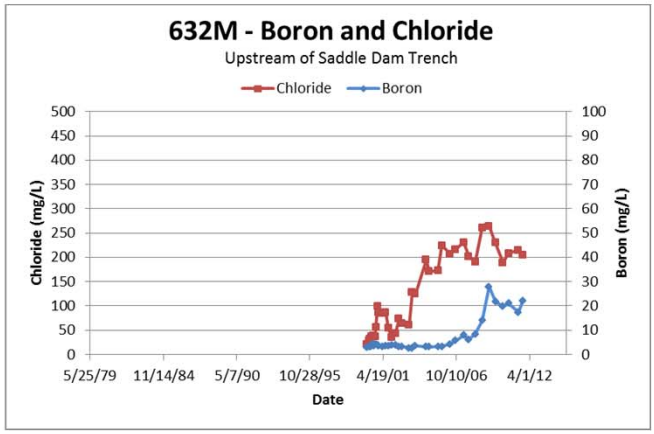
General Direction of Groundwater Flow



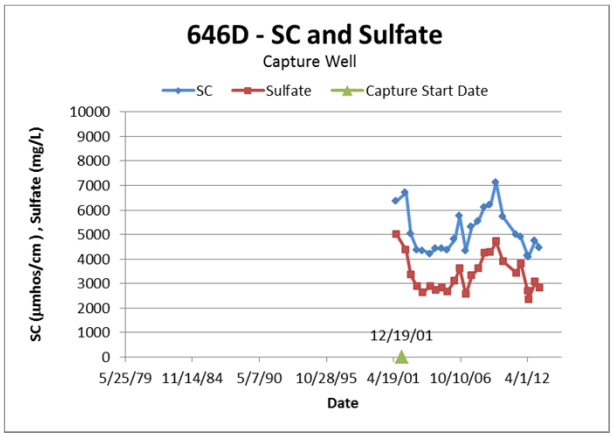


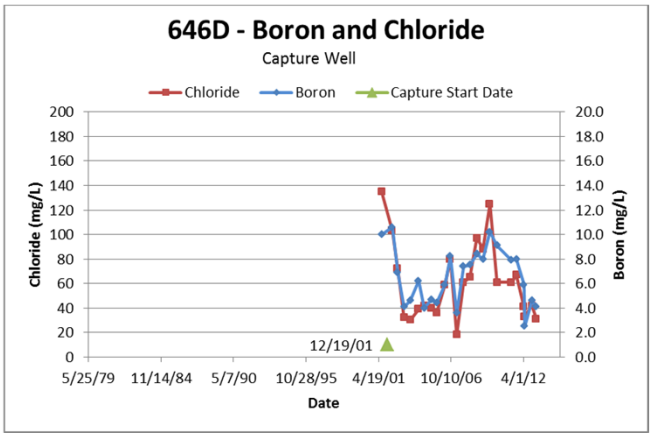
General Direction of Groundwater Flow



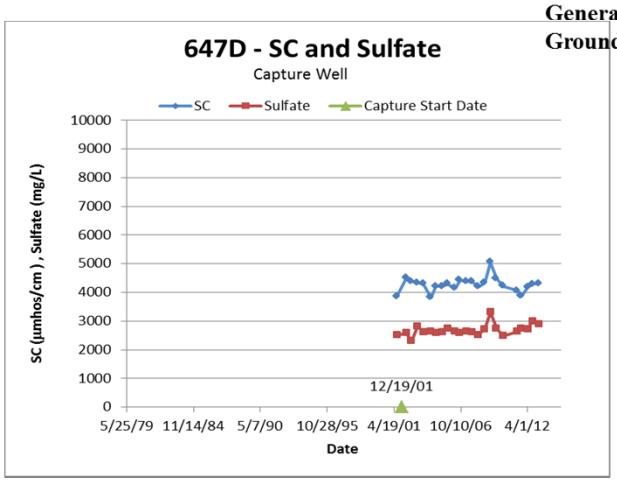


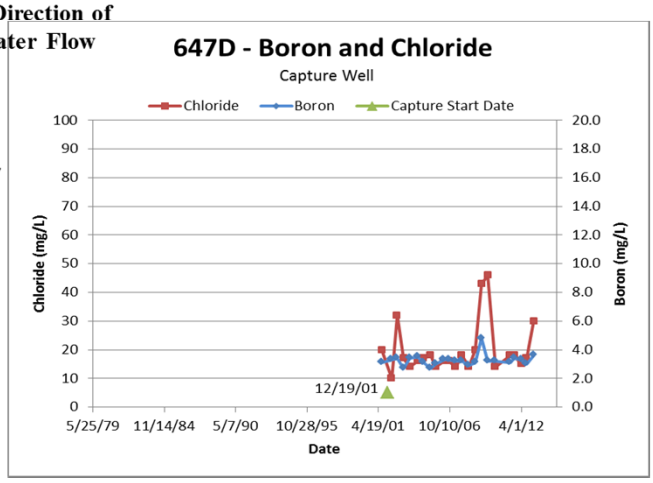
PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR WELLS EAST OF THE 3&4 EHP SADDLE DAM	FIGURE 3-23A

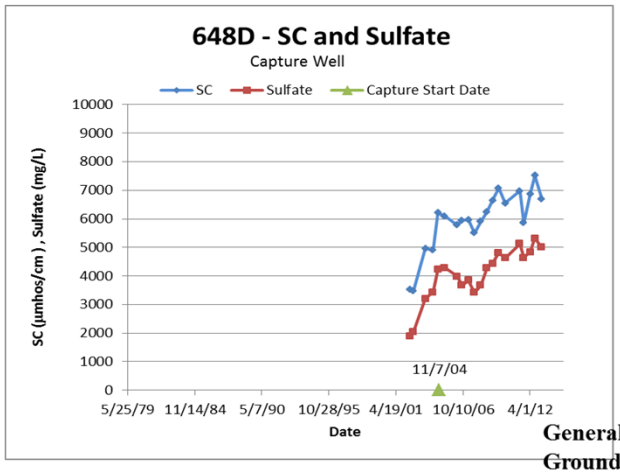


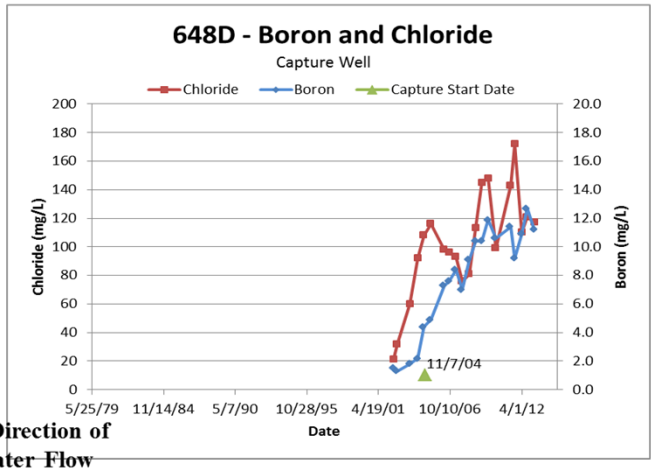


General Direction of Groundwater Flow

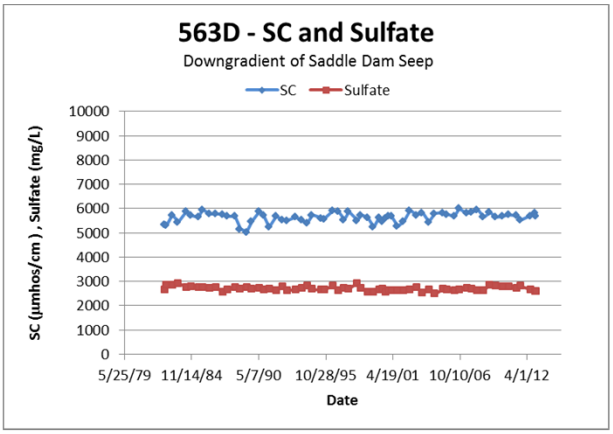


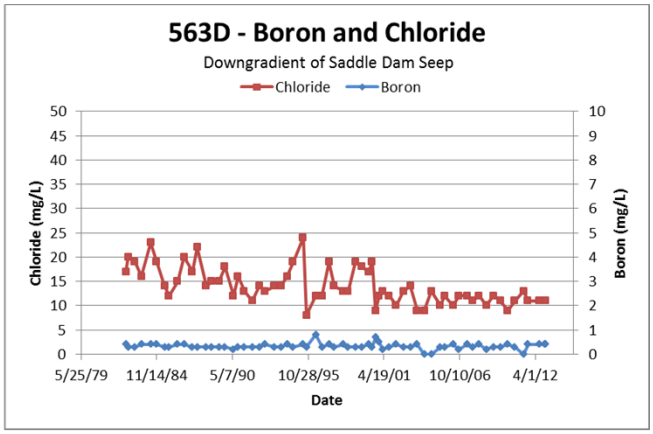






General Direction of Groundwater Flow





PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR WELLS EAST OF THE 3&4 EHP SADDLE DAM	FIGURE 3-23B

H:\Projects\PPLMT\12073 3&4 EHP AOC\WQ_GRAPHS

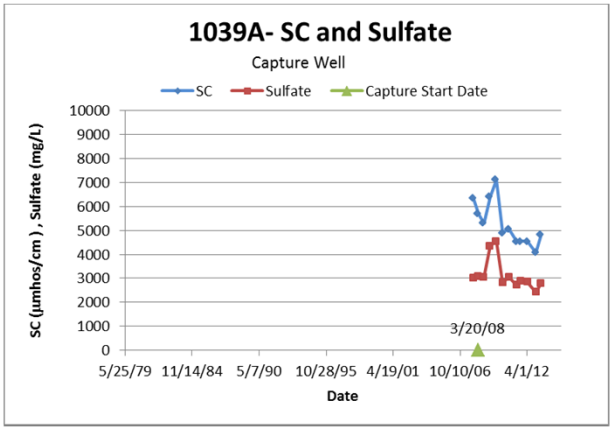
water quality at well 648D has generally declined throughout the period of record. A laboratory SC of 7,510 µmhos/cm was measured at well 648D in August of 2012; however, the average field SC from measurements made over the most recent six month period of available data was 6,605 µmhos/cm. The initial decline in groundwater quality at well 648D is not uncommon of a pumping well that is inducing flow from a source of process water impacts. The absence of the declining groundwater quality trend nearby capture wells 646D and 647D and several monitoring wells suggests that the impacts at 648D are localized. Water quality graphs for well 563D are included in Figure 3-23B and indicate that process water impacts are not widespread in bedrock east of the 3&4 EHP Saddle Dam.

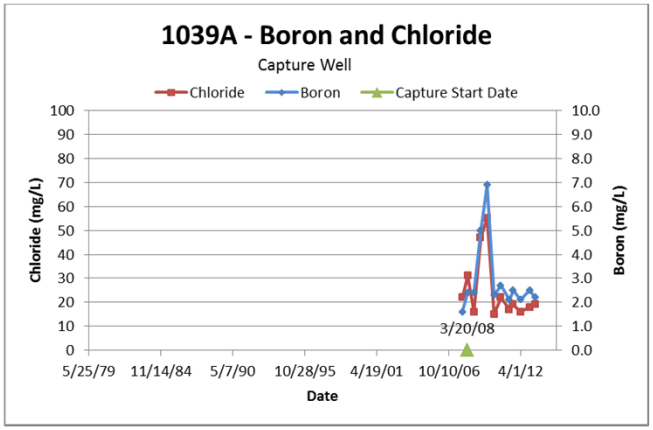
As noted, extensive groundwater investigation and capture has been initiated in the 560A Area east of the 3&4 EHP Saddle Dam. Water quality mitigation efforts have focused on both alluvial and bedrock groundwater. The average decrease in SC between the latest six month average and the highest recorded value for all sites in the 560A Area is 23 percent. Water quality graphs of representative sites in the 560A Area are presented in Figure 3-23C. Well 1039A is not commonly associated with the 560A Area; but capture was initiated there on the same day as the 560A-Trench. The water quality graph of well 1039A is included in Figure 3-23C). SC at well 1039A over the most recent six-month period is 26 percent lower than the highest recorded value.

Well 1099D is a capture well in the 560A Area adjacent to the property boundary. The well is completed in shallow sandstone and has an estimated yield of 15 gpm. Well 1099D was converted to a capture well and became operational in April 2010. Since that time water quality has shown an overall improving trend. For example, concentrations of TDS have dropped from 6,740 mg/L to 4,560 mg/L, chloride from 46 to 20 mg/L, sulfate from 4,530 to 2,930 mg/L and dissolved boron from 5.1. to 2.2 mg/L (Figure 3-23C).

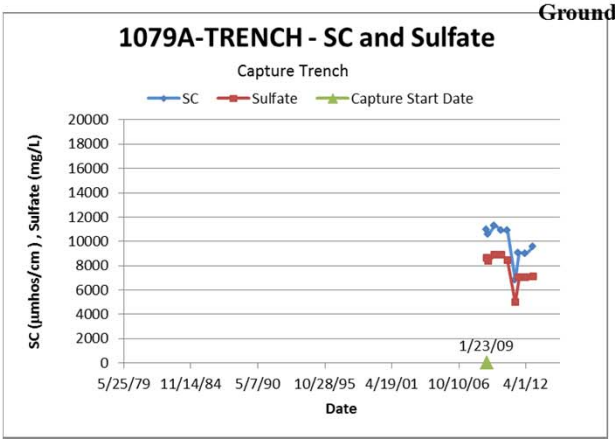
3.6.4 EHP South and Southwest Side

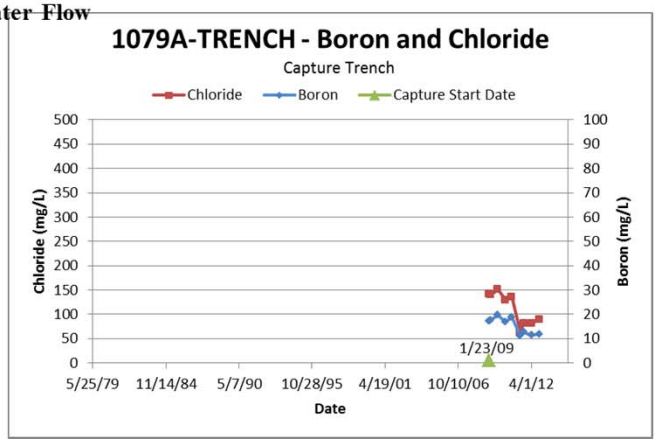
Capture wells 694R, 695R, 1001R, 1002R, 1007R 1016R, and 1017R are completed in Rosebud Clinker are operated outside of the bentonite amended concrete cutoff wall on the

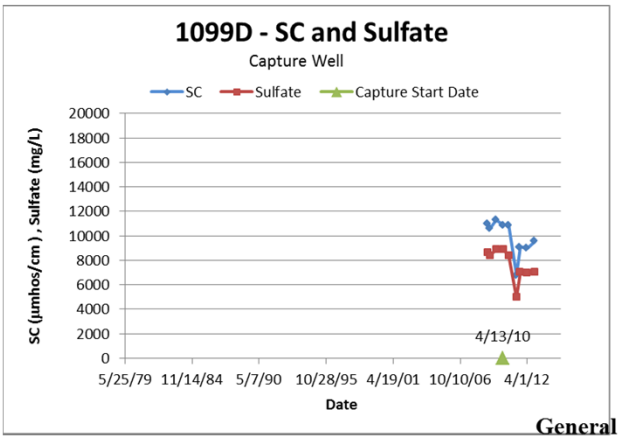


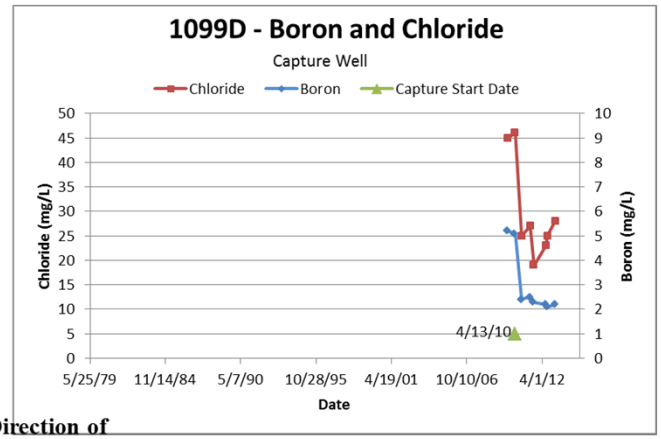


General Direction of Groundwater Flow

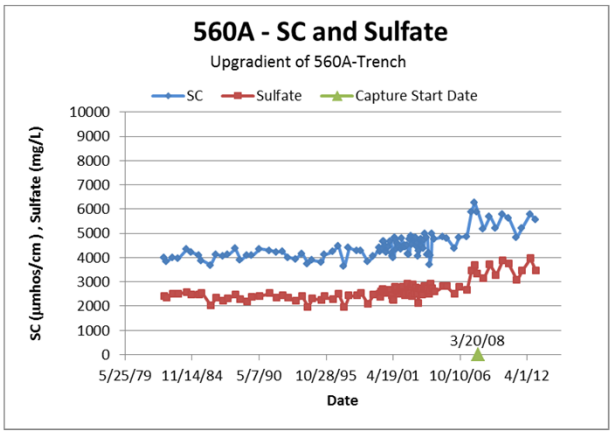


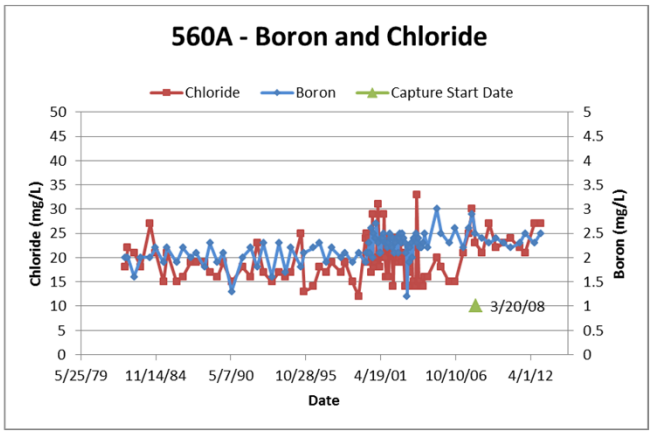






General Direction of Groundwater Flow





PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR WELLS EAST OF THE 3&4 EHP SADDLE DAM	FIGURE 3-23C

H:\Projects\PPLMT\12073 3&4 EHP AOC\WQ_GRAPHS

south and southwest side of the 3&4 EHP. The wells were installed to collect process water that entered the interval during 2004 (see Hydrometrics, June 2005). After startup during late 2005, these wells were capturing groundwater at a total pumping rate of about 445 gpm. Rates have dropped of substantially since the pumping started and as of 2013 the wells were only pumping at a combined rate of about 16 gpm, with all but about 3 gpm coming from wells 1002R and 1017R. Water levels at 1016R had dropped below the contact of the clinker and underlying bedrock and it was essentially dry. Well 676R was initially evaluated for groundwater capture but upon testing it was discovered the water levels were near the clinker-bedrock contact and yields could not be sustained for effective capture.

Groundwater yield at these (1016R - 0 gpm, 1017R - 6.6 gpm, and 1002R – 0.8 gpm etc.) wells is currently low to very low; but SC measurements indicate a water quality signature that is consistent with minimally diluted process water. Combined yield at these three wells was in excess of 600 gpm at the beginning of groundwater capture. Groundwater is not commonly present in this interval in this area due to the high permeability and limited precipitation recharge that occurs. Regional groundwater flow through this area does not occur so an influx of better quality does not occur and improvements to water quality rely on precipitation recharge. Comparison of average SC values measured during the past six months, compared to the highest values for the wells, shows that SC has decreased by 10 to 58 percent, indicating a marked improvement of water quality. As noted above, well 1016R was also operated as a capture well south of the 3&4 EHP. This well dried up after less than one year of pumping after exhibiting several months of steady groundwater quality improvement.

Well 696R is located at the southwest corner of the ponds. This well showed pond water impacts when installed as part of the 2005 investigation of the SFCC seep. SC at this well was initially 14,900 µmhos/cm. Water quality improved rapidly and significantly after groundwater capture started at the abovementioned wells. By June 2012, measured SC had dropped to 4210 µmhos/cm. Rapid water quality recovery at this well suggests an area of rapid precipitation recharge with limited horizontal flow through the area near the well.

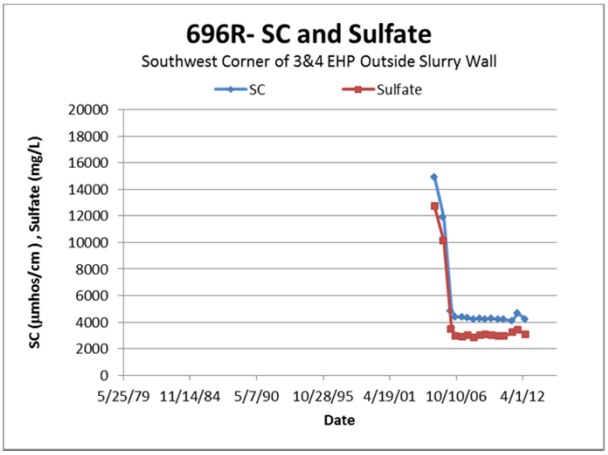
Water quality graphs for wells 696R, 1001R, 1002R, and 1007R are presented in Figure 3-24.

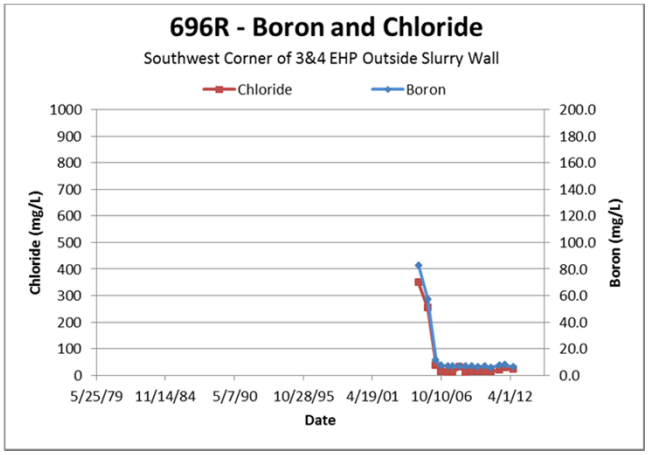
The changes in water quality at well 696R were heavily influenced by groundwater capture at well 1002R given the rapid improvement in quality and lowering of the water levels shortly after pumping began. As previously mentioned, well 1002R is located on the south side of the 3&4 EHP cutoff wall. It was started for capture in September 2005. The base of the Rosebud Coal interval at well 1002R forms a small structural depression lending to effective capture in an unconsolidated unit.

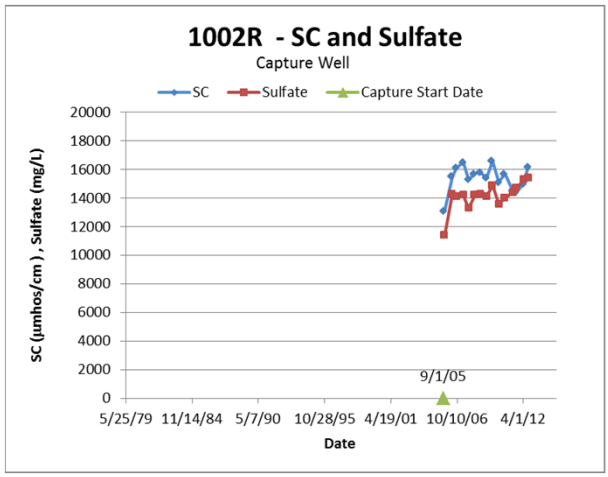
Water quality graphs for monitoring wells 1036R and 588D and for capture well 695R are included in Figure 3-25. As indicated by the "R" designation, wells 1036R and 695R are completed in clinker of the Rosebud Coal. Water quality graphs for each of these wells indicate a high degree of process water impacts, albeit with a distinct trend of improvement. Well 588D is completed in sub-McKay bedrock. Throughout the period of record, groundwater at well 588D has remained un-impacted. Sub-McKay bedrock west of the 3&4 EHP has remained largely un-impacted by process water, owing possibly—at least in part—to effective capture in upper hydrostratigraphic intervals.

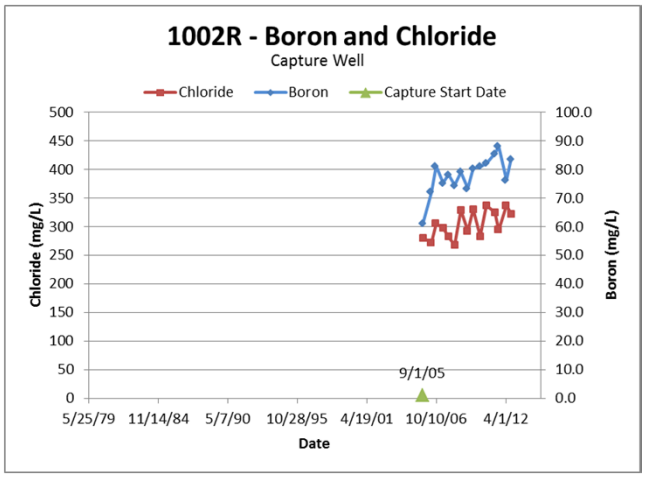
3.6.5 South Fork Cow Creek

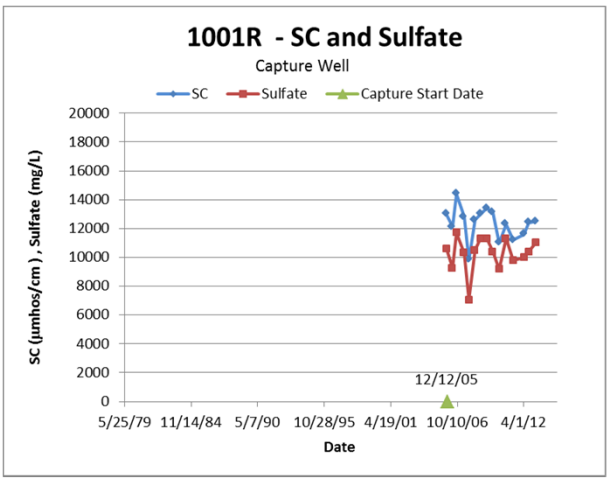
Extensive groundwater mitigation measures have been put in place in the SFCC drainage south of the 3&4 EHP in response to the SFCC seep (Hydrometrics, June, 2005). The 22 capture locations installed in SFCC primarily targeted groundwater in alluvium and McKay Coal in direct contact with alluvium; these sites are listed in Table 3-3. The current average of SC observations at all SFCC capture wells is 26 percent less than the average of the highest SC measurements at the same wells. Examples of declining SC and improved water quality in the SFCC drainage are presented in Figures 3-26A and 3-26B. Monitoring well WA-137 is installed in alluvium up-gradient of all SFCC capture wells. Water quality observations at the monitoring well are not indicative of process water impacts. The highest recorded SC at capture wells 1019AM and 1024AM was 8,330 µmhos/cm and 8,920

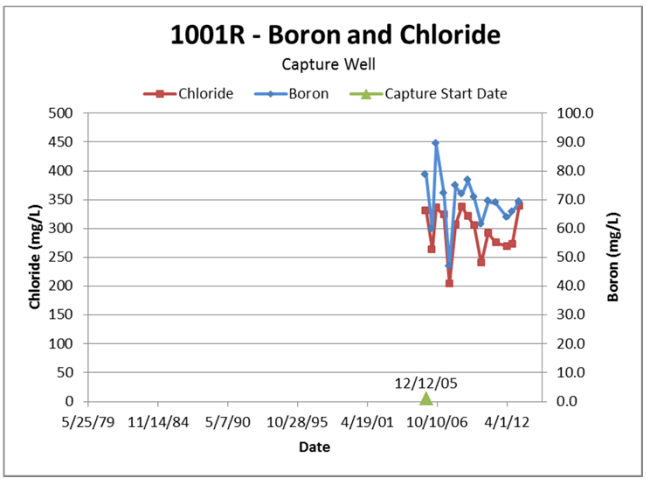


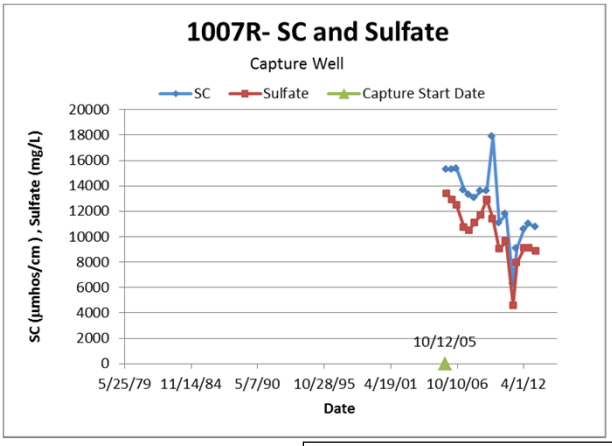


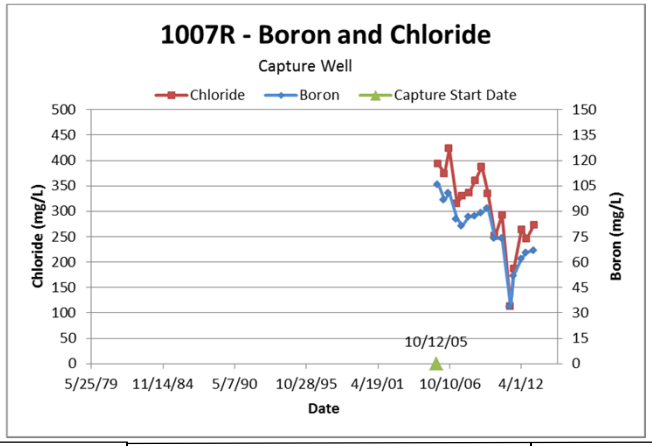






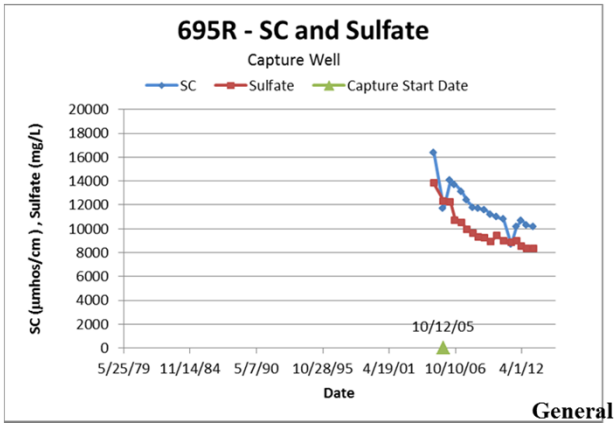


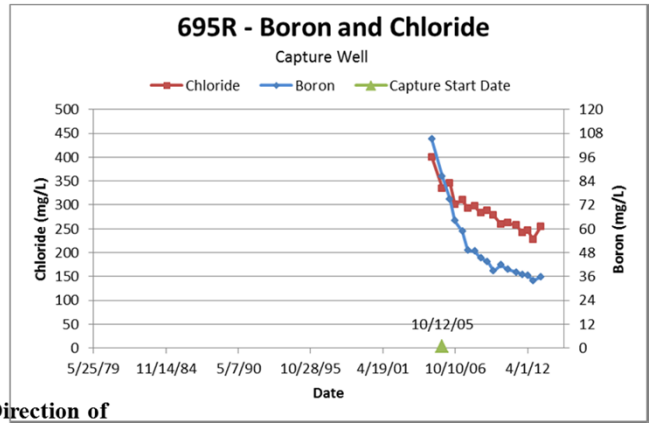




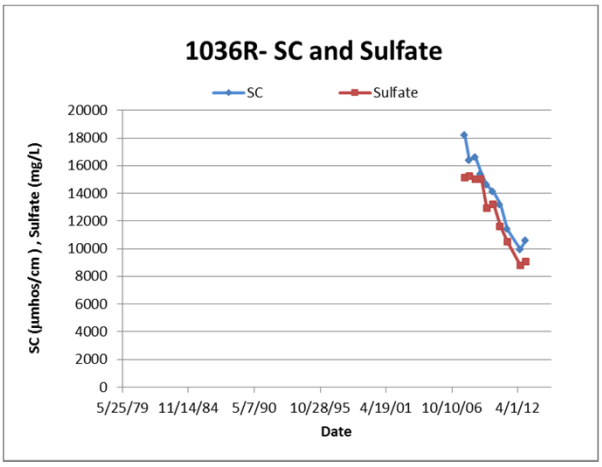
PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR WELLS SOUTH/ SOUTHWEST OF 3&4 EHP	FIGURE 3-24

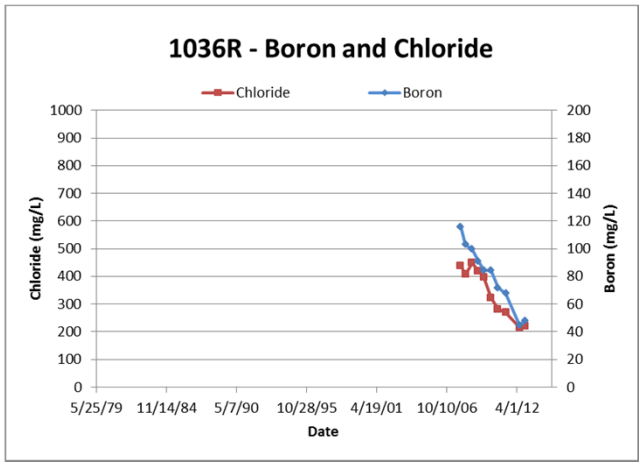
H:\Projects\PPLMT\12073 3&4 EHP AOC\WQ_GRAPHS



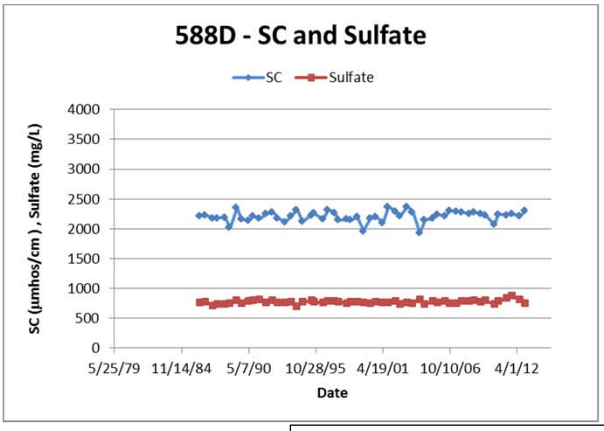


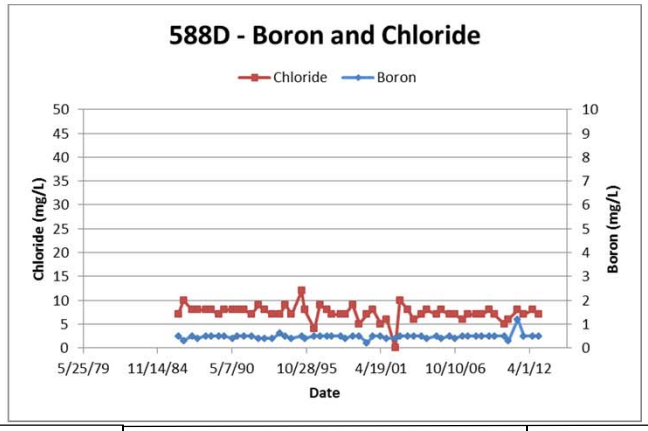
General Direction of Groundwater Flow



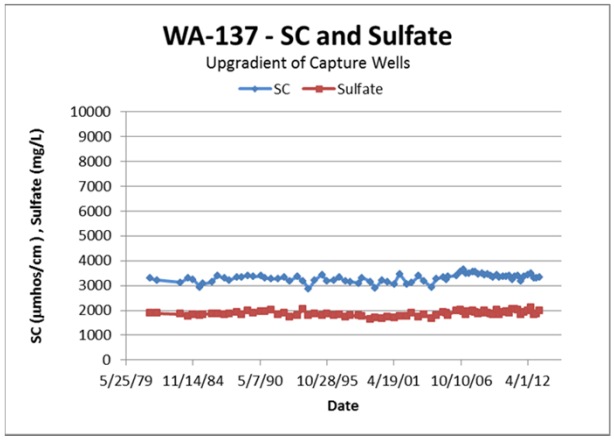


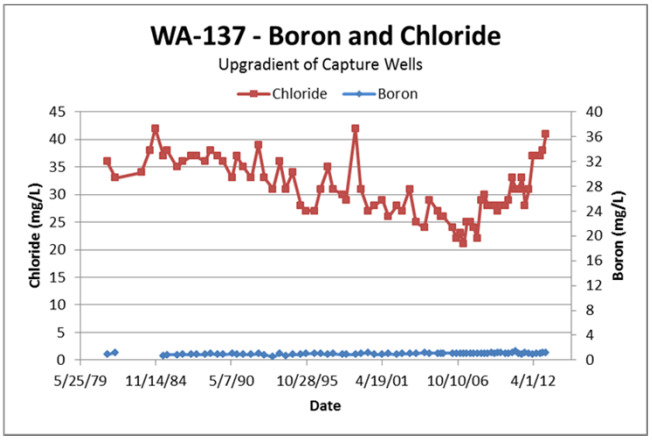
General Direction of Groundwater Flow



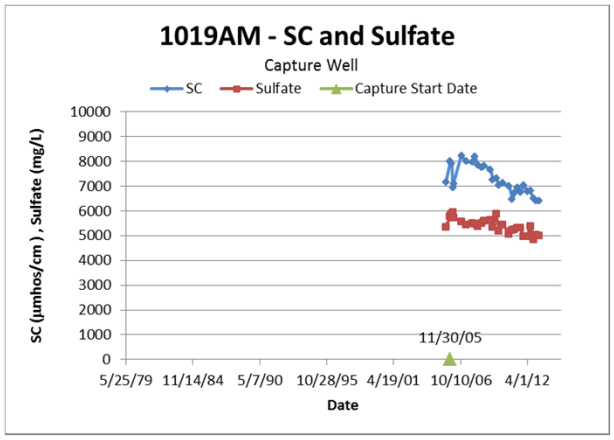


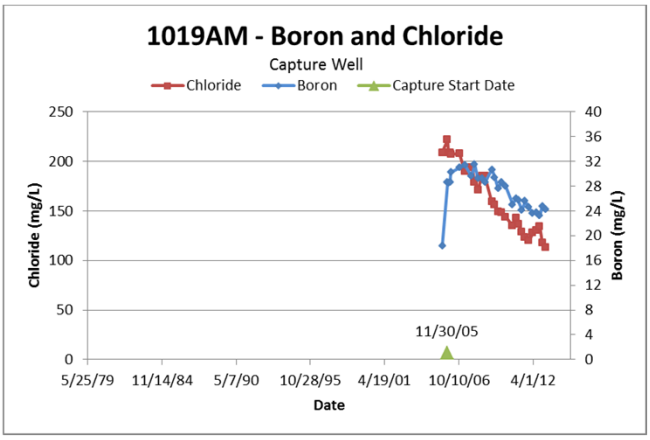
PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR WELLS COMPLETED WEST/ SOUTHWEST OF 3&4 EHP	FIGURE 3-25



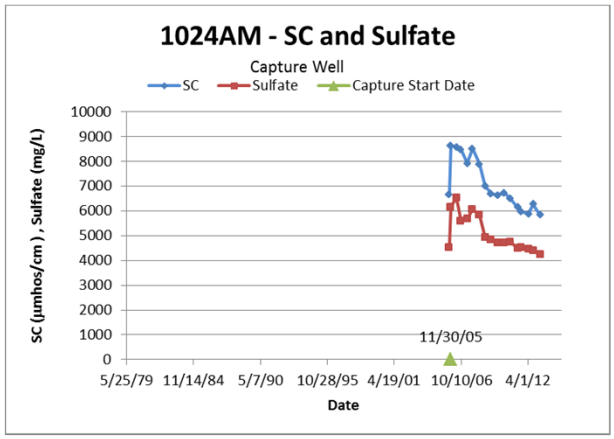


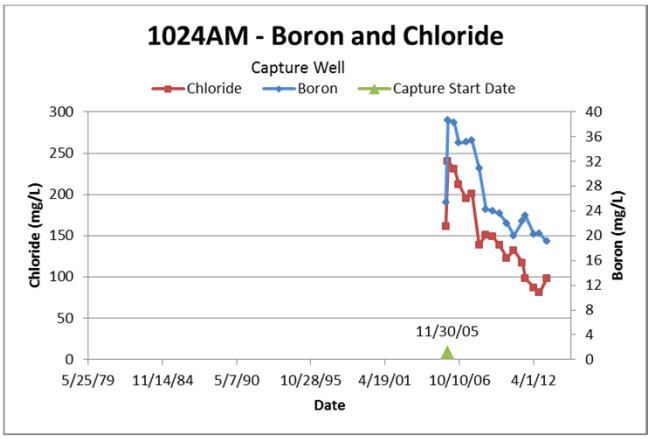
General Direction of Groundwater Flow



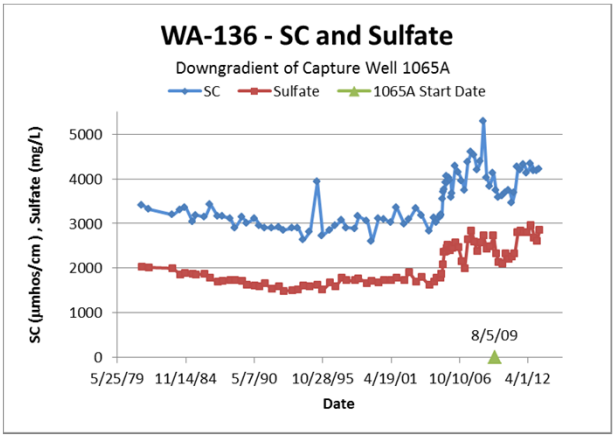


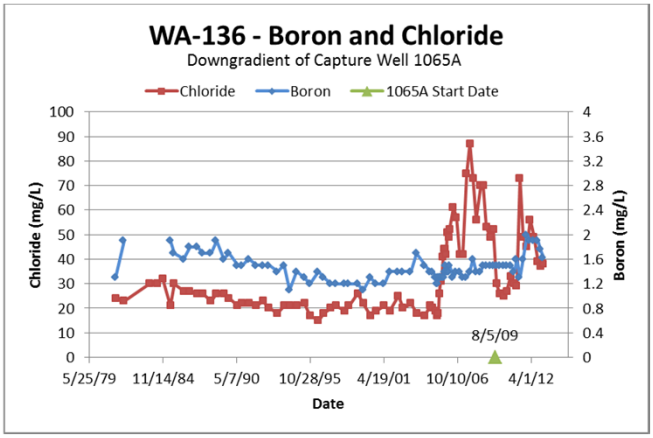
General Direction of Groundwater Flow



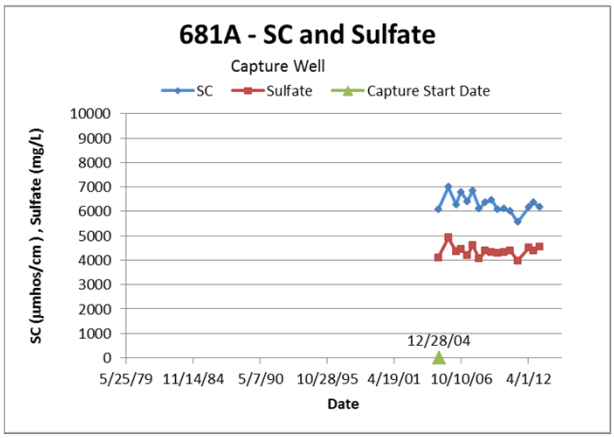


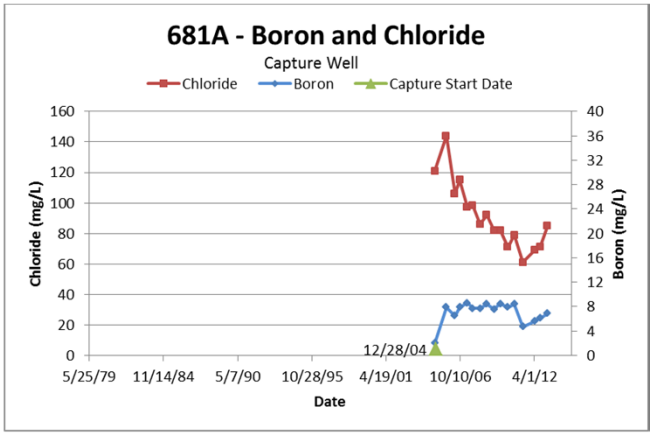
PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR WELLS IN SOUTH FORK COW CREEK AREA	FIGURE 3-26A





General Direction of Groundwater Flow





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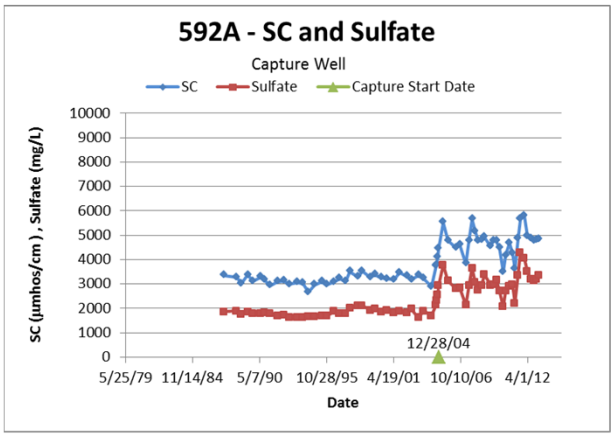
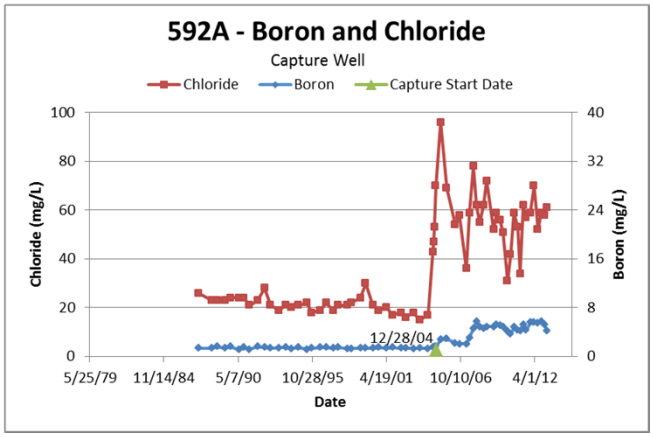




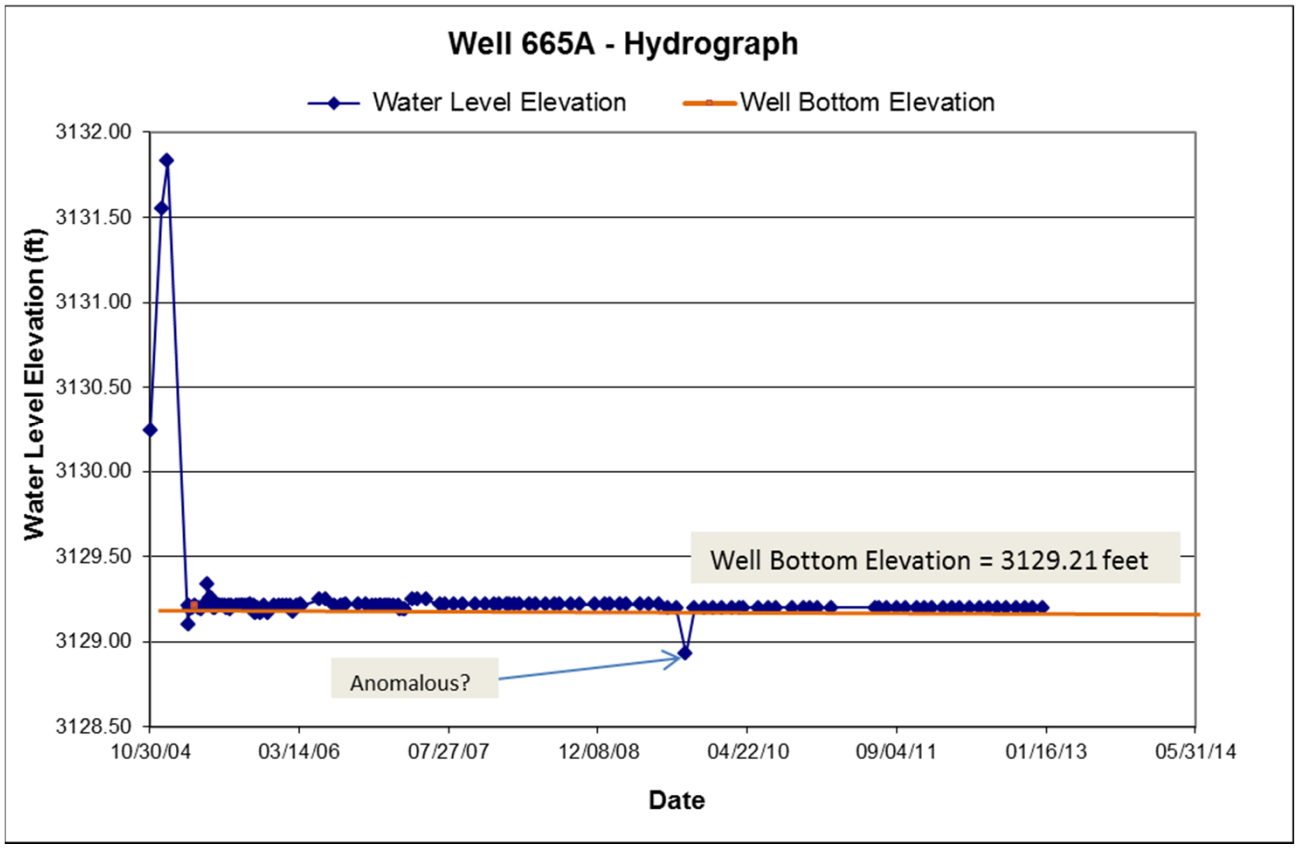
PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR WELLS IN SOUTH FORK COW CREEK AREA	FIGURE 3-26B

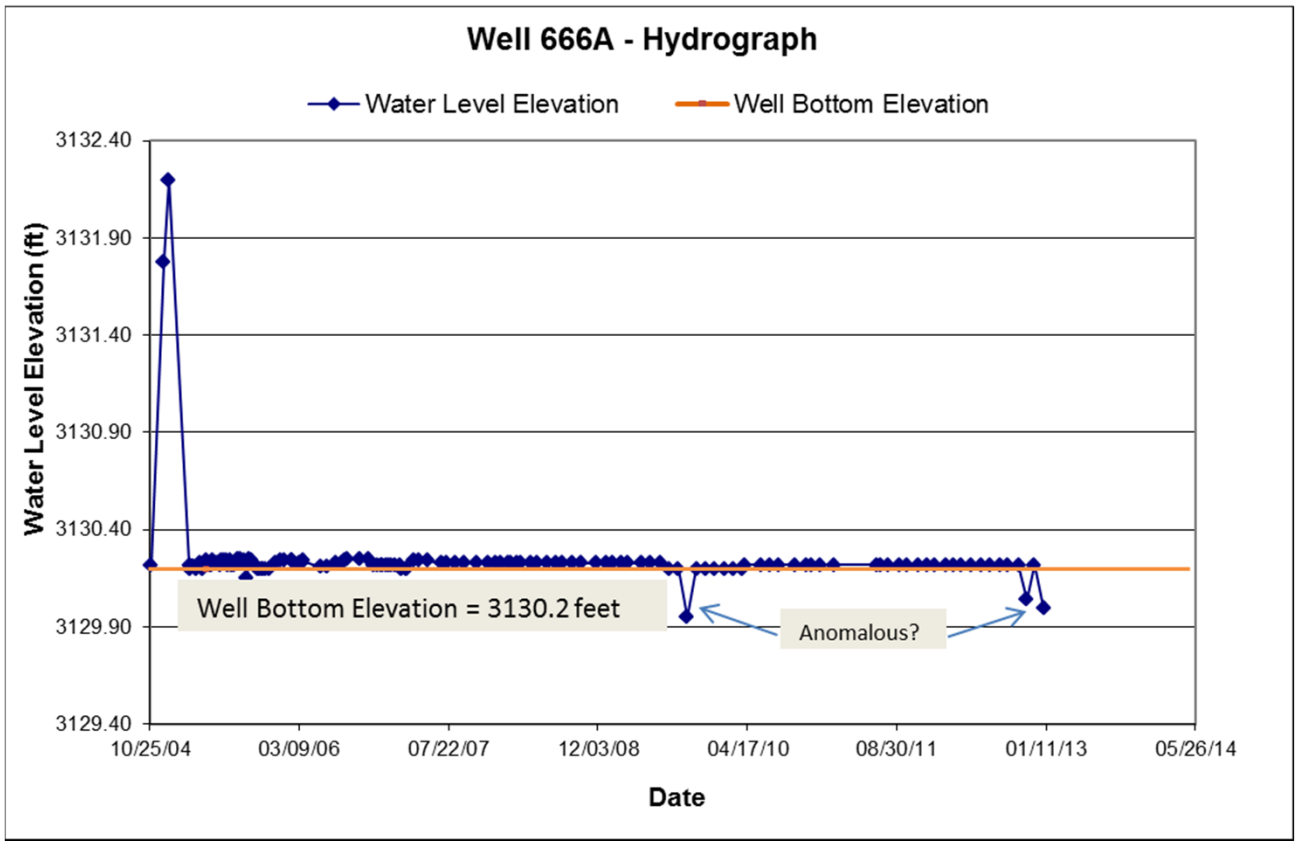
H:\Projects\PPLMT\12073 3&4 EHP AOC\WQ_GRAPHS

µmhos/cm, respectively. The latest six month averages at the corresponding wells are 6,827 µmhos/cm and 5,555 µmhos/cm, which equates to reductions of 18 percent and 38 percent.

Long term water quality records at monitoring well WA-136 and capture well 592A exhibit distinct changes in process water indicator parameters shortly after the SFCC Seep of 2004. Recall that the SFCC seep triggered the groundwater mitigation effort in SFCC. Well WA-136 was not converted for capture due to the size of the casing (2 inches); instead, it was paired with capture well 1065A. SC peaked at 5,300 µmhos/cm at well WA-136 in fall of 2008 but began to decline after startup of well 1065A in 2009. SC measurements made in December 2012 at wells WA-136 and 1065A were 4,190 µmhos/cm and 4,370 µmhos/cm, respectively. Well 592A is one of a series of wells located near PPLM's property boundary near the eastern extent of the SFCC capture system. In general, water quality in this area has improved and/or the alluvium has been pumped dry as a result of capture system pumping. Recall, however, that water quality and yield at well 1030A does not appear to be impacted by upgradient capture. Well 1030A is installed about one-half mile downgradient of SFCC capture wells. SC at well 592A for the latest six month period of observation was 4,780 µmhos/cm, as compared to the highest recorded SC of 5,580 µmhos/cm. The difference in observations suggests an improvement SC of 14 percent.

Effectiveness of SFCC capture systems is also measured by their hydrologic control on groundwater at the PPLM property boundary. Hydrologic control is demonstrated in monitoring observations at wells 665A, 666A, 669A, and 670A; which are downgradient of the entire SFCC capture system. Each of these wells was installed in October of 2004 in response to discovery of the SFCC Seep. Water columns of approximately 3 feet were initially present at wells 665A and 666A. Wells 669A and 670A were dry when completed. Shortly after startup of the original SFCC capture system, wells 665A and 666A became dry. Wells 669A and 670A have remained dry throughout operation of the capture system. Recall, however, that water quality and yield at well 1030A does not appear to be impacted by upgradient capture. Well 1030A is installed about one-half mile downgradient of SFCC capture wells. Hydrographs for wells 665A and 666A are included in Figure 3-27. The





PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	HYDROGRAPHS TO DEMONSTRATE HYDROLOGIC CONTROL AT PROPERTY BOUNDARY EAST OF SFCC	FIGURE 3-27

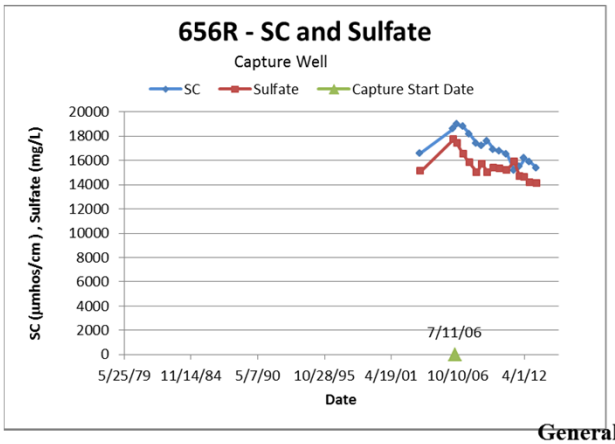
locations of wells in the SFCC Capture System, including those discussed above, are included in Figure 3-17.

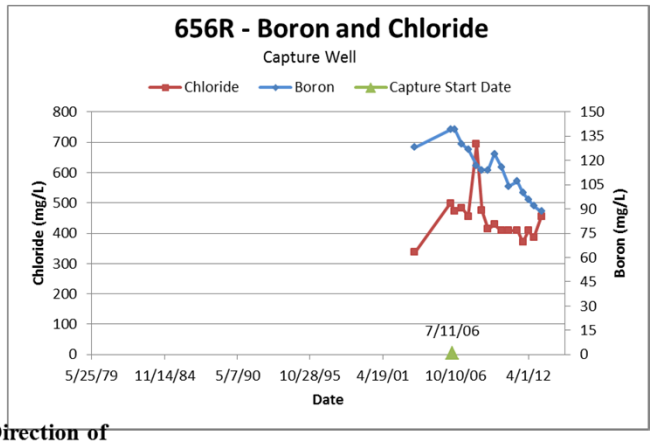
3.6.6 EHP West and Northwest Side

For the sake of this discussion, the EHP West Side includes all monitoring and capture wells installed between the bentonite amended concrete cutoff wall on the EHP west boundary and the SP-15 Trench capture system. The 11 capture locations included in this area are listed in Table 3-3. The average improvement in SC at these wells, when compared to the highest recorded SC measurements, is 33 percent. Relatively large changes in SC in this area are indicative of the effectiveness of both source reduction and groundwater. Noticeable reductions in process water indicator parameters have also been observed at monitoring wells west of the 3&4 EHP. Examples of water quality graphs for select monitoring and capture wells west of the 3&4 EHP are included in Figure 3-28.

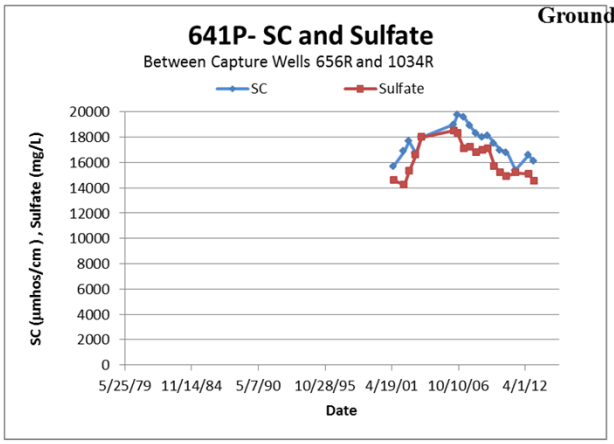
Monitoring well 641P, located between capture wells 656R and 1034R, has shown a declining trend in SC since 2006. A gradual increasing trend in concentrations of some process water indicator parameters has been observed at McKay Coal monitoring well 657M (Figure 3-28). Additional investigation is planned for the McKay Coal interval in this area in fall/winter 2013.

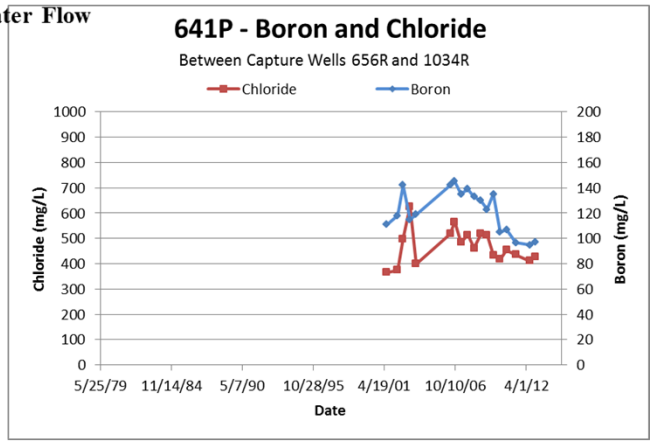
Trends of process water indicator parameters are more erratic at the SP-15 trenches, owing to its shallow construction and influence from precipitation driven recharge. However, the SP-15 capture trenches have been effectively removing groundwater impacted by process water since 2006. SC and concentrations of other process water indicator parameters rose when North SP-15 was initially started because active pumping at the trench induced flow of groundwater impacted by process water. A period of decreasing SC was observed at North SP-15 from 2009 to 2011; likely because the source of impacted groundwater was becoming depleted and/or more dilute (i.e. from increased precipitation in spring 2011). SC over the latest six month period of observation at North SP-15 was 10,577 µmhos/cm; which is a

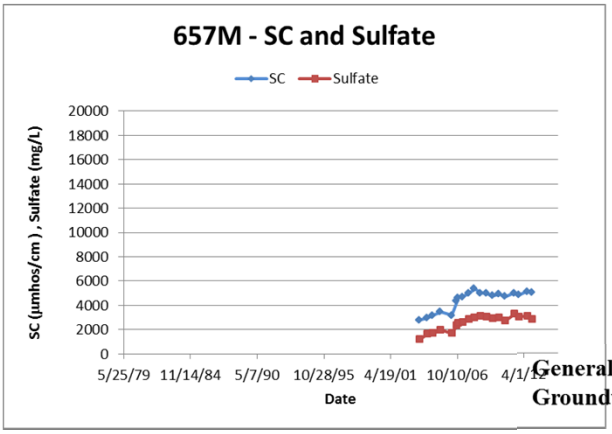


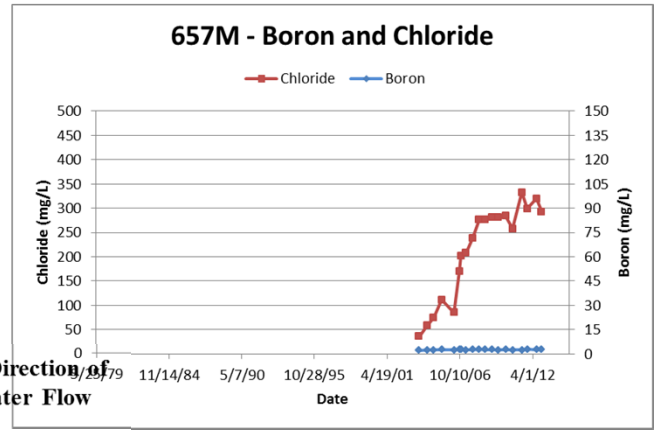


General Direction of Groundwater Flow

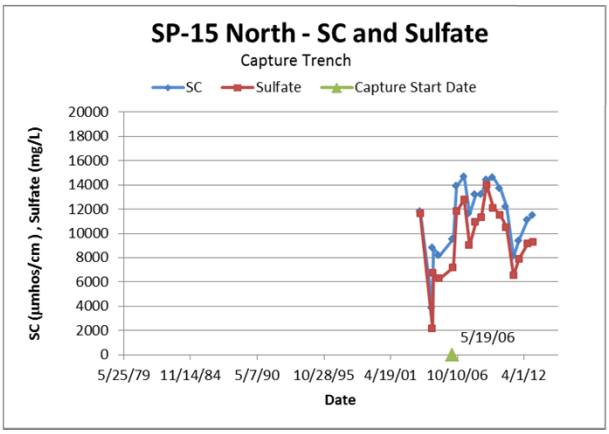


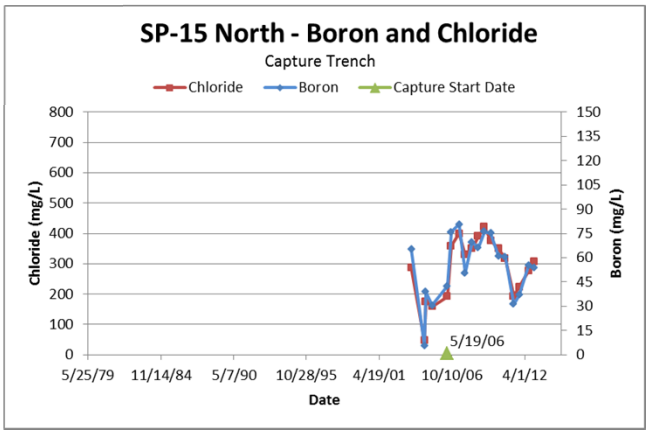






General Direction of Groundwater Flow





PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR WELLS COMPLETED WEST/NORTHWEST OF 3&4 EHP	FIGURE 3-28

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reduction of 28 percent when compared to the highest measurement of record (14,600 µmhos/cm).

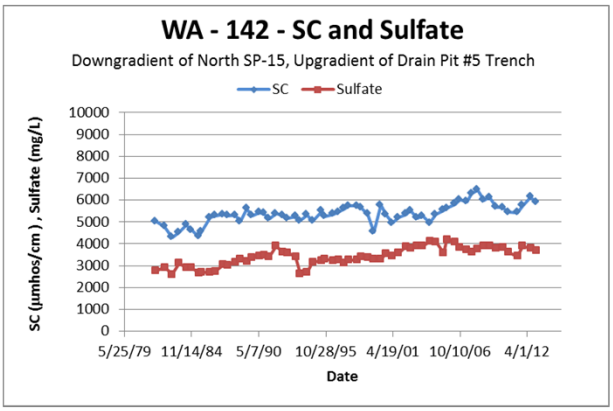
3.6.7 Drain Pit #5 Interception Trench Area

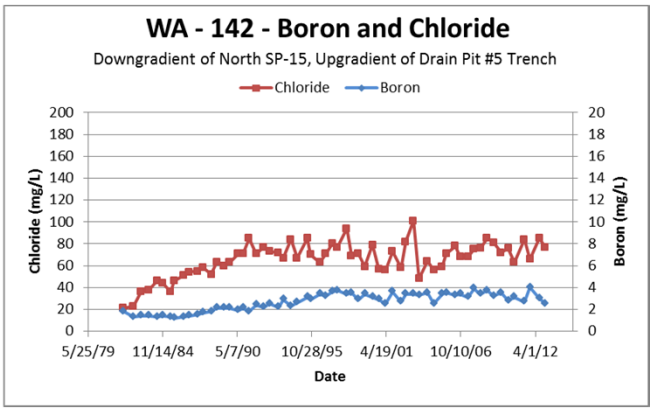
Groundwater capture began at the Drain Pit #5 Interception Trench in 2000 to mitigate potential process water impacts originating from Drain Pit #5. Well WA-135 was pumped to collect impacted groundwater from 1998 to 2000, prior to construction of the trench.

Monitoring well WA-142 is located downgradient of Drain Pit #5 but upgradient of the interception trench. Concentrations of process water indicator parameters at the upgradient monitoring well have shown a gradual increases since operation of the 3&4 EHP began. Well WA-135 is just downgradient of the Drain Pit #5 Interception Trench. Water quality observations at WA-135 mimicked that of WA-142; but concentrations of process water indicator parameters have gone down since pumping from the trench was initiated. Water quality at well 617A-P has also improved since 2000. SC over the latest six month period of observation at the Drain Pit #5 Interception Trench was 5,488 µmhos/cm; which is a reduction of 16 percent when compared to the highest measurement of record (6,540 µmhos/cm). Water quality graphs for sites in the Drain Pit #5 Interception Trench Area are included in Figure 3-29.

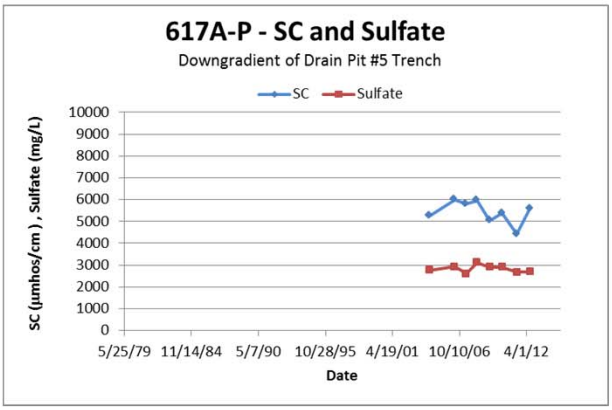
3.6.8 Drain Pit #3 Interception Trench Area

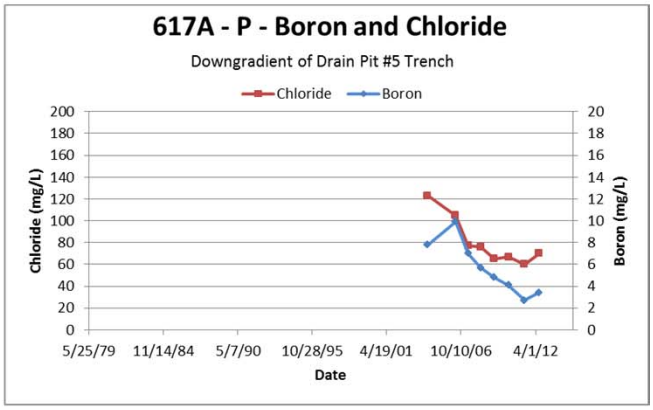
Groundwater capture began at the Drain Pit #3 Interception Trench in 2000 to mitigate potential process water impacts originating from a spill at Drain Pit #3. The alluvium downgradient of Drain Pit #3 contains very little groundwater; as such, the Interception trench typically yields less than two gpm. Monitoring well DP3-637A is located downgradient of Drain Pit #3 but upgradient of the interception trench. Concentrations of process water indicator parameters at well DP3-637A increased from 2000 to 2006, but have exhibited a continuous trend of improvement from 2006 to present. Concentrations of process water indicator parameters at the Drain Pit #3 Interception Trench also rose from 2000 to 2006; but have yet to recede. The discrepancy in water quality trends between the

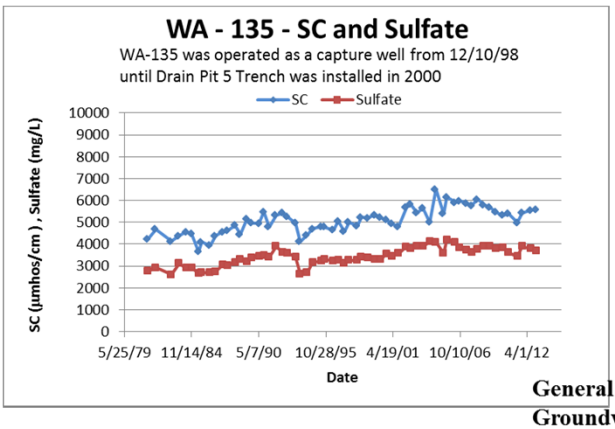


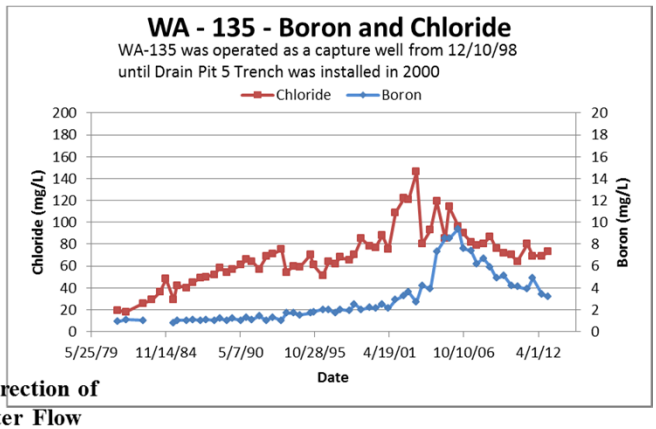


General Direction of Groundwater Flow

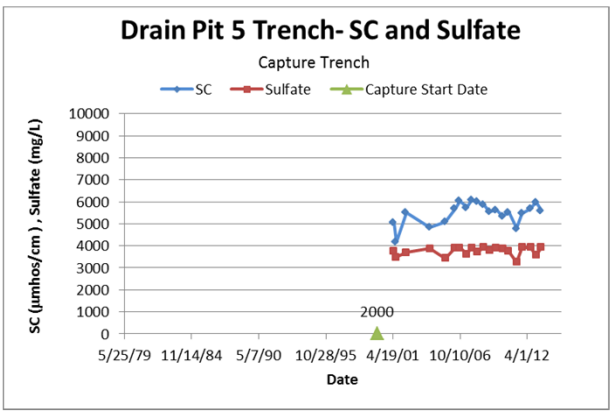


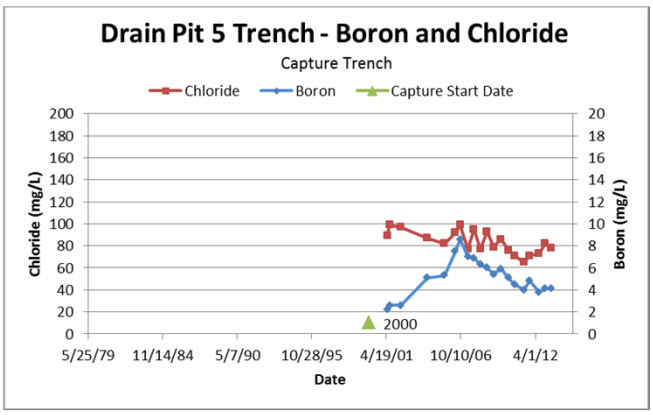






General Direction of Groundwater Flow



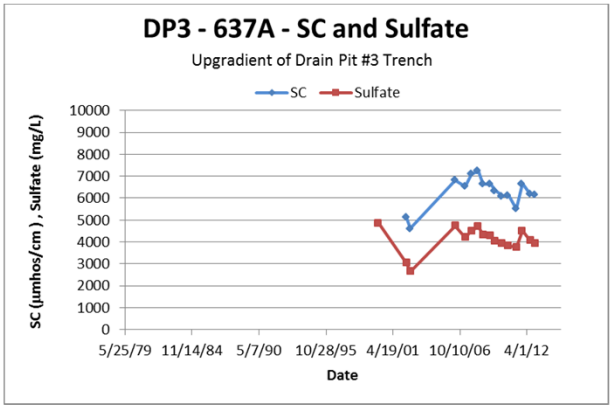


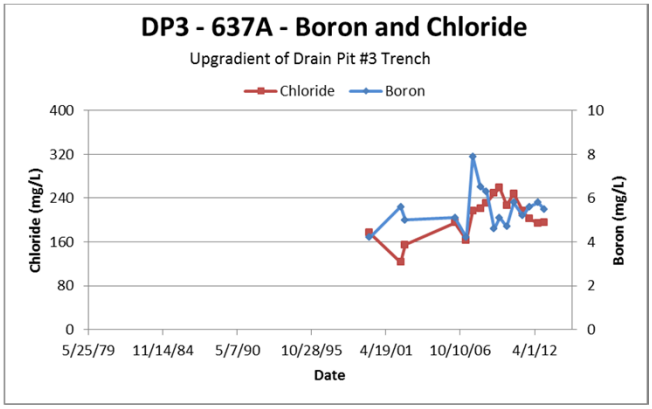
PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR WELLS COMPLETED DOWNGRADIENT OF DRAIN PIT 5	FIGURE 3-29

capture trench and up-gradient monitoring well may indicate that a pulse of impacted groundwater was/is flowing through alluvium of the Drain Pit #3 drainage. The pulse has already traveled beyond monitoring well DP3-637A and is actively being captured by the Drain Pit #3 Interception Trench. Low yield conditions in the alluvium may result in a long period of pumping before changes in water quality are apparent. Water quality observations made during semi-annual sampling at the Drain Pit #3 Interception Trench suggest process water impacts are increasing or remaining steady (Figure 3-30). However, SC observations made over the latest six month period of more frequent observation at the trench averaged 6,625 µmhos/cm; which is a reduction of 19 percent when compared to the highest measurement of record (8,200 µmhos/cm). Well DP3-639D is completed in shallow bedrock downgradient of the Drain Pit #3 Interception Trench. Water quality at this well appears un-impacted by process water. Water quality at well PSW-2 is inconsistent with either the Drain Pit #3 Interception Trench or well DP3-639D; and fluctuations. Water quality monitoring will continue at PSW-2. Water quality graphs for sites in the Drain Pit #3 Interception Trench Area are included in Figure 3-30.

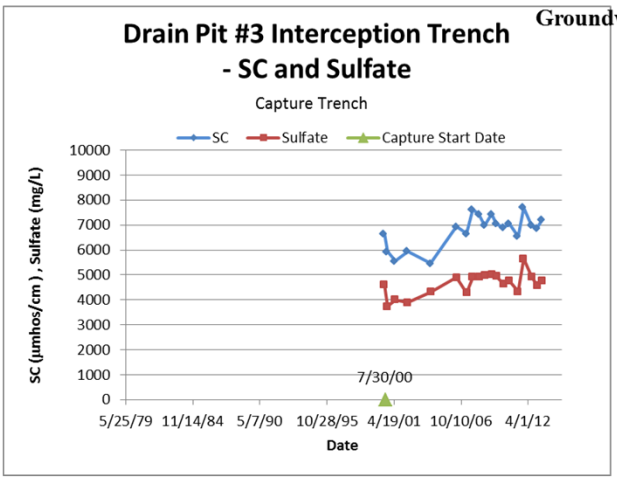
3.7 ON-GOING INVESTIGATIONS/ACTIVITIES

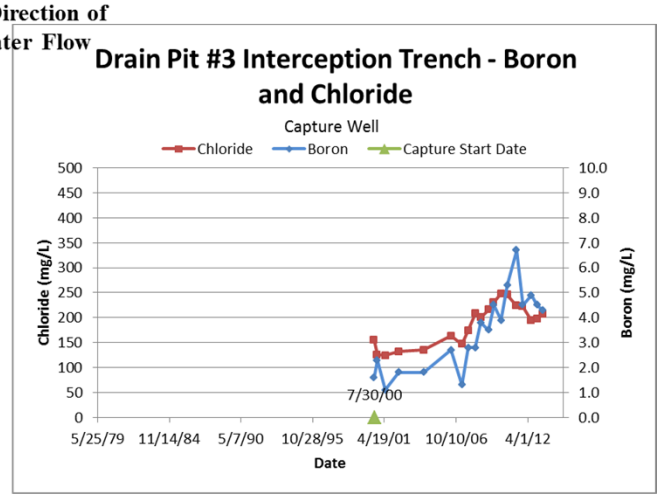
Additional investigation is currently planned or is being conducted in the 3&4 EHP area. PPLM is committed to preventing groundwater impacts through BMPs including the installation of double-lined ponds with leachate collection, paste processing to reduce seepage and water storage requirements, evaporation and water treatment to reduce inventory, extensive groundwater monitoring, and consultation with regulatory agencies. Operational monitoring as discussed will continue. The monitoring program will be revised as additional wells are installed or in response to additional monitoring needs.

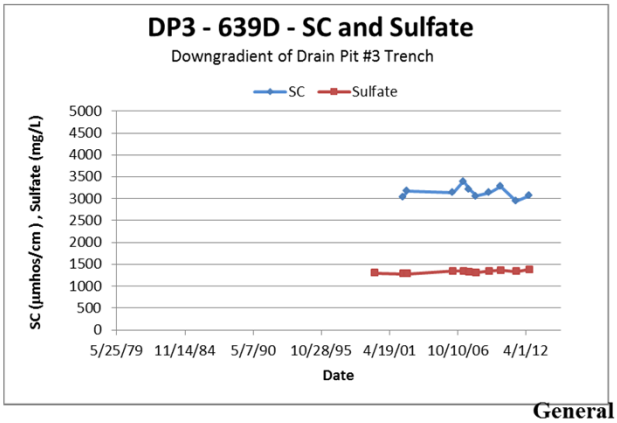


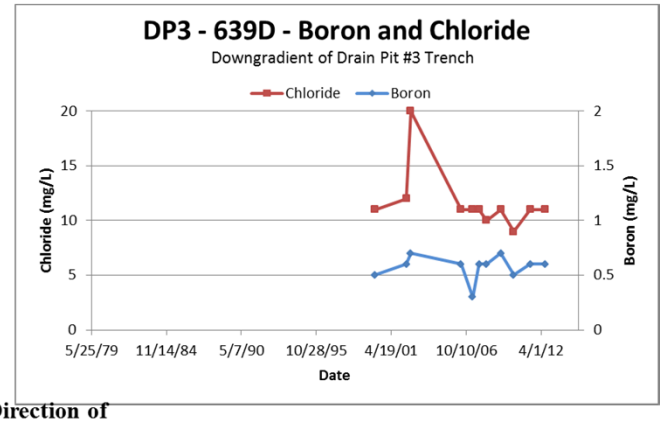


General Direction of Groundwater Flow

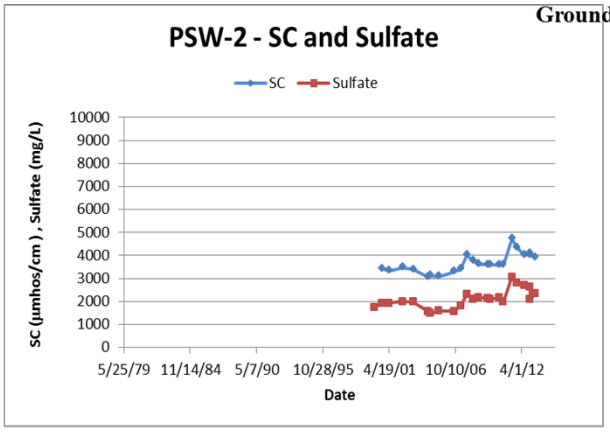


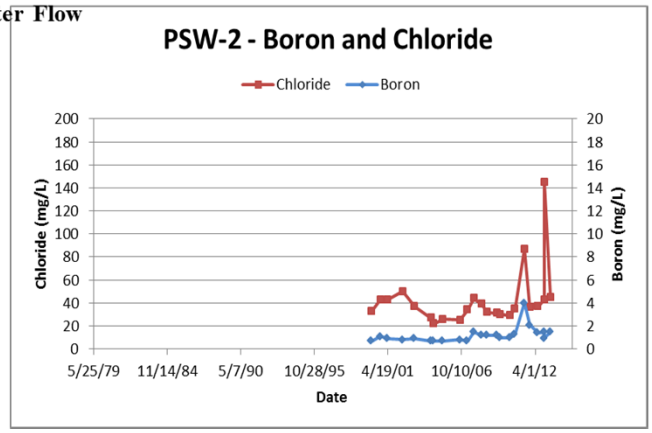






General Direction of Groundwater Flow





PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT UNITS 3&4 EFFLUENT HOLDING POND SITE REPORT	WATER QUALITY GRAPHS FOR WELLS COMPLETED DOWNGRADIENT OF DRAIN PIT 3	FIGURE 3-30

Current additional investigational and/or mitigation work that is being conducted or planned includes:

- Conversion of wells 1153A and 1136A for groundwater capture. These wells are in the vicinity of existing capture near well 1023A/M in upper SFCC. Capture system performance, water quality trends at 1136A and 673A, and results of further investigation led to the conclusion that additional capture in this area would be beneficial. At the date of this writing, the capture wells had been converted and pumping had been started. System evaluation is currently underway. Reporting will be conducted upon review of startup data.
- Preliminary investigation of the area around well 657M has recently been initiated. Monitoring wells and plug boreholes have been advanced. Pumping and slug testing is planned for new wells. Each well will be sampled for groundwater quality and analyzed. A report summarizing the investigation will be completed upon completion of the evaluation.

4.0 GROUNDWATER MODEL RESULTS AND INTERPRETATION

PPLM contracted with Geomatrix to develop a conceptual model of the hydrogeologic system in the Units 3 and 4 EHP area. NewFields refined the existing conceptual model and used it to design a numerical flow model (Newfields, 2013). The numerical model provides a tool for simulating groundwater flow patterns in the 3&4 EHP area and for assessing the effectiveness of existing groundwater capture systems.

The computer code MODFLOW-SURFACT (HydroGeoLogic Inc., 1996) was used to process the Units 3&4 EHP numerical flow model because of previous success at simulating groundwater flow and advective transport of dissolved constituents in similar environments, including the Stage I and II Evaporation Ponds and Plant Site areas of the Colstrip SES (Plant). MODFLOW–SURFACT is a fully integrated flow and transport code based on the U.S. Geological Survey (USGS) groundwater modeling software, MODFLOW (Harbaugh et. al., 2000).

The model report (Newfields, 2013) is included in its entirety in Appendix A. The report provides a description of the model design including model limits, boundary conditions, flow layers, and hydraulic parameters. Hydrogeologic data from 2003 and 2012 were used to calibrate and validate model simulations. Calibration methods and results were presented. A capture zone analysis was conducted using steady-state and transient simulations. A sensitivity analysis was performed to identify which areas in the model were most subject to change through variations in individual parameters; and model limitations were discussed.

The following recommendations were offered by Newfields (2013) based on the results of their simulated capture analysis:

- "*Continue to track changes in water quality trends in monitoring wells north of the EHP including wells 625A, 626A, and 608D.*
- *Consider installing a monitoring well north and northeast of the EHP in the Sub-McKay shallowest saturated sandstone northeast of wells 1121D and 1148D.*

- *Consider installing a monitoring well north of the EHP in the shallowest saturated Sub-McKay interval between wells 611D and 565D targeting elevations between 3,050 and 3,090 feet amsl.*
- *Continue to track changes in water quality trends in the Drain Pit 5 drainage West of the EHP including wells 1140D, 1141D, and 1142D.*
- *Continue to track changes in water quality trends in Sub-McKay monitoring wells south of the EHP including well 1134D.*
- *Continue to track changes in McKay monitoring wells southeast of the EHP including well 600M.*
- *If groundwater impacts are discovered in these areas, monitoring wells should be converted to capture wells*
- *Future updates of the model should include calibration of the model to a long-term transient set of groundwater elevation data."*

5.0 IDENTIFICATION OF DATA GAPS

Bulleted items listed below are data gaps identified through review of existing data, past reports, and current water quality data. Many of these gaps in data are the basis of recommended additional work described in Section 6.

- Additional data are needed in the area southeast of the 3&4 EHP Saddle Dam. Increases in indicator parameters have recently been observed in this area. Additional monitoring wells were installed and conversion of existing well 565D for groundwater capture will be completed. Data will be collected from new monitoring wells through testing. Data regarding hydraulic properties and groundwater capture radius and potential effectiveness will also be gathered through this investigation.
- Groundwater model simulations (AMEC Environmental & Infrastructure 2012) suggest groundwater capture systems are intercepting the vast majority of groundwater impacted by process pond water. Based on model simulations additional data are needed in the vicinity of wells 1121D and 1148D, and between wells 611D and 565D.
- Currently, flow rates at capture wells are measured from the majority of wells at the well heads. This method results in an overestimation of actual amount of water captured. More accurate measurement of flow is necessary to better evaluate system performance. A select number of wells in various areas should be instrumented to develop a conversion factor for measured flow rates.
- Additional information is needed to better characterize groundwater conditions in the 1123A area. Water from well 1123A showed possible process water impacts. However, a pathway from the pond to the area has not been identified. It is possible the quality of water at this well is reflective of local conditions which may be influenced by ash layers near the base of the Rosebud clinker interval. It is also considered necessary to further define hydrogeologic conditions east of well 1123A to identify possible flow paths to the east and or south. Note that this evaluation will also further evaluate geophysical anomalies that were identified in the vicinity. Work plans will be prepared and submitted to MDEQ prior to conducting the work.

- Groundwater quality at well 657M has shown a declining quality. Additional investigation is under way for the area including installation of wells, groundwater quality sampling and well testing.
- The understanding of hydrogeologic conditions would benefit by obtaining more data from the area between well 615D and the SP-15 South Trench. A well(s) in this area would provide data for identifying potential flow paths between the pond and this area if they exist.
- The understanding of hydrogeological conditions southwest of the 3&4 EHP would be better understood by filling data gaps by installing a well along the roadway south of well 696R. Another well along the road southwest of well 695R would help define conditions in this area.
- A well south and west of 675M is recommended. This well shows elevated levels of indicator parameters. It should be noted that well 589M, installed prior to pond use in this same area, also exhibited elevated levels of indicator parameters prior to pond use. A well south of 675M would provide information of possible sources for the 1023A/M area.
- Additional data is needed to further evaluate hydrogeologic conditions between well 615D and the South SP-15 Interception Trench, southwest of well 696R and, south of 675M from the McKay Coal interval.

6.0 RECOMMENDATIONS FOR ADDITIONAL SITE CHARACTERIZATION

- Continue groundwater capture efforts. Evaluate data on an ongoing basis and make adjustments to various capture systems, or individual wells, to maximize the effectiveness of mitigation efforts. It is recommended that groundwater wells showing improvement to BSLs, or better, be considered for shutdown. However, it is further recommended that the wells be maintained as operational capture points. If water quality deteriorates at these wells, indicating further process pond impacts, they should be restarted.
- Continue to evaluate groundwater potentiometric surfaces as they relate to groundwater flow near, or upgradient, of groundwater capture systems. This activity is routinely conducted as part of annual reporting and is essential for on-going site characterization.
- Continue operational groundwater and surface water quality monitoring of capture systems. Convert wells for groundwater capture, and if necessary, add additional monitoring wells to evaluate capture effectiveness. Particular attention should be given to the area north of the 3&4 EHP near wells 625A and 626A, 600M, and 1134D. Maintain capture wells as part of the sampling and analysis program.
- Make necessary repairs to groundwater capture systems as they are identified.
- Best management practices - BMPs -
    - Continue to further educate employees regarding the importance of process water management.
    - Continue with plans to line the currently unlined cells in the pond.
    - Manage paste, forced evaporation and water management practices to reduce process water volumes and seepage potential.
- Conduct further evaluation to better define groundwater capture system volumes, particularly in areas where excessive scaling problems have not occurred. This will allow better calibration of groundwater models for capture system analysis.

- Continue to address changes in water quality identified during operational monitoring and associated with spills or other releases by conducting further evaluation, monitoring or investigation. Mitigation measures should be taken, if necessary.
- Obtain more accurate pumping rate and volume data from capture wells so capture system analysis can be further refined.
- Update the groundwater model on a periodic basis using data obtained since the previous update. Future updates of the model should include calibration of the model to a long-term transient set of groundwater elevation data.
- PPLM has, and is, conducting activities to identify and mitigate process pond seepage. This includes, extensive water resources monitoring, implementation of mitigation measures, development and application of best management practices, and employee education. As such, Plant personnel should continue to evaluate its pond and process water systems so areas with seepage affecting groundwater can be identified and mitigated, including measures to address source reduction.
- Construction of future cells, or alterations of existing ponds (if possible), should include a synthetic liner system capable of detecting and removing water below the liner.
- Further evaluate groundwater conditions at the south end of the Saddle Dam in the vicinity of well 565D. Convert 565D or 566D for groundwater capture.
- Evaluate recovery in the area of SFCC near well 1024A/M. Two new capture wells have been added to this system and additional data from these and other local capture wells will be helpful in evaluation of capture system effectiveness and the understanding of the hydrologic system.
- Further evaluate groundwater conditions east of the Saddle Dam in the vicinity of well 1123A. Water quality at this well is somewhat indicative of process water impacts, although elevated constituent concentrations could be a function of localized natural sources (ash in burn). Flow paths to the area, and away from the area have not been completely defined.
- Further evaluate the TP624-2 and well 624D area north of the Main Dam.

- Further evaluate the area around well 657M northwest of the Main Dam. As of this writing, field work has been initiated.
- Capture in the vicinity of well 552D, north of the Main Dam, should be further evaluated and considered. Capture well density in this area may need to be increased. Water quality is quite poor and, with the exception of well 618D only minor, if any, improvements in water quality has been observed. The shallow poorly consolidated sandstone, which correlates to the sandstone underlying the pond, should be targeted.
- Consider installing additional wells as follows: into first water between well 615D and the South SP-15 Interception Trench; into first water southwest of well 696R; and, into the McKay Coal south of 675M and southwest of well 1134D.
- Increase capture density near well 610D. Groundwater quality in this area is showing decreasing trends. Additional capture and monitoring appears necessary.
- Monitor wells in the Drain Pit #5 area, specifically wells WD-222 and WA-145, to evaluate changes in water quality, if any, following the installation of lining in the drain pit. In this same area, but slightly to the east, continue to track water quality trends in wells 1140D, 1141D, and 1142D.
- Install a monitoring well into first groundwater downstream from the North SP-15 Secondary Trench. It is recommended that the well be installed as far upstream of the confluence of the drainage with the drainage holding Drain Pit #5 as access allows. This will allow detection of impacted groundwater, if any, that may bypass the upgradient interception trenches and secondary containment system.
- Conduct further evaluation around clinker well 1120C, located near the northwest edge of the Saddle Dam. Impacted groundwater appears to be present at this location.
- Conduct further evaluation east of well 611D, north of the Saddle Dam, targeting strata between 3,050 and 3,090 elevation.
- Dewater clinker within the cutoff wall following completion of planned cell lining as storage is available in lined ponds. This can be accomplished by pumping from the underdrain standpipe, and wells completed in the clinker on the inboard side of the bentonite amended concrete cutoff wall. Additional wells, inboard of the cutoff wall may be necessary at the northeast on southeast corners of the pond.

- Review and revise the groundwater monitoring program, in coordination with MDEQ, to reduce the number of monitoring wells in the current program. Several of the wells in the current program could be removed or sampled on a less frequent interval, or for fewer parameters.

7.0 REFERENCES

AMEC Geomatrix 2009. DRAFT Groundwater Model Expansion and Calibration Stage I and II Evaporation Ponds Area Colstrip Steam Electric Station, Colstrip, Montana. May 2012.

____2012. DRAFT Groundwater Model Expansion and Calibration Stage I and II Evaporation Ponds Area Colstrip Steam Electric Station, Colstrip, Montana. February 2012.

Anderson, M.P. and W.W. Woessner 1992. Applied Groundwater Modeling, Simulation of Flow and Advective Transport. Academic Press, Inc.

Battelle Pacific Northwest Laboratory 1986. Data Report Hydrogeochemical Study of the Cow and Pony Creek Drainages, Rosebud County, MT August 1986.

_____1987. DRAFT Hydrogeochemical Study of the Cow and Pony Creek Drainages, Rosebud County, MT. May 1987. (Report was not finalized)

_____1990. Hydrogeochmical Study of Cow and Pony Creek Drainages, Rosebud County, Montana CY 1989, April 1990.

_____1991. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1990, May 1991.

_____1992. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1991, April 1992.

_____1993. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1992, April 1993.

_____1994. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1993. April 1994.

_____1995. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1994. May 1995.

_____1996. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1995. May 1996.

_____1997. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1996. May 1997.

_____1998. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1997. May 1998.

_____1999. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1998. May 1999.

_____2000. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 1999. May 2000.

_____2001. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2000. May 2001.

_____2002. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2001. May 2002.

_____2003. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2002. May 2003.

_____2004. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2003. May 2004.

_____2005. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2004. May 2005.

_____2006. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2005. May 2006.

_____2007. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2006. May 2007.

_____2008. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2007. May 2008.

_____2009. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2008, May 2009.

_____2010. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2009, May 2010.

_____2011. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2010, May 2011.

_____2012. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2011, May 2012.

_____2013. Hydrogeochemical Study of Cow and Pony Creek Drainages, Rosebud County, Montana, for CY 2012, May 2013.

Bechtel Power Corporation. (1982). Colstrip Project Montana Effluent Holding Pond Design Report

Bechtel Power Corporation February 1985a, Colstrip Project Montana. Effluent Holding Pond Embankments Construction Report.

_____February 1985b, Colstrip Project Montana. Effluent Holding Pond Slurry Cutoff Wall Final Construction Report.

Botz, M.K., Westech. 1978. Characteristics and Potential Impact of Wastewaters from a Coal-Fired Power Plant at Colstrip, Montana. Submitted to Water Quality Bureau, Department of Health and Environmental Sciences. June 1978.

Bouwer, H, 1982. Design Considerations for Earth Linings for Seepage Control. Groundwater, Vol. 20, No. 5. September-October 1982.

Chen Northern, Inc. 1988. Phase I Inspection of Units 3 and 4 Effluent Pond, Colstrip, MT., Chen Northern, Inc. December 9, 1988.

Exponent, 2011. Data Analysis and Statistical Evaluation of Unimpacted Groundwater Quality, Units 3&4 Effluent Holding Pond Area, Colstrip Steam Electrical Station, Colstrip, Montana. DRAFT External Memorandum from Exponent to Arnold and Porter. April 18, 2011

Geophysics, Inc. 2005. Geophysical Results for the Process Water Retention Pond, PPL-Montana Site. January 13, 2005.

Giroud, J., Badu-Tweneboah, K., & Bonaparte, R. (1992). Rate of Leakage Through a Composite Liner Due to Geomembrane Defects. Geotextiles and Geomembranes Vol. 11, No. 1, 1 - 28.

Giroud, J., Badu-Tweneboah, K., & and Soderman, K. (September 1994). Evaluation of Landfill Liners. Proceedings of the Fifth International Conference on Geotextiles, Geomembranes and Related Products, Vol. 3, 981- 986.

Giroud, J.P. 1997. Equations for Calculating the Rate of Liquid Migration Through Composite Liners Due to Geomembrane Defects. Geosynthetics International, Vol. 4, Nos. 3-4, pp. 335-348, 1997.

Golder Associates, Inc. 2002. Report of Geotechnical Laboratory Testing Bentonite-modified Paste Fly Ash, Units 3&4 Effluent Holding Pond, Colstrip Steam Electric Station, Colstrip, Montana. January 11, 2002.

Harbaugh et al 2000. Harbaugh, A. W., E. R. Banta, M. C. Hill, and M. G. McDonald, MODFLOW-2000, the U.S. Geological Survey modular ground-water model user

guide to modularization concepts and the ground-water flow process. Denver, CO, Reston, VA: U.S. Geological Survey, 2000.

Heffern, E., & Coates, D. (1999). Hydrogeology and Ecology of Clinker in the Powder River Basin, Wyoming and Montana. Wyoming Geological Association Guidebook, Fiftieth Field Conference.

HydroGeologic, Inc., 1996. MODFLOW-SURFACT v 3.0: A comprehensive MODFLOW-based flow and transport simulator. Code Documentation Report. HydroGeologic, Reston, Virginia.

Hydrometrics, Inc. 1980. Evaluation of Data From the Montana Power Company Process Pond Monitoring System at Colstrip, Montana. April 15, 1980.

____1983. Evaluation of 1982 Monitoring Data from the Montana Power Company Process Pond Systems at Colstrip, Montana. February 2, 1983.

____1984. Evaluation of 1983 Monitoring Data from the Montana Power Company Process Pond Systems at Colstrip, Montana. April 30, 1984.

____1984. Water Level Addendum Evaluation of 1983 Data for the Montana Power Company Process Pond Monitoring System at Colstrip, MT.

____1985. Installation and Testing of Groundwater Monitoring Wells near the Units 3 and 4 Effluent Holding Pond, Colstrip, Montana. March

____1985. Evaluation of 1984 Monitoring Data from the Montana Power Company Process Pond Systems at Colstrip, Montana. July, 1985.

____1985. Drilling and Completion of Genie Alternate Stock Wells Rosebud County, Montana. December 1985.

____1986. Evaluation of 1985 Monitoring Data from the Montana Power Company Process Pond Systems at Colstrip, Montana. June 25, 1986.

____1987. Evaluation of 1986 Monitoring Data from the Montana Power Company Process Pond Systems at Colstrip, Montana. May 1987.

____1988. Investigation of Hydrogeological Conditions Downstream of the Main Dam – Effluent Holding Pond – Colstrip Units 3 and 4, Colstrip Montana. January 1988.

____1988. Hydrogeological Investigation of the MPC Units 3 and 4 Effluent Holding Pond Colstrip, Montana. April 21, 1988.

____1988. Evaluation of 1987 Monitoring Data from the Montana Power Company Process Pond Systems at Colstrip, Montana. June 1988.

____1989. Interception of Degraded Groundwater near the Units 3 and 4 Effluent Holding Pond Colstrip, Montana. January 24, 1989.

____1989. Evaluation of 1988 Monitoring Data from the Montana Power Company Process Pond Systems at Colstrip, Montana. July 21, 1989.

____1989. Drilling, Completion and Testing of Genie Alternate Stock Wells – Rosebud County, Montana. August 1989.

____1990. Evaluation of 1989 Monitoring Data from the Montana Power Company Process Pond Systems at Colstrip, Montana. 1990.

____1990. Site Investigation, Design, Construction and Performance of the Groundwater Interception System Downgradient of the Colstrip Units 3 and 4 Effluent Holding Pond Colstrip, Montana. March 1990.

____1991. Evaluation of 1990 Monitoring Data from the Montana Power Company Process Pond Systems at Colstrip, Montana. May, 1991.

____1992. Evaluation of 1991 Monitoring Data from the Montana Power Company Process Pond Systems at Colstrip, Montana. April 30, 1992.

____1998. Groundwater Investigation of the Stage II and 3 & 4 Effluent Holding Pond Areas. . September 1998.

____1999. The Montana Power Company Fall 1998 Groundwater Evaluation 3&4 Evaporation Holding Pond Area. January 1999.

____1999. The Montana Power Company Groundwater Capture System Installation Summary Report. April 1999.

____2000. PPL Montana, LLC Fall 1999/Winter 2000 Groundwater Investigation Report Colstrip, MT. March 2000.

____2000. Drain Pit #3 Investigation Report. April 14, 2000.

____2000. Units 3&4 EHP Saddle Dam – Interim Report. May 2000.

____2000. Units 3&4 EHP Saddle Dam Geotechnical and Groundwater Report. July 2000.

____2000. Drain Pit #5 Interceptor Trench Drawings. December 6, 2000.

____2001. PPL Montana Fall 2000 Groundwater Investigation Report. January 2001.

____2001. Seep 3 Interception Trench Drawings. January 31, 2001.

____2001. Units 3&4 EHP Saddle Dam Remedial Measures Preliminary Design. February 2001.

____2001. Analysis of Water Reuse and Treatment Options at the PPL Montana Colstrip Site – Draft, September 2001.

____2001. PPL Montana LLC Fall 2001 Groundwater Investigation and Capture System Installation Report. December 2001.

____2001. PPL Montana LLC Fall North EHP and Scoria Seep (SP-15) Investigation Report. December 2001.

____2003. December 2002/January 2003 Process Pond Sampling and Analysis Report, January 2003.

____2003. 2002 Groundwater Investigation Report PPL Montana, LLC. January 2003.

____2003. Units 3&4 EHP Saddle Dam Slope Inclinometer Monitoring. May 2003.

____2003. Well 356D Area Groundwater Evaluation. June 2003.

____2003. Memorandum: North SP-15 Interception Trench Installation. July 30, 2003.

____2003. Memorandum: East Fork Armells Creek. July 31, 2003.

____2004. PPL Montana, LLC 2003 Groundwater Investigation Report, Colstrip, Montana. May 2004.

_____2004. Units 3&4 EHP Saddle Dam Slope Inclinometer Monitoring, April 2004. June 14, 2004.

_____2005. PPL Montana, LLC 3&4 Seep Investigation Progress Report, June 2005.

_____2006. Units 3&4 EHP Saddle Dam Slope Inclinometer Monitoring, October 2005. January 4, 2006.

_____2007. Units 3&4 EHP Saddle Dam Slope Inclinometer Monitoring, November 2006. . March 21, 2007.

_____2007. PPL Montana, LLC Colstrip Steam Electric Station Units 3&4 Data Report 2004-2006. August 2007.

_____2008. PPL Montana, LLC North SP-15 /1031 Area Well Installation/Conversion & Pipeline Colstrip Steam Electric Station, Hydrometrics, July 2008, (Revised August 2008).

_____2008. Technical Memorandum: Test Pit Investigation Near Well 624D. July 24, 2008.

_____2008. Technical Memorandum: 560A Area – Status Memorandum. September 16, 2008.

_____2008. Test Pit 624-2 Sample Tube Installation –Technical Memorandum Hydrometrics to PPLM. October 27, 2008.

_____2008. Units 3&4 EHP Paste Infiltration Studies -Memorandum from Hydrometrics to PPLM. November 6, 2008.

_____2008. Technical Memorandum: Test Pit 624-2 Water Quality Results. November 13, 2008.

_____2009. PPL Montana, LLC North SP-15 and South SP-15 Area Well Installation and Testing. March 2009.

_____2009. Evaluation of 2008 Hydrologic Monitoring Data from Colstrip Units 1 through 4 Process Pond System, Colstrip Steam Electric Station, Colstrip Montana. April 2009.

____2009. 560A/1051A – Status Report – Technical Memorandum from Hydrometrics to PPLM dated June 1, 2009.

____2009. Well Testing – Well 626A: Technical Memorandum Hydrometrics to PPLM dated August 5, 2009.

____2009. PPL Montana, LLC 2009 Pond Capacity Survey. July 2009.

____2009. TP624-2 Stock Tank Installation –Technical Memorandum Hydrometrics to PPLM. October 2, 2009.

____2009. Well Installation, Testing and Sampling – 602S Area, Hydrometrics, Inc. November 17, 2009.

____2009. Technical Memorandum: 560A/1051A – Status Report. June 1, 2009.

____2009. PPL Montana, LLC 2009 Pond Capacity Survey. July 2009.

____2009. Technical Memorandum: 3&4 Bottom Ash Pond Clearwell Sampling. July 8, 2009.

____2009. Technical Memorandum: Well Installation, Testing, and Sampling – PW-734, PW-735, and PW-736. July 17, 2009.

____2009. Technical Memorandum: Well Testing – Well 626A. August 5, 2009.

____2009. Technical Memorandum: TP624-2 Stock Tank Installation. October 2, 2009.

____2009. Well Installation, Testing and Sampling – 602S Area. November 17, 2009.

____2009. Technical Memorandum: PSW-9 Well and Stock Tank Installation. November 18, 2009.

____2009. Technical Memorandum: 560A/1051A Area Phase IV – Status Report. December 10, 2009

____2010. Technical Memorandum: Results of Investigation at Area East of Units 3&4 Effluent Holding Pond Saddle Dam and 560A/1051A Area. January 26, 2010.

____2010. PPL Montana Colstrip Steam Electric Station 1073A Area Alluvial Capture Options – Letter from Hydrometrics to PPL dated January 26, 2010.

____2010. Technical Memorandum: Well 1084A Conversion/Well 581D Abandonment. March 12, 2010.

____2010. DRAFT: Technical Memorandum: Joint Trend Study. March 25, 2010.

____2010. Technical Memorandum: Interpretive Summary of October 2009 Geophysics Survey. April 26, 2010.

____2010. Technical Memorandum: 1073A Area Borehole Drilling. May 21, 2010.

____2010. Technical Memorandum: Drain Pit #3 Investigation. May 28, 2010.

____2010. Evaluation of 2009 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System Colstrip Steam Electric Station Colstrip, Montana. June 8, 2010.

____2010. Technical Memorandum: Results of Drilling and Testing Geophysics Anomalies. December 2, 2010.

____2010. Capture System Expansion North of 3&4 Effluent Holding Ponds Main Dam – 602S Area. December 2010.

____2011a. PPL Montana, LLC 2010 Pond Capacity Survey. February 2011.

____2011b. PPL Montana, LLC Capture System Construction, Startup, and Performance 560A/1051A Area and 1073A-Trench. February 2011.

____2011. Evaluation of 2010 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System Colstrip Steam Electric Station Colstrip, Montana, Hydrometrics, Inc. February 2, 2011.

____2011. Evaluation of 2010 Hydrologic Monitoring Data from Colstrip Units 1 through 4 Process Pond System, Colstrip Steam Electric Station, Colstrip Montana. April 2011.

____2011. Technical Memorandum: Interpretive Summary of April 2011 Geophysics Survey. September 30, 2011.

____2011. Installation and Startup of Capture Wells 1128D and 1129D North of Units 3&4 Effluent Holding Pond, 602S Area. November 21, 2011.

____2011. Technical Memorandum: PSW-10- Well Installation. December 14, 2011.

____2012. Technical Memorandum: Results of Supplementary Drilling and Testing at Geophysical Anomalies North of the 3&4 EHP. January 9, 2012.

____2012. Technical Memorandum: Results of Drilling and Testing at Geophysics Anomalies Between the Units 3&4 Effluent Holding Ponds and South Fork Cow Creek. January 16, 2012.

____2012. Evaluation of 2011 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System Colstrip Steam Electric Station Colstrip, Montana. June 2012.

____2012. PPL Montana, LLC 2012 Pond Capacity Survey, September 2012.

____2013. Interim Report – Investigation and Capture System Construction North of 1079A-Trench. January 14, 2013.

_____2013. Pumping Tests at 3&4 EHP Underdrain and 1003R, Technical Memorandum. Hydrometrics to PPLM. January 30, 2013.

____2013. Technical Memorandum: Interim Report – South Fork Cow Creek Diversion Sediment Removal. March 5, 2013.

____2013. Evaluation of 2012 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System Colstrip Steam Electric Station Colstrip, Montana. April 17, 2013.

____2013a. Well PW-704 Abandonment and Replacement, Hydrometrics, Inc. April 2013.

____2013b. Monitoring Well Installation and Groundwater Investigation In The 1068A and Drain Pit #5 Areas. April 2013.

____2013. Technical Memorandum: Addendum – South Fork Cow Creek Diversion Sediment Removal. September 9, 2013.

Hydrus, 2012. "Hydrus 2D/3D," Version 2.01.1160, PC-Progress.

KC Harvey Environmental, LLC. 2012. Plant Community Studies on the Stage I Ash Disposal Pond Cap, Stage 2 Ash Ponds, and Areas Near the Effluent Holding Ponds, Colstrip, Montana 2012. December 4, 2012.

____2012. Water Balance Activities on Phase 1 Ash Disposal Pond An Update of On-going Monitoring at the Stage I Ash Disposal Ponds, Colstrip, MT 2012. December 21, 2012.

Newfields Companies LLC, 2013. Numerical Groundwater Model Development and Calibration Units 3 and 4 EHP Area Colstrip Steam Electric Station, Colstrip, Montana.

MDEQ/PPL Montana, 2012. Administrative Order on Consent Regarding Impacts Related to Wastewater Facilities Comprising the Closed-Loop System at Colstrip Steam Electric Station, Colstrip Montana.

The Montana Power Company 1993. CPD/EED Evaluation of 1992 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana. April, 1993.

____1994. CPD/EED Evaluation of 1993 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana. May 1994.

____1995. CPD/EED Evaluation of 1994 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana. May 24, 1995.

____1996. CPD/EED Evaluation of 1995 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana. March 20, 1996.

____1997. CPD/EED Evaluation of 1996 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana. May 1997.

____1998. CPD/EED Evaluation of 1997 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana. Spring 1998.

____1999. CPD/EED Evaluation of 1998 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, Montana Power Company Colstrip, Montana. April 15, 1999.

PPL Montana, LLC 2000. CPD/EED Evaluation of 1999 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana. April 23, 2000.

____2001. CPD/EED Evaluation of 2000 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana. March 21, 2001.

____2002. CPD/EED Evaluation of 2001 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana. April 17, 2002.

____2003. PPLM submits results of pond sampling for 51 parameters to MDEQ. January 20, 2003.

____2003. CPD/EED Evaluation of 2002 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana. March 24, 2003.

____2004. CPD/EED Evaluation of 2003 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana. April 6, 2004.

____2005. CPD/EED Evaluation of 2004 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana. March 5, 2005.

____2006. CPD/EED Evaluation of 2005 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana. April 28, 2006.

____2007. CPD/EED Evaluation of 2006 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana. October 2007.

____2008. CPD/EED Evaluation of 2007 Hydrologic Monitoring Data from Colstrip Units 1-4 Process Pond System, PPL Montana, LLC Colstrip, Montana. December 12, 2008.

____2011. PPL Montana, LLC Colstrip Steam Electric Station Water Resources Monitoring Plan. September 2011.

____2012. Pond Return Water Release Colstrip Units 1 & 2. Letter report dated August 1, 2012.

Pokorny, M., L. Franklin, and S. Jennings, 2012. “Water Balance Activities Stage I Ash Holding Pond Cap,” KC Harvey Environmental - Reclamation Research Group. 2012.

Portage, 2007. PPLM/Colstrip Units 1 & 2 STEP B Cell Geosynthetics Quality Assurance Report, May 31, 2007.

Puckorius & Associates, Inc. 1996. Montana Power Company Colstrip Project Division Bottom Ash Systems Water Chemistry Study. December 1996.

Reclamation Research Unit, Montana State University Bozeman, MT, 1990. Ash Disposal Pond Reclamation, Montana Power Company, Colstrip, MT. May 21, 1990.

____1993. Growth of Vegetation on Ash Disposal Ponds; A Report of Revegetation Activities at the 1 and 2 Ponds Since June 1990.

____1995. Growth of Vegetation on Ash Disposal Ponds; A Report of Revegetation Activities at the Colstrip 1 and 2 Ash Disposal Ponds. January 1995.

____1997. Report Of 1997 Activities On Stage I Ash Disposal Pond; An Update of Reclamation Research Unit Activities on and near the Stage I Ash Disposal Ponds, Colstrip, Montana; Reclamation Research Unit Publ. No. 9704. December 1997.

____1998. Report Of 1998 Activities On Stage I Ash Disposal Pond; An Update of Reclamation Research Unit Activities On and Near the Stage I Ash Disposal Ponds, Colstrip, Montana; Reclamation Research Unit Publ. No. 9804. December 1998, Revised February 1999.

____1999. Report of 1999 Activities on Stage I Ash Disposal Pond; An Update of Reclamation Research Unit Activities on and Near the Stage I Ash Disposal Ponds, Colstrip, Montana; Reclamation Research Unit Publ. No. 9902. December 1999, Revised January 2000.

____2000. Report of 2000 Activities on Stage I Ash Disposal Pond; An Update of Reclamation Research Unit Activities on and Near the Stage I Ash Disposal Ponds, Colstrip, Montana; Reclamation Research Unit Publ. No. 2003. December 11, 2000.

____2001. Report of 2001 Activities on Stage I Ash Disposal Pond; An Update of Reclamation Research Unit Activities on and Near the Stage I Ash Disposal Ponds, Colstrip, Montana; Reclamation Research Unit Publ. No. 0102. December 12, 2001.

____2002. Report of 2002 Activities on Stage I Ash Disposal Pond Final Report; An Update of Reclamation Research Unit Activities on and Near the Stage I Ash Disposal Ponds, Colstrip, Montana; Reclamation Research Unit Publ. No. 0203. December 31, 2002.

____2003. Report of 2003 Activities on Stage I Ash Disposal Pond; An Update of Reclamation Research Unit Activities on and Near the Stage I Ash Disposal Ponds, Colstrip, Montana; Reclamation Research Unit Publ. No. 0301. December 2003.

____2004. Report of 2004 Activities on Stage I Ash Disposal Pond; An Update of Reclamation Research Unit Activities on and Near the Stage I Ash Disposal Ponds, Colstrip, Montana; Reclamation Research Unit Publ. No. 0401. October 14, 2004.

____2005. Report of 2005 Activities on 1&2 and 3&4 Ash Disposal Ponds. November 7, 2005.

____2006. Report of 2006 Activities on 1&2 and 3&4 Ash Disposal Ponds. November 17, 2006.

____2007. Report of 2007 Activities on 1&2 and 3&4 Ash Disposal Ponds. November 2007.

____2008. Report of 2007 Activities on 1&2 and 3&4 Ash Disposal Ponds. December 2008.

____2008. Interim Report of 2008 Activities on 1&2 and 3&4 Ash Disposal Ponds. Reclamation Research Group. December 2008.

____2009. Plant Identification Survey, Memorandum for May 28, 2009 Plant Identification Survey.

____2009. Technical Memorandum: Boron in vegetation and cattle grazing. Frank Munshower, Reclamation Research Group, LLC. June 22, 2009

____2009. Interim Report of 2009 Activities on 1&2 and 3&4 Ash Disposal Ponds. Reclamation Research Group. December 2009.

____2010. Report of Water Balance Activities on Phase 1 Ash Disposal Ponds. April 2010.

____2010. Report of the 2010 Water Balance Activities on Phase 1 Ash Disposal Ponds An Update of ON-going Monitoring at the Stage ! Ash Disposal Ponds, Colstrip, MT Reclamation Research Group. December 2010.

____2010. Plant Diversity and Boron Studies Adjacent to the Power Plan Ash Disposal Ponds, Colstrip, Montana 2010. December 2010.

___ 2011. Plant Diversity and Boron Studies on the Stage I Ash Disposal Pond Cap and Areas near the Effluent Holding Ponds, Colstrip, Montana 2011. Reclamation Research Group. December 2011.

____2011. Report of the 2011 Water Balance Activities on Phase 1 Ash Disposal Pond An Update of On-going Monitoring at the Stage 1 Ash Disposal Ponds, Colstrip, MT. December 2011.

Sterrett, Robert J., 2007. Groundwater and Wells, Third Edition. Johnson Well Screens.

UMS, Inc. 2008. Geophysical Survey Services Electromagnetic Induction (EMI) Conductivity Mapping PPL Montana, LLC 560A Area Expanded Investigation Colstrip, MT. August 1, 2008.

URS Greiner Woodward Clyde 2000. Groundwater Quality Data Assessment for Montana Power Company Regarding the Colstrip Project. June 2, 2000.

U.S. Bureau of Land Management and the Montana Department of State Lands 1989. Chemical Characteristics, Including Stable-Isotope Ratios, of Surface Water and Ground Water from Selected Sources In and Near East Fork Armells Creek Basin, Southeastern U.S. Montana, 1985. U.S. Geological Survey 1989.

U.S. Department of the Interior, Bureau of Reclamation, 2013. The Great Plains Cooperative Agriculture Weather Network, <http://www.usbr.gov/gp/agrimet > accessed 4/9/2013.

U.S. Environmental Protection Agency (EPA), 2009. Field Observations Report Colstrip Steam Electric Station Colstrip, Montana August 31- September 3, 2009. November 2009.

Utah State University, 2013. Utah Climate Center, <http://climate.usurf.usu.edu> accessed 4/9/2013.

Utility Mapping Services, 2010. Geophysical Survey Services Electromagnetic Induction (EMI) Conductivity and Streaming Potential(SP) Survey PPL Montana, LLC Units 3 and 4 Effluent Holding Ponds Area Colstrip, Montana. February 5, 2010

Van Voast, W.A., R.B. Hedges, and J.J. McDermott, 1977. Hydrologic Conditions and Projections Related to Mining near Colstrip, Southeastern Montana. Montana Bureau of Mines and Geology Bulletin 97.

Van Voast, W.A., J.C. Reiten, 1988. Hydrogeologic responses: Twenty Years of Surface Coal Mining in Southeastern Montana. Montana Bureau of Mines and Geology Bulletin 62.

Vuke, Susan M. Heffern, Edward L. Bergantino, Robert N. and Colton, Roger B, 2001 (revised 2007). Geologic Map of the Lame Deer 30’ x 60’ Quadrangle, Eastern Montana. Montana Bureau of Mines and Geology Open File 428.

Westech Environmental Services, 1978. Characteristics and Potential Impact of Wastewaters from a Coal-Fired Power Plant at Colstrip, MT. June, 1978.

Womack & Associates, Inc., 2009. 3&4 EHP Main Dam Observations and Stability Review Update. Letter Report. May 29, 2009.

APPENDIX A

GROUNDWATER MODEL REPORT

APPENDIX B

SUMMARY OF GROUNDWATER MONITORING SITES AND ANALYTICAL PARAMETER LISTS

APPENDIX B
GROUNDWATER SAMPLING SITES
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3&4 EFFLUENT HOLDING POND

Site Name Description	Site Type	Site status (PPL)	Date Installed (Mo-Yr)	Target Aquifer(s)	Interval Screened Below G.S.	Sampling Frequency	Sample parameters*
551D	monitoring well	active	6/1/82	Sub-McKay	55-90	semiannual	WRMP, table 2, list 1
552D	recovery well	active	6/1/82	Sub-McKay	37-59	semiannual	WRMP, table 2, list 1
554D	monitoring well	active	6/1/82	Sub-McKay	85-95; 100-115	semiannual	WRMP, table 2, list 1
555M	monitoring well	active	6/1/82	McKay Coal	66-76	semiannual	WRMP, table 2, list 1
556D	recovery well	active	6/1/82	Sub-McKay	91-128	semiannual	WRMP, table 2, list 1
557A	monitoring well	active	6/1/82	Alluvium	16-20; 26-32	semiannual	WRMP, table 2, list 1
558A	monitoring well	active	6/1/82	Alluvium	12-36	semiannual	WRMP, table 2, list 1
559A	monitoring well	active	6/1/82	Alluvium	25-40	semiannual	WRMP, table 2, list 1
560A	monitoring well	active	6/1/82	Alluvium	10-13	semiannual	WRMP, table 2, list 1
560A Interception Trench	interception trench	active	3/20/08	Alluvium	Int. Trench	semiannual	WRMP, table 2, list 1
561A	monitoring well	active	6/1/82	Alluvium	7-11	semiannual	WRMP, table 2, list 1
562A	monitoring well	active	6/1/82	Alluvium	6-10.5	semiannual	WRMP, table 2, list 1
563D	monitoring well	active	6/1/82	Sub-McKay	75-91	semiannual	WRMP, table 2, list 1
564D	monitoring well	active	6/1/82	Sub-McKay	17-34	semiannual	WRMP, table 2, list 1
565D	monitoring well	active	6/1/82	Sub-McKay	62-106	every 2 years (2014)	WRMP, table 2, list 1
566D	monitoring well	active	6/1/82	Sub-McKay	61-105	semiannual	WRMP, table 2, list 1
568A	monitoring well	active	6/1/82	Alluvium	9.5-19.5	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1: List 3 Quarterly
569A	monitoring well	active	6/1/82	Alluvium	11-21	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1: List 3 Quarterly
570A	monitoring well	active	6/1/82	Alluvium	3-6	semiannual	WRMP, table 2, list 1
572D	monitoring well	active	6/1/82	Sub-McKay	118-155	semiannual	WRMP, table 2, list 1
573D	monitoring well	active	6/1/82	Sub-McKay	101-134	semiannual	WRMP, table 2, list 1
574D	monitoring well	active	9/1/82	Sub-McKay	136-198	semiannual	WRMP, table 2, list 1
576D	monitoring well	active	6/1/83	Sub-McKay	56-89	every 2 years (2014)	WRMP, table 2, list 1
577D	monitoring well	active	6/1/83	Sub-McKay	157-197	semiannual	WRMP, table 2, list 1
578D	monitoring well	active	6/1/83	Sub-McKay	54-59	semiannual	WRMP, table 2, list 1
579D	monitoring well	active	6/1/83	Sub-McKay	45-55; 58-70	semiannual	WRMP, table 2, list 1
580D	monitoring well	active	6/1/83	Sub-McKay	43-59	semiannual	WRMP, table 2, list 1
581D-2	monitoring well	active	11/17/08	Sub-McKay	60-75	semiannual	WRMP, table 2, list 1
582A	monitoring well	active	11/1/83	Alluvium	14-20	semiannual	WRMP, table 2, list 1
583DD	monitoring well	active	11/1/83	Deep sub-McKay	360-430	semiannual	WRMP, table 2, list 1
584D	monitoring well	active	11/1/83	Sub-McKay	210-270	semiannual	WRMP, table 2, list 1
585D	monitoring well	active	11/1/83	Sub-McKay	181-241	semiannual	WRMP, table 2, list 1
586R (586M re-completed as 586R 9-13-05)	monitoring well	active	9/13/05	Rosebud	pen from ~ 57 to 6	semiannual	WRMP, table 2, list 1
587D	monitoring well	active	11/1/83	Sub-McKay	161-201	semiannual	WRMP, table 2, list 1
588D	monitoring well	active	10/1/85	Sub McKay	120-160	semiannual	WRMP, table 2, list 1
589D	monitoring well	active	10/1/85	Sub McKay	133-176	semiannual	WRMP, table 2, list 1
590I	monitoring well	active	10/1/85	Interburden	10-20	semiannual	WRMP, table 2, list 1
590M	monitoring well	active	10/1/85	McKay	25-33	semiannual	WRMP, table 2, list 1
591A	monitoring well	active	10/1/86	Cow Cr. alluvium	20-40	semiannual	WRMP, table 2, list 1
592A	recovery well	active	10/1/86	South Fork Cow Cr alluvium	10-30	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1: List 3 Quarterly
593A	monitoring well	active	10/1/87	Alluvium gravels	11-16	semiannual	WRMP, table 2, list 1
594D	monitoring well	active	10/1/87	Sandstone below alluvium	36-40	semiannual	WRMP, table 2, list 1
595D	monitoring well	active	10/1/87	Deep Sands below approx 170'	180-220	semiannual	WRMP, table 2, list 1
596D	monitoring well	active	10/1/87	Sands below 90'	109-149	semiannual	WRMP, table 2, list 1
598D-2 (replaced 598D)	monitoring well	active	11/1/91	Bedrock (SLTST)	36-56	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1: List 3 Quarterly
599D	monitoring well	active	10/1/87	Sands at 255' to 298'	250-300	semiannual	WRMP, table 2, list 1
600M	monitoring well	active	10/1/87	McKay	123-133	semiannual	WRMP, table 2, list 1
601M	monitoring well	active	10/1/87	McKay	74-84	semiannual	WRMP, table 2, list 1
602S	monitoring well	active	8/1/93	Shallow	45 - 65	semiannual	WRMP, table 2, list 1
603D	monitoring well	active	10/1/88	SS, SH, SLTST E. of channel	35-55	semiannual	WRMP, table 2, list 1
604A	recovery well	active	10/1/88	Channel alluvium	10-25	semiannual	WRMP, table 2, list 1
605A-2 (replaced 605A)	recovery well	active	2/1/99	Shallow alluvium	8 - 18	semiannual	WRMP, table 2, list 1
606A	monitoring well	active	10/1/88	Alluvium	15-25	semiannual	WRMP, table 2, list 1

APPENDIX B
GROUNDWATER SAMPLING SITES
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3&4 EFFLUENT HOLDING POND

Site Name Description	Site Type	Site status (PPL)	Date Installed (Mo-Yr)	Target Aquifer(s)	Interval Screened Below G.S.	Sampling Frequency	Sample parameters*
607A	monitoring well	active	11/1/91	Alluvium	7.5-17.5	semiannual	WRMP, table 2, list 1
608D	monitoring well	active	11/1/91	Bedrock - Ft. Union	35-55	semiannual	WRMP, table 2, list 1
609D	recovery well	active	4/1/98	Sub-McKay	83 - 120	semiannual	WRMP, table 2, list 1
610D	recovery well	active	4/1/98	Sub-McKay	88.5 - 133	semiannual	WRMP, table 2, list 1
611D	monitoring well	active	4/1/98	Sub-McKay	80 - 120	semiannual	WRMP, table 2, list 1
612D	monitoring well	active	4/1/98	Sub-McKay	96 - 146	semiannual	WRMP, table 2, list 1
613D	recovery well	active	10/1/98	Shallow sandstone	22 - 42	semiannual	WRMP, table 2, list 1
614D	monitoring well	active	11/1/98	Shallow sandstone	80 - 120	annual	WRMP, table 2, list 1
615D	monitoring well	active	11/1/98	Sub-McKay	85 - 125	annual	WRMP, table 2, list 1
616D	recovery well	active	11/1/98	Sub-McKay	45 - 85	semiannual	WRMP, table 2, list 1
617A-P	monitoring well	active	11/1/98	Shallow alluvial	6 - 16	annual	WRMP, table 2, list 1
618D	recovery well	active	2/1/99	Sub-McKay	85 - 120	semiannual	WRMP, table 2, list 1
619D	recovery well	active	2/1/99	Sub-McKay	36 - 76	semiannual	WRMP, table 2, list 1
620D-P	monitoring well	active	2/1/99	Sub-McKay	25 - 50	annual	WRMP, table 2, list 1
621D	recovery well	active	2/1/99	Sub-McKay	85 - 125	semiannual	WRMP, table 2, list 1
622D-P	monitoring well	active	2/1/99	Sub-McKay	40 - 75	not sampled	
623D	monitoring well	active	9/1/99	Sub-McKay	35 - 65	semiannual	WRMP, table 2, list 1
624D	monitoring well	active	9/1/99	Sub-McKay	30 - 50	semiannual	WRMP, table 2, list 1
625A	monitoring well	active	9/1/99	Shallow	7 - 17	semiannual	WRMP, table 2, list 1
626A	monitoring well	active	9/1/99	Shallow	7 - 17	semiannual	
627D	monitoring well	active	9/1/99	Sub-McKay	52 - 82	semiannual	WRMP, table 2, list 1
628D	monitoring well	active	9/1/99	Sub-McKay	80 - 120	semiannual	WRMP, table 2, list 1
629D	monitoring well	active	2/1/00	Shallow	29.5 - 59.5	semiannual	WRMP, table 2, list 1
630D	monitoring well	active	2/1/00	Shallow	38.5 - 58.5	semiannual	WRMP, table 2, list 1
631D	monitoring well	active	2/1/00	Shallow	36.5 - 66.5	semiannual	WRMP, table 2, list 1
632M	monitoring well	active	2/1/00	Clinker/SS	7 - 17	semiannual	WRMP, table 2, list 1
633M	monitoring well	active	2/1/00	Clinker/SS	8 - 16	semiannual	WRMP, table 2, list 1
634D	monitoring well	active	2/1/00	Shallow	32.5 - 67.5	semiannual	WRMP, table 2, list 1
635A	monitoring well	active	2/1/00	Shallow	15 - 35	semiannual	WRMP, table 2, list 1
640P	monitoring well	active	6/1/01	Rosebud burn	40 - 50	semiannual	WRMP, table 2, list 1
641P	monitoring well	active	6/1/01	Rosebud burn	47 - 54	semiannual	WRMP, table 2, list 1
642P	monitoring well	active	6/1/01	McKay coal / burn/	22 - 27	semiannual	WRMP, table 2, list 1
643P	monitoring well	active	6/1/01	Rosebud burn	34 - 39	semiannual	WRMP, table 2, list 1
644D	recovery well	active	6/1/01	Sandstone	90 - 130	semiannual	WRMP, table 2, list 1
645D	recovery well	active	6/1/01	Sandstone	69 - 109	semiannual	WRMP, table 2, list 1
646D	recovery well	active	6/1/01	Sandstone	12.5 - 32.5	semiannual	WRMP, table 2, list 1
647D	recovery well	active	6/1/01	Sandstone	30 - 60	semiannual	WRMP, table 2, list 1
648D	recovery well	active	04-02	Sub-Mckay	30 - 50	semiannual	WRMP, table 2, list 1
649D	monitoring well	active	04-02	Sub-Mckay	35 - 55	semiannual	WRMP, table 2, list 1
650M	monitoring well	active	05-02	McKay	86 - 94	semiannual	WRMP, table 2, list 1
651M	monitoring well	active	05-02	McKay	71 - 79	annual	WRMP, table 2, list 1
652M	monitoring well	active	05-02	McKay	83 - 91	annual	WRMP, table 2, list 1
653M	monitoring well	active	05-02	McKay	84 - 92	annual	WRMP, table 2, list 1
654A	recovery well	active	7/2/02	Alluvium	Trench/well	semiannual	WRMP, table 2, list 1
655M	monitoring well	active	06-02	McKay	82.5 - 90.5	semiannual	WRMP, table 2, list 1
656R	recovery well	active	09-03	Rosebud burn	42 - 52	semiannual	WRMP, table 2, list 1
657M	monitoring well	active	09-03	Mckay	52 - 60	semiannual	WRMP, table 2, list 1
658R	monitoring well	active	08-04	Rosebud/McKay	37 - 47	annual	WRMP, table 2, list 1
659D	monitoring well	active	08-04	Sub-McKay	98 - 138	annual	WRMP, table 2, list 1
660P	monitoring well	active	08-04	Shallow alluvial	4 - 14	semiannual	WRMP, table 2, list 1
661D	monitoring well	active	08-04	Sub- McKay	25 - 45	annual	WRMP, table 2, list 1
662D	monitoring well	active	08-04	Sub- McKay	32 - 52	semiannual	WRMP, table 2, list 1
663D	monitoring well	active	08-04	Sub- McKay	80 - 120	annual	WRMP, table 2, list 1

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GROUNDWATER SAMPLING SITES
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3&4 EFFLUENT HOLDING POND

Site Name Description	Site Type	Site status (PPL)	Date Installed (Mo-Yr)	Target Aquifer(s)	Interval Screened Below G.S.	Sampling Frequency	Sample parameters*
664D	monitoring well	active	08-04	Sub- McKay	90- 130	annual	WRMP, table 2, list 1
665A	monitoring well	active	10-04	Alluvial	7 - 12	semiannual	WRMP, table 2, list 1
666A	monitoring well	active	10-04	Alluvial	6 - 12	semiannual	WRMP, table 2, list 1
667A	recovery well	active	10-04	Alluvial	7 - 17	semiannual	WRMP, table 2, list 1
668A	recovery well	active	10-04	Alluvial	7 - 17	semiannual	WRMP, table 2, list 1
669A	monitoring well	active	10-04	Alluvial	16 - 26	semiannual	WRMP, table 2, list 1
670A	monitoring well	active	10-04	Alluvial	10 - 20	semiannual	WRMP, table 2, list 1
671A	monitoring well	active	10-04	Alluvial	10 - 20	semiannual	WRMP, table 2, list 1
672A	monitoring well	active	10-04	Alluvial	4 - 9	semiannual	WRMP, table 2, list 1
673A	monitoring well	active	10-04	Alluvial	6 - 11	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1: List 3 Quarterly
674E	monitoring well	active	11-04	Rosebud	40 - 60	semiannual	WRMP, table 2, list 1
675M	monitoring well	active	11-04	McKay	90 - 99	semiannual	WRMP, table 2, list 1
676R	monitoring well	active	11-04	Rosebud	38 - 56	semiannual	WRMP, table 2, list 1
677M	monitoring well	active	11-04	McKay	46 - 56	semiannual	WRMP, table 2, list 1
678D	monitoring well	active	11-04	Shallow	30 - 40	semiannual	WRMP, table 2, list 1
679A	monitoring well	active	11-04	Alluvial	4 - 8	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1: List 3 Quarterly
680A	recovery well	active	11-04	Alluvial	7 - 17	semiannual	WRMP, table 2, list 1
681A	recovery well	active	11-04	Alluvial	14 - 23	semiannual	WRMP, table 2, list 1
682A	monitoring well	active	11-04	Alluvial	10 - 17	semiannual	WRMP, table 2, list 1
683A	recovery well	active	11-04	Alluvial	10 - 25	semiannual	WRMP, table 2, list 1
684A	recovery well	active	11-04	Alluvial	16 - 25.5	semiannual	WRMP, table 2, list 1
685A	recovery well	active	11-04	Alluvial	18 - 33	semiannual	WRMP, table 2, list 1
686A	recovery well	active	11-04	Alluvial	11 - 26	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1: List 3 Quarterly
687A	recovery well	active	11-04	Alluvial	10 - 20	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1: List 3 Quarterly
688A	recovery well	active	12-04	Alluvial	10 - 20	semiannual	WRMP, table 2, list 1
689A	recovery well	active	12-04	Alluvial	9 - 19	semiannual	WRMP, table 2, list 1
690A	recovery well	active	12-04	Alluvial	10.5 - 20.5	semiannual	WRMP, table 2, list 1
691A	recovery well	active	12-04	Alluvial	18 - 28	semiannual	WRMP, table 2, list 1
692A	monitoring well	active	12-04	Alluvial	9 - 19	semiannual	WRMP, table 2, list 1
693M	monitoring well	active	12-04	McKay	52 - 59	semiannual	WRMP, table 2, list 1
694R	recovery well	active	12-04	Rosebud	35 - 45	semiannual	WRMP, table 2, list 1
695R	recovery well	active	12-04	Rosebud	75 - 87	semiannual	WRMP, table 2, list 1
696R	monitoring well	active	12-04	Clinker	47 - 57	semiannual	WRMP, table 2, list 1
697R	monitoring well	active	12-04	Clinker	67 - 77	semiannual	WRMP, table 2, list 1
698R	monitoring well	active	1/5/05	Rosebud	60 - 68	semiannual	WRMP, table 2, list 1
699R	monitoring well	active	1/5/05	Rosebud burn	70 - 80	semiannual	WRMP, table 2, list 1
1000M	monitoring well	active	38357	McKay	82 - 92	semiannual	WRMP, table 2, list 1
1001R	recovery well	active	38357	Rosebud	45 - 55	semiannual	WRMP, table 2, list 1
1002R	recovery well	active	38357	Rosebud	61 - 66	semiannual	WRMP, table 2, list 1
1003R	monitoring well	active	1/5/05	Rosebud	Open end	semiannual	WRMP, table 2, list 1
1004M	monitoring well	active	1/5/05	McKay	94 - 104	semiannual	WRMP, table 2, list 1
1005R	monitoring well	active	1/5/05	Rosebud	59 - 71	semiannual	WRMP, table 2, list 1
1006M	monitoring well	active	1/5/05	McKay	86 - 96	semiannual	WRMP, table 2, list 1
1007R	recovery well	active	1/5/05	Rosebud	46 - 56	semiannual	WRMP, table 2, list 1
1008D	monitoring well	active	1/5/05	Sub-McKay	140 - 160	semiannual	WRMP, table 2, list 1
1009D	monitoring well	active	1/5/05	Sub-McKay	184 - 204	semiannual	WRMP, table 2, list 1
1010R	monitoring well	active	1/5/05	Rosebud	16 - 36	semiannual	WRMP, table 2, list 1
1011R	monitoring well	active	1/5/05	Rosebud	46 - 56	semiannual	WRMP, table 2, list 1
1012M	monitoring well	active	1/5/05	McKay	88 - 98	semiannual	WRMP, table 2, list 1
1013R	monitoring well	active	1/5/05	Rosebud	52 - 58	semiannual	WRMP, table 2, list 1
1014R	monitoring well	active	3/5/05	Rosebud Clinker	45 - 55	semiannual	WRMP, table 2, list 1
1015R	monitoring well	active	3/5/05	Rosebud Clinker	55 - 65	semiannual	WRMP, table 2, list 1
1016R	monitoring well	active	3/5/05	Rosebud Clinker	55 - 64	semiannual	WRMP, table 2, list 1

APPENDIX B
GROUNDWATER SAMPLING SITES
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3&4 EFFLUENT HOLDING POND

Site Name Description	Site Type	Site status (PPL)	Date Installed (Mo-Yr)	Target Aquifer(s)	Interval Screened Below G.S.	Sampling Frequency	Sample parameters*
1017R	recovery well	active	3/5/05	Rosebud Clinker	55 - 64	semiannual	WRMP, table 2, list 1
1018D	monitoring well	active	7/5/05	Sub-McKay	78-89	semiannual	WRMP, table 2, list 1
1019AM	recovery well	active	7/5/05	Alluvial/McKay contact	9-18	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1
1020D	monitoring well	active	7/5/05	Sub-McKay	57-70	semiannual	WRMP, table 2, list 1
1021A	monitoring well	active	7/5/05	Alluvium	5-15	quarterly (Hydrometrics samples quarterly)	WRMP, table 2, list 1
1022A	monitoring well	active	7/5/05	Alluvium	7-17	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1
1023AM	monitoring well	active	7/5/05	Alluvial/McKay contact	11-20	(quarterly, Al) (Hydrometrics samples quarterly)	WRMP, table 2, list 1
1024AM	recovery well	active	9/5/05	Alluvial/McKay contact	9.5 - 24.5	semiannual	WRMP, table 2, list 1
1025AM	recovery well	active	9/5/05	Alluvial/McKay contact	10 - 20	semiannual	WRMP, table 2, list 1
1026AM	recovery well	active	9/5/05	Alluvial/McKay contact	9 - 15	semiannual	WRMP, table 2, list 1
1027A	monitoring well	active	5/1/06	Alluvium	5 - 10.5	semiannual	WRMP, table 2, list 1
1028A	monitoring well	active	5/1/06	Alluvium	16 - 21	semiannual	WRMP, table 2, list 1
1029M	monitoring well	active	5/2/06	McKay	91 - 99.5	semiannual	WRMP, table 2, list 1
1030A	monitoring well	active	8/8/06	Alluvium	11 - 23	semiannual	WRMP, table 2, list 1
1031R	recovery well	active	10/12/07	Rosebud Clinker	53 - 63	semiannual	WRMP, table 2, list 1
1032M	monitoring well	active	10/15/07	McKay	65 - 71	semiannual	WRMP, table 2, list 1
1033R	monitoring well	active	10/15/07	Rosebud Clinker	53 - 58	semiannual	WRMP, table 2, list 1
1034R	recovery well	active	10/16/07	Rosebud Clinker	50 - 60	semiannual	WRMP, table 2, list 1
1035R	monitoring well	active	10/16/07	Rosebud Clinker	59 - 69	semiannual	WRMP, table 2, list 1
1036R	monitoring well	active	10/17/07	Rosebud Clinker	59 - 69	semiannual	WRMP, table 2, list 1
1037R	recovery well	active	10/17/07	Rosebud Clinker	53 - 63	semiannual	WRMP, table 2, list 1
1038D	monitoring well	active	10/18/07	Sub McKay	20 - 27	semiannual	WRMP, table 2, list 1
1039A	recovery well	active	10/18/07	Alluvium	3 - 40	semiannual	WRMP, table 2, list 1
1040D	monitoring well	active	10/18/07	Sub McKay	15 - 25	semiannual	WRMP, table 2, list 1
1041D	monitoring well	active	10/18/07	Sub McKay	15 - 25	semiannual	WRMP, table 2, list 1
1042D	monitoring well	active	10/18/07	Sub McKay	64 - 74	semiannual	WRMP, table 2, list 1
1043D	monitoring well	active	10/19/07	Sub McKay	21 - 31	semiannual	WRMP, table 2, list 1
1044D	monitoring well	active	10/19/07	Sub McKay	50 - 60	semiannual	WRMP, table 2, list 1
1045D	monitoring well	active	10/22/07	Sub McKay	55 - 75	semiannual	WRMP, table 2, list 1
1046D	monitoring well	active	10/22/07	Sub-McKay	28 - 40	semiannual	WRMP, table 2, list 1
1047A	monitoring well	active	10/22/07	Alluvium	13 - 20	semiannual	WRMP, table 2, list 1
1048A	monitoring well	active	10/22/07	Alluvium	11 - 20	semiannual	WRMP, table 2, list 1
1049M	monitoring well	active	10/23/07	McKay	82 - 88	semiannual	WRMP, table 2, list 1
1051A trench	interception trench	active	12/11/07	Alluvium	10 - 19.3	semiannual	WRMP, table 2, list 1
1052A-P	monitoring well	active	12/11/07	Alluvium	7.5 - 12.5	semiannual	WRMP, table 2, list 1
1053A-P	monitoring well	active	12/11/07	Alluvium	10 - 14	semiannual	WRMP, table 2, list 1
1054A-P	monitoring well	active	12/11/07	Alluvium	6 - 11	semiannual	WRMP, table 2, list 1
1055A-P	monitoring well	active	12/11/07	Alluvium	7.5 - 12.5	semiannual	WRMP, table 2, list 1
1056A-P	monitoring well	active	12/11/07	Alluvium	13 - 23	semiannual	WRMP, table 2, list 1
1057A-P	monitoring well	active	12/12/07	Alluvium	14 - 19	semiannual	WRMP, table 2, list 1
1058A-P	monitoring well	active	12/12/07	Alluvium	11 - 16	semiannual	WRMP, table 2, list 1
1059D-P	monitoring well	active	12/12/07	Sub McKay	24 - 29	semiannual	WRMP, table 2, list 1
1060C	monitoring well	active	3/26/08	clinker	25 - 35	semiannual	WRMP, table 2, list 1
1061A	monitoring well	active	6/16/08	Alluvum	10-18	semiannual	WRMP, table 2, list 1
1062D	monitoring well	active	6/16/08	Sub McKay	22-32	semiannual	WRMP, table 2, list 1
1063D	monitoring well	active	6/16/08	Sub McKay	60-99	semiannual	WRMP, table 2, list 1
1064D	monitoring well	active	6/16/08	Sub McKay	75-80	semiannual	WRMP, table 2, list 1
1065A	recovery well	active	11/17/08	Alluvium	10-22	semiannual	WRMP, table 2, list 1
1066M	monitoring well	active	11/17/08	McKay	53-63	semiannual	WRMP, table 2, list 1
1067D	monitoring well	active	11/18/08	Sub McKay	52-72	semiannual	WRMP, table 2, list 1
1068A	recovery well	active	11/18/08	Alluvium	22-32	semiannual	WRMP, table 2, list 1
1069D	monitoring well	active	11/19/08	Sub McKay	52-92	semiannual	WRMP, table 2, list 1
1070D	monitoring well	active	11/19/08	Sub McKay	45-80	semiannual	WRMP, table 2, list 1

APPENDIX B
GROUNDWATER SAMPLING SITES
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3&4 EFFLUENT HOLDING POND

Site Name Description	Site Type	Site status (PPL)	Date Installed (Mo-Yr)	Target Aquifer(s)	Interval Screened Below G.S.	Sampling Frequency	Sample parameters*
1071D	monitoring well	active	11/19/08	R-M Interburden	39-49	semiannual	WRMP, table 2, list 1
1072D	monitoring well	active	11/19/08	Sub McKay	43-83	semiannual	WRMP, table 2, list 1
1073A	monitoring well	active	12/10/08	Alluvium	15-20	semiannual	WRMP, table 2, list 1
1073A trench	interception trench	active	7/1/10	Alluvium	Int. Trench	semiannual	WRMP, table 2, list 2
1074D	monitoring well	active	12/10/08	Sub McKay	48-56	semiannual	WRMP, table 2, list 1
1075D	monitoring well	active	12/10/08	Sub McKay	36-43	semiannual	WRMP, table 2, list 1
1076D	monitoring well	active	12/10/08	Sub McKay	45-50	semiannual	WRMP, table 2, list 1
1077D	monitoring well	active	12/11/08	Sub McKay	32-36	semiannual	WRMP, table 2, list 1
1078D	monitoring well	active	12/11/08	Sub McKay	86-121	semiannual	WRMP, table 2, list 1
1079A trench	interception trench	active	1/22/09	Alluvium	9-12.5	semiannual	WRMP, table 2, list 1
1080D	recovery well	active	4/21/09	Sub McKay	110-135	semiannual	WRMP, table 2, list 1
1081D	recovery well	active	4/22/09	Sub McKay	110-140	semiannual	WRMP, table 2, list 1
1082D	monitoring well	active	4/23/09	Sub McKay	94-124	semiannual	WRMP, table 2, list 1
1083D	recovery well	active	4/23/09	Sub McKay	142-152	semiannual	WRMP, table 2, list 1
1084A	recovery well	active	5/4/09	Alluvium	26-31	semiannual	WRMP, table 2, list 1
1085R	monitoring well	active	5/4/09	clinker	open hole	semiannual	WRMP, table 2, list 1
1086D	monitoring well	active	5/4/09	Sub McKay	35-43	semiannual	WRMP, table 2, list 1
1087D	recovery well	active	6/18/09	Sub McKay	41-46	semiannual	WRMP, table 2, list 1
1088A	monitoring well	active	6/18/09	Allulvium/Colluvium	4-8	semiannual	WRMP, table 2, list 1
1089D	recovery well	active	6/18/09	Sub McKay	42-49	semiannual	WRMP, table 2, list 1
1090D	recovery well	active	6/18/09	Sub McKay	40-49	semiannual	WRMP, table 2, list 1
1091D	monitoring well	active	6/18/09	Sub McKay	67-77	semiannual	WRMP, table 2, list 1
1092D	monitoring well	active	9/21/09	Sub McKay	51-71	semiannual	WRMP, table 2, list 1
1093D	recovery well	active	9/21/09	Sub McKay	36-56	semiannual	WRMP, table 2, list 1
1094D	monitoring well	active	9/21/09	Sub McKay	80-100	semiannual	WRMP, table 2, list 1
1095D	recovery well	active	9/21/09	Sub McKay	36-59	semiannual	WRMP, table 2, list 1
1096D	monitoring well	active	9/22/09	Sub McKay	80-100	semiannual	WRMP, table 2, list 1
1097D	recovery well	active	9/22/09	Sub McKay	37-44	semiannual	WRMP, table 2, list 1
1098D	recovery well	active	9/22/09	Sub McKay	30-40	semiannual	WRMP, table 2, list 1
1099D	recovery well	active	9/22/09	Sub McKay	28-40	semiannual	WRMP, table 2, list 1
1100D	recovery well	active	9/23/09	Sub McKay	30-38	semiannual	WRMP, table 2, list 1
1101D	recovery well	active	9/23/09	Sub McKay	51-71	semiannual	WRMP, table 2, list 1
1102D	recovery well	active	9/23/09	Sub McKay	37-57	semiannual	WRMP, table 2, list 1
1103D	monitoring well	active	9/23/09	Sub McKay	27-42	semiannual	WRMP, table 2, list 1
1104D	monitoring well	active	9/23/09	Sub McKay	10-20	semiannual	WRMP, table 2, list 1
1105D	monitoring well	active	9/24/09	Sub McKay	33-58	semiannual	WRMP, table 2, list 1
1106D	monitoring well	active	9/24/09	Sub McKay	32-42	semiannual	WRMP, table 2, list 1
1107D	monitoring well	active	9/24/09	Sub McKay	67-79	semiannual	WRMP, table 2, list 1
1108D	monitoring well	active	2/17/10	Sub McKay	68-74	semiannual	WRMP, table 2, list 1
1109D	monitoring well	active	4/6/10	Sub McKay	60-80	semiannual	WRMP, table 2, list 1
1110D	monitoring well	active	4/6/10	Sub McKay	30-40	semiannual	WRMP, table 2, list 1
1111D	monitoring well	active	4/6/10	Sub McKay	17-22	semiannual	WRMP, table 2, list 1
1112D	monitoring well	active	4/6/10	Sub McKay	20-25	semiannual	WRMP, table 2, list 1
1113D	monitoring well	active	4/6/10	Sub McKay	60-80	semiannual	WRMP, table 2, list 1
1114D	monitoring well	active	4/7/10	Sub-McKay	75-90	semiannual	WRMP, table 2, list 1
1115D	recovery well	active	8/3/10	Sub McKay	89-129	semiannual	WRMP, table 2, list 1
1116D	monitoring well	active	8/4/10	Sub McKay	103-143	semiannual	WRMP, table 2, list 1
1117D	monitoring well	active	8/4/10	Sub McKay	100-160	semiannual	WRMP, table 2, list 1
1118D	monitoring well	active	8/5/10	Sub McKay	142-150	semiannual	WRMP, table 2, list 1
1119D	monitoring well	active	8/6/10	Sub McKay	174-186	semiannual	WRMP, table 2, list 1
1120C	monitoring well	active	8/9/10	Sub McKay	23-28	semiannual	WRMP, table 2, list 1
1121D	monitoring well	active	8/10/10	Sub McKay	54-64	semiannual	WRMP, table 2, list 1
1122D	monitoring well	active	8/10/10	Sub McKay	90-140	semiannual	WRMP, table 2, list 1

APPENDIX B
GROUNDWATER SAMPLING SITES
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3&4 EFFLUENT HOLDING POND

Site Name Description	Site Type	Site status (PPL)	Date Installed (Mo-Yr)	Target Aquifer(s)	Interval Screened Below G.S.	Sampling Frequency	Sample parameters*
1123A	monitoring well	active	8/10/10	Colluvium	10-20	semiannual	WRMP, table 2, list 1
1124D	monitoring well	active	8/11/10	Sub McKay	94-120	semiannual	WRMP, table 2, list 1
1125D	monitoring well	active	8/11/10	Sub McKay	32-39	semiannual	WRMP, table 2, list 1
1126A	monitoring well	active	8/11/10	Alluvium	9-19	semiannual	WRMP, table 2, list 1
1127D	recovery well	active	8/13/10	Sub McKay	40-80	semiannual	WRMP, table 2, list 1
1128D	recovery well	active	6/2/11	Sub McKay	105-145	semiannual	Table 2, List 3 initial, List 1 thereafter
1129D	recovery well	active	6/3/11	Sub McKay	129-144	semiannual	Table 2, List 3 initial, List 1 thereafter
1130D	monitoring well	active	6/6/11	Sub McKay	27-32	semiannual	Table 2, List 3 initial, List 1 thereafter
1131D	monitoring well	active	6/6/11	Sub McKay	36-42	semiannual	Table 2, List 3 initial, List 1 thereafter
1132D	monitoring well	active	6/6/11	Sub McKay	100-140	semiannual	Table 2, List 3 initial, List 1 thereafter
1133D	monitoring well	active	11/7/11	Sub McKay	175-195	semiannual	Table 2, List 3 initial, List 1 thereafter
1134D	monitoring well	active	11/8/11	R-M Interburden	89-109	semiannual	Table 2, List 3 initial, List 1 thereafter
1135D	monitoring well	active	11/8/11	Sub McKay	170-190	semiannual	Table 2, List 3 initial, List 1 thereafter
1136D	monitoring well	active	11/9/11	Alluvium	8-18	semiannual	Table 2, List 3 initial, List 1 thereafter
1137D	monitoring well	active	11/9/11	McKay	33-42	semiannual	Table 2, List 3 initial, List 1 thereafter
1138D	monitoring well	active	11/9/11	Sub-McKay	65-75	semiannual	Table 2, List 3 initial, List 1 thereafter
1139D	monitoring well	active	11/9/11	McKay	39-49	semiannual	Table 2, List 3 initial, List 1 thereafter
1140D	monitoring well	active	8/7/12	Sub-McKay	46-56	semiannual	Table 2, List 3 initial, List 1 thereafter
1141D	monitoring well	active	8/7/12	Sub-McKay	48-58	semiannual	Table 2, List 3 initial, List 1 thereafter
1142D	monitoring well	active	8/7/12	Sub-McKay	30-35	semiannual	Table 2, List 3 initial, List 1 thereafter
1143D	monitoring well	active	8/8/12	Sub-McKay	37-46	semiannual	Table 2, List 3 initial, List 1 thereafter
1144D	monitoring well	active	8/8/12	Sub-McKay	37-86	semiannual	Table 2, List 3 initial, List 1 thereafter
1145D	monitoring well	active	8/8/12	Sub-McKay	48-58	semiannual	Table 2, List 3 initial, List 1 thereafter
1146D	monitoring well	active	11/15/12	Sub-McKay	42-82	semiannual	Table 2, List 3 initial, List 1 thereafter
1147D	monitoring well	active	11/15/12	Sub-McKay	29-69	semiannual	Table 2, List 3 initial, List 1 thereafter
1148D	recovery well	active	11/15/12	Sub-McKay	53-63	semiannual	Table 2, List 3 initial, List 1 thereafter
1149M	monitoring well	active	11/16/12	McKay	39-48	semiannual	Table 2, List 3 initial, List 1 thereafter
1150A	monitoring well	active	11/16/12	Alluvium	20-30	semiannual	Table 2, List 3 initial, List 1 thereafter
1151M	monitoring well	active	11/16/12	McKay	12-22	semiannual	Table 2, List 3 initial, List 1 thereafter
1152D	recovery well	active	11/16/12	Sub-McKay	15-23	semiannual	Table 2, List 3 initial, List 1 thereafter
DP-3 IT - Drain Pit 3 interception trench sump	interception trench	active	Jul-00	Alluvium	Int. Trench	semiannual	WRMP, table 2, list 1
DP3-636R	monitoring well	active	2/7/00	Rosebud	9 - 19	annual	WRMP, table 2, list 1
DP3-637A	monitoring well	active	2/5/00	Alluvium	6 - 14	semiannual	WRMP, table 2, list 1
DP3-638A	monitoring well	active	2/5/00	Alluvium	6 - 13	annual	WRMP, table 2, list 1
DP3-639D	monitoring well	active	2/8/00	Sub-McKay	36 - 74	annual	WRMP, table 2, list 1
DP3- MTP - DP3-Main Trench Piezometer	monitoring well	active	Jul-00	Alluvium	5 - 10	not sampled	
DP3-TP1	monitoring well	active	Jul-00	Alluvium	5 - 10	not sampled	
DP3-TP2	monitoring well	active	Jul-00	Alluvium	5 - 10	not sampled	
DP5- IT - Drain Pit 5 interception trench sump	interception trench	active	2000	Alluvium	Int. Trench	semiannual	WRMP, table 2, list 1
DP5-P1	monitoring well	active	9/1/00	Alluvium	3.5 - 13.5	not sampled	
DP5-P2	monitoring well	active	9/1/00	Alluvium	5 - 15	not sampled	
DP5-P4	monitoring well	active	9/1/00	Alluvium	10 - 20	not sampled	
EAP-502	monitoring well	active	12/1/81	Sub-McKay	162-172	every 2 years (2014)	WRMP, table 2, list 1
EAP-514	monitoring well	active	11/1/81	Sub-McKay	165-170	semiannual	WRMP, table 2, list 1
EAP-515	monitoring well	active	11/1/81	Sub-McKay	157-167	semiannual	WRMP, table 2, list 1
IT-1	monitoring well	active	10/1/98	Alluvium	20 - 25	not sampled	
IT-2	monitoring well	active	10/1/98	Alluvium	17 - 22	not sampled	
IT-3	monitoring well	active	10/1/98	Alluvium	18 - 23	not sampled	
IT-4	monitoring well	active	10/1/98	Alluvium	19 - 24	not sampled	
MDS-1	monitoring well	active	10/1/98	Shallow alluvial	15 - 20	not sampled	
MDS-2	monitoring well	active	10/1/98	Shallow alluvial	17 - 22	not sampled	
P-DP5-10-1 Temporary. Installed w/back hoe to monitor pipeline leak	monitoring well	active	12/16/10	Alluvium	4-5 feet	not sampled	
PSW-1 Egan	stock well	active	re-drilled 7/22/04	Sub-McKay	250 - 300	annual	WRMP, table 2, list 1

APPENDIX B
GROUNDWATER SAMPLING SITES
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3&4 EFFLUENT HOLDING POND

Site Name Description	Site Type	Site status (PPL)	Date Installed (Mo-Yr)	Target Aquifer(s)	Interval Screened Below G.S.	Sampling Frequency	Sample parameters*
PSW-2 state land	stock well	active	Unknown	no well log	No well log	semiannual	WRMP, table 2, list 1
PSW-3 Egan	stock well	active	7/22/04	Sub-McKay	120 - 170	annual	WRMP, table 2, list 1
PSW-4A	recovery well	active	9/26/07	Alluvium	14 - 23	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1: List 3 Quarterly
PSW-5 Egan	stock well	active	Unknown	no well log	No well log	every 2 years (2014)	WRMP, table 2, list 1
PSW-6 (initially intended as stock well)	monitoring well	active	5/26/05	Sub-McKay	118 - 178	annual	WRMP, table 2, list 1
PSW-7 McRae	stock well	active	7/27/05	Sub-McKay	150 - 180	annual	WRMP, table 2, list 1
PSW-8 - stock well - Kim & Doug McRae	stock well	active	Unknown	no well log	No well log	not routinely monitored	
PSW-9 Egan	stock well	active	7/23/09	Sub-McKay	100 - 160	annual	
spring east of ponds	surface site	active	Not applicable	Spring	Not applicable	semiannual	WRMP, table 2, list 1
SP-15 North trench	interception trench	active	12/10/02	Base McKay/Alluvium	Int. Trench	semiannual	WRMP, table 2, list 1
SP-15 Northwest trench	interception trench	active	5/19/06	Alluvium	Int. Trench	semiannual	WRMP, table 2, list 1
SP-15 South trench	interception trench	active	9/15/02	Alluvium	Int. Trench	semiannual	WRMP, table 2, list 1
test pit by well 624D - added stock tank summer 2009	test pit	active	9/9/09	Colluvium	Dev. Spring	annual	
TR-P1 (formerly 688P)	monitoring well	active	12/15/04	Alluvium	13.5 - 23.5	semiannual	WRMP, table 2, list 1
TR-P2 (formerly 689P)	monitoring well	active	12/16/04	Alluvium	14 - 24	semiannual	WRMP, table 2, list 1
WA-133	WeCo monitoring well	active	4/1/81	Alluvium	7-12	semiannual	WRMP, table 2, list 1
WA-135	WeCo monitoring well	active	4/1/81	Alluvium	8-12.5	semiannual	WRMP, table 2, list 1
WA-136	WeCo monitoring well	active	4/1/81	Alluvium	12-21	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1: List 3 Quarterly
WA-137	WeCo monitoring well	active	4/1/81	Alluvium	12-21	semiannual (Hydrometrics samples quarterly)	WRMP, table 2, list 1: List 3 Quarterly
WA-142	WeCo monitoring well	active	11/1/81	Alluvium	8-16	semiannual	WRMP, table 2, list 1
WI-108	WeCo monitoring well	active	4/1/81	Interburden	42-47	semiannual	WRMP, table 2, list 1
WI-109	WeCo monitoring well	active	4/1/81	Interburden	63-66	semiannual	WRMP, table 2, list 1
WM-124	WeCo monitoring well	active	4/1/81	McKay Coal	58-64	semiannual	WRMP, table 2, list 1
WM-126	WeCo monitoring well	active	4/1/81	McKay Coal	68.5-77.5	semiannual	WRMP, table 2, list 1
WM-127	WeCo monitoring well	active	4/1/81	McKay Coal	85-94	semiannual	WRMP, table 2, list 1
WR-128	WeCo monitoring well	active	4/1/81	Rosebud Coal	38-62	semiannual	WRMP, table 2, list 1
WR-129	WeCo monitoring well	active	4/1/81	Rosebud	70-77	semiannual	WRMP, table 2, list 1
test pit north (west seep)	test pit	inactive	12/8/04	Rosebud burn	8 - 9	inactive	
test pit south (west seep)	test pit	inactive	12/8/04	Rosebud burn	7.5 - 9	inactive	
Upper Spring-NW	spring	inactive	Spring	Spring	Not applicable	inactive	
WA-129	WeCo monitoring well	inactive	Unknown	Alluvium	Unknown	inactive	
WA-132	WeCo monitoring well	inactive	4/1/81	Alluvium	16-21	inactive	
WA-134	WeCo monitoring well	inactive	4/1/81	Alluvium	13 - 18	inactive	
WA-138	WeCo monitoring well	inactive	Unknown	Alluvium	Unknown	inactive	
WA-144	WeCo monitoring well	inactive	7/1/82	Alluvium	3.5 - 8.5	inactive	
WA-145	WeCo monitoring well	inactive	7/1/82	Alluvium	10 - 15	inactive	
WA-217	WeCo monitoring well	inactive	11/1/88	Alluvium	7 - 22	inactive	
WA-218	WeCo monitoring well	inactive	11/1/88	Alluvium	3 - 23	inactive	
WA-219	WeCo monitoring well	inactive	11/1/88	Alluvium	3 - 10	inactive	
WA-220	WeCo monitoring well	inactive	11/1/88	Alluvium	7 - 17	inactive	
WA-221	WeCo monitoring well	inactive	11/1/88	Alluvium	3 - 10	inactive	
WA-222	WeCo monitoring well	inactive	11/1/88	Alluvium	14 - 24	inactive	
WD-104	WeCo monitoring well	inactive	5/22/80	Sub-McKay	Unknown	inactive	
WD-106	WeCo monitoring well	inactive	4/1/81	Sub-McKay	20 - 50	inactive	
WD-185	WeCo monitoring well	inactive	Unknown	Sub-McKay	Unknown	inactive	
WD-186	WeCo monitoring well	inactive	Unknown	Sub-McKay	Unknown	inactive	
WI-107	WeCo monitoring well	inactive	Unknown	R-M Interburden	Unknown	inactive	
WI-110	WeCo monitoring well	inactive	Unknown	R-M Interburden	Unknown	inactive	
WI-185	WeCo monitoring well	inactive	Unknown	R-M Interburden	Unknown	inactive	
WI-186	WeCo monitoring well	inactive	Unknown	R-M Interburden	Unknown	inactive	
WM-128	WeCo monitoring well	inactive	Unknown	McKay	Unknown	inactive	
WM-138 (stopped sampling in 1995)	WeCo monitoring well	inactive	11/20/81	McKay	63-71	Not applicable	
WM-185	WeCo monitoring well	inactive	Unknown	McKay	Unknown	inactive	

APPENDIX B
GROUNDWATER SAMPLING SITES
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
UNITS 3&4 EFFLUENT HOLDING POND

Site Name Description	Site Type	Site status (PPL)	Date Installed (Mo-Yr)	Target Aquifer(s)	Interval Screened Below G.S.	Sampling Frequency	Sample parameters*
WM-186	WeCo monitoring well	inactive	Unknown	McKay	Unknown	inactive	
WR-128	WeCo monitoring well	inactive	4/18/81	Rosebud	38-62	inactive	
WS-110	WeCo monitoring well	inactive	Unknown	Spoil	Unknown	inactive	
WS-184	WeCo monitoring well	inactive	Unknown	Spoil	Unknown	inactive	

*WRMP = Water Resources Monitoring Plan

APPENDIX B LIST 1 OF 4

PPL Montana Colstrip Steam Electric Station
Environmental Compliance Department

Water Quality Sample Parameter List 1
(Energy Lab Quote B1618)

Physical Properties

Specific Conductivity (umhos/cm)
pH (lab)
Total Dissolved Solids Measured at 180 ºC

Inorganics

Alkalinity, Total as CaCO3
Bicarbonate as HCO3
Bromide (Br)
Carbonate as CO3
Chloride (Cl)
Sulfate (SO4)

Trace Elements (Dissolved metals)

Boron (B)
Calcium (Ca)
Magnesium (Mg)
Potassium (K)
Selenium (Se)
Sodium (Na)

Quality Control

A/C Balance Sigma
TDS ratio

APPENDIX B LIST 2 OF 4

PPL Montana Colstrip Steam Electric Station
Environmental Compliance Department

Water Quality Sample Parameter List 2
(Energy Lab Quote B1619)

Physical Parameters

Specific Conductivity (umhos/cm)
pH (lab)
Total Dissolved Solids Measured at 180 ºC

Common Ions

Alkalinity, Total as CaCO3
Bicarbonate as HCO3
Bromide (Br)
Carbonate as CO3
Chloride (Cl)
Sulfate (SO4)

Trace Elements (Dissolved metals)

Boron (B)
Calcium (Ca)
Magnesium (Mg)
Mercury (Hg)
Potassium (K)
Selenium (Se)
Sodium (Na)

Quality Control

A/C Balance Sigma
TDS ratio

APPENDIX B LIST 3 OF 4

PPL Montana Colstrip Steam Electric Station
Environmental Compliance Department

Water Quality Sample Parameter List 3

Physical Parameters

Specific Conductivity (umhos/cm)
pH (lab)
Total Dissolved Solids Measured at 180 ºC
Total Hardness as CaCO3

Common Ions

Acidity
Alkalinity, Total as CaCO3
Bicarbonate as HCO3
Bromide (Br)
Carbonate as CO3
Chloride (Cl)
Sulfate (SO4)

Nutrients

Nitrogen, Nitrate +Nitrite as N

Trace Elements (Dissolved metals)

Boron (B)
Calcium (Ca)
Magnesium (Mg)
Potassium (K)
Selenium (Se)
Sodium (Na)

APPENDIX B LIST 4 OF 4

PPL Montana Colstrip Steam Electric Station
Environmental Compliance Department

Water Quality Sample Parameter List 4

Physical Parameters

Specific Conductivity (umhos/cm)
pH (lab)
Total Dissolved Solids Measured at 180 ºC

Common Ions

Alkalinity, Total as CaCO3
Bicarbonate as HCO3
Bromide (Br)
Carbonate as CO3
Chloride (Cl)
Sulfate (SO4)

Nutrients

Nitrogen, Nitrite as N
Nitrogen, Nitrate as N
Nitrogen, Nitrate+ Nitrite as N

Trace Elements (Dissolved metals)

Arsenic
Boron (B)
Chromium
Calcium (Ca)
Iron
Lead
Magnesium (Mg)
Manganese
Mercury
Potassium (K)
Selenium (Se)
Sodium (Na)