PPL MONTANA, LLC
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE REPORT

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PPL MONTANA, LLC
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE REPORT

EXCECUTIVE 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 (Colstrip SES). 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);
- 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 Characterization Report provides information required in the AOC for the Plant Site.

PPLM is the operator of the Colstrip SES, which consists of 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. The Colstrip SES (the 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. Scrubber flyash slurry disposal does not occur at the Plant Site but rather in disposal ponds at separate locations. Scrubber slurry from Units 3 and 4 is routed to the 3&4 EHP, located about three miles east-southeast of Colstrip. Scrubber slurry from Units 1 and 2 is routed to the STEP, located about three miles west-northwest of Colstrip. Bottom ash from each of the four units is held in Plant Site ponds. A detailed description of each of the Plant Site process ponds is included in this report, including dates of service, use, volume, and liner information. In addition, water quality for each of the ponds including minimum, maximum, average and median concentrations are tabulated in the report. Water quality in the ponds is highly variable and depends on the use of the water (to transport scrubber slurry, bottom ash water, cooling water, storm water runoff, etc.). Variability in the water quality occurs due to changes in use, water management (transfers between ponds), evaporation, and precipitation.

Elevated concentrations of total dissolved solids (TDS), sulfate, boron, chloride, and increased specific conductance (SC) are present in process water liquids/solids within some of the Plant Site ponds. These parameters are used as indicators for process water impacts in groundwater outside of the ponds. In addition, the majority of ponds have a high concentration of magnesium in relation to calcium, which makes the ratio of these two parameters an important indicator parameter of process water impacts outside of the ponds.

Estimates of pond seepage to local groundwater are presented in Section 2. Methods of seepage calculation appropriate for geomembrane-lined and compacted clay-lined pond specifications were selected for the analyses. The cumulative estimate of seepage to groundwater from the five geomembrane-lined ponds on the Plant Site was less than one gpm. The cumulative estimate of seepage from the Plant Site ponds constructed with native compacted clay liners was approximately 80 gpm. Note that clay-lined ponds do not service the current scrubber loop; rather they are used primarily to hold storm water runoff and raw water.

Water quality monitoring is conducted routinely by PPLM at a network of over 150 monitoring sites on the Plant Site. Monitoring sites include process ponds, monitoring wells, and groundwater capture wells. Groundwater quality data are evaluated and further investigation and/or mitigation actions are conducted in areas showing process water impacts.

The AOC provides for investigations and mitigation to be implemented via Interim Response Actions (IRA). IRA are implemented in response to circumstances identified through hydrogeologic evaluation and not because of an acute threat to human health or a recent spill. A summary of past releases of process water, a description of investigations performed to date, a list of reports resulting from the investigations, and a summary of the findings and results from investigations conducted on the Plant Site are included in Section 3 of the following report.

Groundwater with process water impacts has been identified on the Plant Site downgradient of PPLM process ponds. To date, 54 groundwater capture wells and four process pond under-liner secondary collection systems are operated at the Colstrip SES to capture the impacted groundwater in the Plant Site. Groundwater is also collected at a well on adjacent property referred to as the WECO well. Groundwater collected at the WECO well is routed to Colstrip SES Plant Site ponds. Evaluation of data associated with the capture systems indicates effective source control and hydraulic gradient control in the majority of the Plant

Site. Impacted groundwater is pumped to lined process ponds or treated via the Vibratory Shear Enhancement Process (VSEP).

A preliminary conceptual groundwater model and a MODFLOW based numerical groundwater flow model was developed for the Plant Site and Stage I and Stage II area in 2004 (Maxim, 2004). Geomatrix (2006) revised the scope of modeling efforts to focus more on the Plant Site; furthermore, the report discussed contaminant transport pathways and receptors and incorporated the USGS code MODPATH. Geomatrix further updated the model in 2008 by integrating data that had been collected since the original model development. The 2008 model was used to perform additional groundwater capture analysis and resulted in recommendations for additional data and expanding the model effort. Additional detail and layers were added to the model based on this assessment. NewFields has taken the existing model and further refined it by adding new data, performing additional calibrations, and performing particle trace and capture zone analysis. Results of the past and current groundwater model (NewFields 2015) predict that the vast majority of potentially impacted groundwater is or will be captured. Areas where incomplete capture may exist are the Units 3&4 Bottom Ash Ponds, the area around well OT-7 (which is apparently not in the groundwater flow path from the Plant Site), near the south end of the Units 1&2 B pond, and in a small area near the Units 3&4 North Area Drain Collection Pond.

Data gaps identified through the modeling effort are identified in the 2015 model report (NewFields). Additional data gaps identified through evaluation of Plant Site for this Site Characterization Report are included in Section 5. These data gaps include the need for more accurate flow data from capture wells, additional hydrogeological information from specific areas, current hydraulic conductivities for the clay lined ponds, elevation and water level data on WECO stormwater ponds, additional stream flow and time equivalent water level data (including wells on Rosebud Mine property), further documentation of activities, water quality and depths to water near the Units 3&4 Bottom Ash Ponds, and depth-stratified water quality samples from Plant Site ponds.

Recommendations to address noted data gaps are included in Section 6. These recommendations include:

- continuation of current groundwater capture activities and expansion, if necessary;
- continuation and refinement of groundwater monitoring;
- continuation of Best Management Practices (BMPs);
- continuation of annual synoptic runs on East Fork Armells Creek (the creek);
- continuation of water balance refinement;
- further study of scaling problems in capture systems; and
- evaluation of pond liner permeability.

PPL MONTANA, LLC
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT 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 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 on line since October 1983. Unit 4 came on line near the end of 1985 and began producing commercial power in April of 1986. Ponds serving Units 1&2 were put into service in 1975. The pond system servicing Units 3&4 has been in use since 1983.

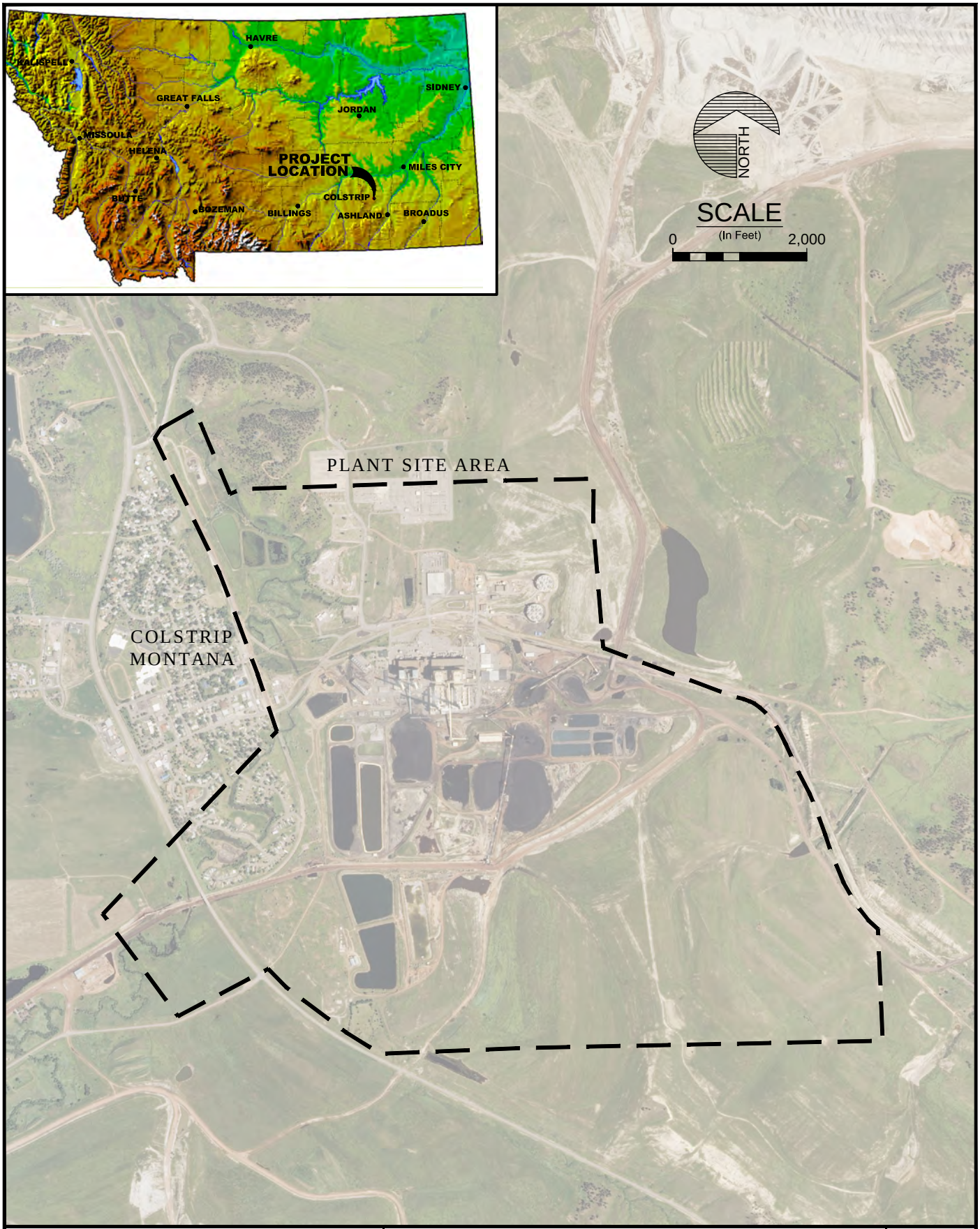
On August 3, 2012, PPLM and the Montana Department of Environmental Quality (MDEQ) entered into an Administrative Order on Consent (AOC) Regarding Impacts Related to Wastewater Facilities Comprising the Closed-Loop System at the Colstrip Steam Electric Station (MDEQ/PPL Montana, 2012). As part of the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

regarding past spills, pond seepage, and current conditions in accordance with the AOC. Figure 1-1 shows the extent of the Plant Site Area as defined in the AOC.

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 Plant Site. Current and future activities described in the AOC all occur inside the boundaries of the Plant Site Area.



PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT PLANT SITE REPORT	**PLANT SITE LOCATION**	FIGURE **1-1**

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Hydrometrics, Inc.
Consulting Scientists and Engineers

2.0. CLOSED LOOP SYSTEM DESCRIPTION, POND CONSTRUCTION AND POND WATER QUALITY

2.1 CLOSED LOOP SYSTEM

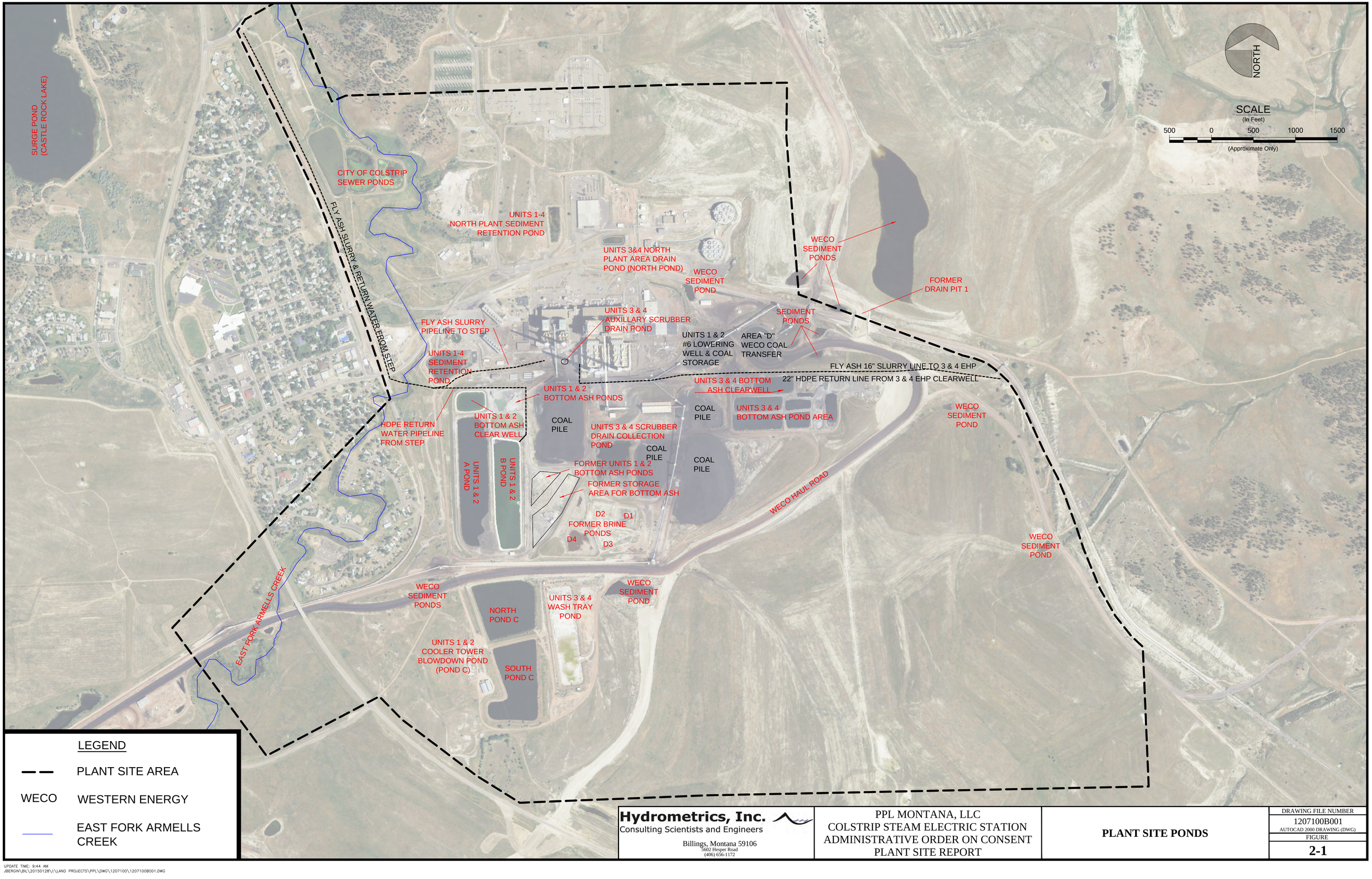
A closed-loop process water/scrubber system is used at the Colstrip SES to minimize impacts to water resources in the area. Water based liquid wastes from the generating plants are impounded in ponds designed and constructed to minimize seepage losses. The Plant Site pond system includes ponds that serve all four generating units in various capacities. Flyash disposal is not conducted on the Plant Site but rather in holding ponds located northwest (SOEP and STEP) and east (3&4 EHP). The pond system presently servicing Colstrip Units 1&2 has been in use since 1975. The pond system servicing Units 3&4 has been in use since 1983.

A variety of ponds located on the Plant Site have been used to support generation activities during this time frame. Process ponds and flyash slurry pipeline locations on the Plant Site are shown on Figure 2-1. Construction material summaries, and changes in materials through time, are summarized on Table 2-1.

2.1.1 Definitions

Several terms used in Table 2-1 and throughout this report require defining as follows:

- Blowdown – A portion of water from the cooling tower which is removed and replaced with raw water containing lower concentrations of dissolved solids. The process is conducted to reduce the potential for scale buildup in the cooling towers.
- Boiler – structure where coal combustion occurs and steam is produced for the turbines. Pulverized coal is injected with air into the boiler resulting in combustion. The heat from the burned coal heats the water in the boiler tubes which generates steam to turn turbines and generate electricity.



LEGEND

- PLANT SITE AREA
- WECO — WESTERN ENERGY
- EAST FORK ARMELLS CREEK

Hydrometrics, Inc. Consulting Scientists and Engineers Billings, Montana 59106 5602 Hesper Road (406) 656-1172	PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT PLANT SITE REPORT	**PLANT SITE PONDS**	DRAWING FILE NUMBER 1207100B001 AUTOCAD 2000 DRAWING (DWG) FIGURE **2-1**

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TABLE 2-1
COLSTRIP STEAM ELECTRIC STATION
ADMINSTRATIVE ORDER ON CONSENT
PLANT SITE PROCESS PONDS

Waste Water Facility	Total Capacity (acre-feet)/ft^3 [1]	Surface Area (acres)/ft^2 [2]	Pond Level (on September 24, 2014) Elev. (ft)/acre-feet	Years in-service	Lining	Pond Function /Comments
Units 1 & 2 Flyash Pond	(490)/21,344,400	(27)/1,176,120	--	1975 - present	See below	Originally received scrubber slurry on an short-term basis until the solids could be dredged to the Stage I or Stage II Evaporation Ponds for final disposal. Clear water from this pond flowed into the Clearwell where it was sent back to the scrubbers for re-use. In 1997, an extension to the existing Sediment Retention Pond (SRP) area groundwater collection was installed in this area. In 2002 and 2003, additional expansion was added to the groundwater collection in this area.
Clearwell	(49)/2,134,440	(3)/130,680	Not Recorded	1975 - present	Clay originally, double-lined RFP with leachate collection system installed in 2006	This section of the pond was removed from scrubber service in May of 2005. In 2006, this area was double-lined with 45 mil RFP and a leachate collection system installed between the liners and under both liners. This area is currently being used as the 1&2 Bottom Ash Pond Clearwell. This is still a collection point for the SRP groundwater collection systems.
A Pond (west)	(245)/10,672,200	(14)/609,840	(3257.56)/223	1975 - present	Clay	This section of the pond was removed from scrubber service in May of 2005. It is currently being used as a clean water storage pond (stormwater runoff, etc).
B Pond (east)	(196)/8,537,760	(10)/435,600	(3260.05)/196	1975 - present	Clay originally, double-lined RFP with leachate collection system installed in 2004.	This section of the pond was double-lined with 45 mil RFP and a leachate collection system between the liners and under both liners and placed in-service in 2004. Normally this section of the pond recieves scrubber return water from the STEP but can receive scrubber slurry during emergency conditions (i.e. scrubber slurry pipeline out of service). Periodically, solids will be dredged to Stage II Evaporation Pond for final disposal.
1&2 Scrubber Pipeline	na	na	na	1975 - present	Lined Steel Pipe, changed to HDPE in 2001	Transports scrubber slurry 3 miles from the scrubbers to the Stage I & II Evaporation ponds and returns clearwater back to the scrubbers. Line was originally lined-steel, changed out to HDPE in 2001. Failure of pipeline reported in 2000 (4), and 2002.
Units 1&2 Wash Tray Pond	(50)/2,178,000	(8)/348,840	na	1975 - 1980	Clay	Originally served as a scrubber pond for the wash tray loop. This pond was abandoned in 1980 when a separate loop for the scrubber wash tray was determined to be unnecessary. This area was converted to the 1&2 Bottom Ash Pond in 1988.
Units 1 & 2 Bottom Ash Pond w/ Clearwell	(24)/1,045,440	(4)/174,240	Not Recorded	1975 - present	Clay, new clearwell double-lined RFP with leachate collection installed in 2006	Collection area for bottom ash and drain collection pit effluent. Clearwater flows into the clearwell section of this pond and is returned to the plant bottom ash system for re-use. In 1988, the bottom ash ponds were relocated to the area just north of the 1&2 Flyash Pond B side. In 2006, the 1&2 Flyash Pond Clearwell was double-lined with 45 mil RFP (with leachate collection between the liners and below both liners) and converted to the new 1&2 Bottom Ash Pond Clearwell.
Units 1 & 2 Brine Waste Disposal Ponds	(60)/2,613,600	(4)/174,240	na	1976 - 2005	Hypalon	Disposal location for brine from Wastewater Concentrator (RCC). The Wastewater Concentrator is no longer in-service (removed in 2000), so these ponds no longer collect brine.
D1 - D3 ponds	(30)/1,306,800	(2)/87,120	na	D1 & D2 1976 - 1994, D3 1980 - 1994	Hypalon	In 1980-1981, a failure of the D3 Pond was identified and repaired. In 1985, the Brine Pond Collection system was installed to collect impacted groundwater. These ponds were closed in 1994. The solids were removed and stored in F cell of the 3&4 EHP. The liner was also removed. The depressions from these ponds were left to provide a clean water collection area for precipitation which would allow for clean water recharge into the area.
D4 pond	(30)/1,306,800	(2)/87,120	na	1984 - 2005	Hypalon, with a underdrain system	This pond has an Underdrain Collection system and is used as a excess water storage area. In November 2005, a problem was identified with the liner and the pond was drained and removed from service. In 2006, the pond was closed with solids stored within a lined section and capped with a 45 mil RFP. In 2007, a soil cover was placed over the liner cap and seeding completed. Soil removed from below former D4 Brine Pond liner in Fall 2014.
Units 1 & 2 Cooling Tower Blowdown Pond (Pond C)	(400)/17,424,000	(20.5)/892,980	--	1978 - present	Clay	Originally received cooling tower blowdown and raw water which was used as make-up to the Wastewater Concentrator. In 1987, the pond was split into two sections (North and South). The Cooling Tower Blowdown Pond C was lined during the intial construction (1978). The South Pond was relined with clay and erosion control was added in the form of a geotextile material and scoria.
North pond	(195)/8,494,200	(10)/435,600	(3263.12)/132	1978 - present	Clay	In 2004, this pond began receiving groundwater collection water (Brine Pond and 10S/10M collection systems)to be used for a highway construction project. In 2005, raw water and storm water runoff was sent to this pond for additional raw water storage because of the anticipated drought conditions. This pond is used to store stormwater runnoff for water management purposes. Size reduce in spring 2012, clay lining remained.
South pond	(205)/8,929,800	(10.5)/457,380	(3264.62)/158	1978 - present	Clay with geotextile and scoria on banks added for erosion control in 1987	Since 2000, this pond has been receiving raw water and storm water runoff to provide road watering for dust control. In 1999, a groundwater collection system was installed on the south end of this pond.
Units 3 & 4 Auxiliary Scrubber Drain Pond	(0.51)/22,216[3]	(0.23)/10,019[3]	Not Recorded	1983 - present	Hypalon/Concrete[3]	Miscellaneous scrubber building drains. Pond being rebuilt as of December 2014.

TABLE 2-1
COLSTRIP STEAM ELECTRIC STATION
ADMINSTRATIVE ORDER ON CONSENT
PLANT SITE PROCESS PONDS

Waste Water Facility	Total Capacity (acre-feet)/ft^3 (1)	Surface Area (acres)/ft^2 (2)	Pond Level (on September 24, 2014) Elev. (ft)/acre-feet	Years in-service	Lining	Pond Function /Comments
Units 3 & 4 North Plant Area Drain Pond (North Pond)	(4.5)/196,020	(1)/43,560	Not Recorded	1984 - present	Hypalon originally, now High Density Polyethylene (HDPE)	Receives raw water pretreatment filter backwash, cooling tower overflow, and miscellaneous north plant drainage. Water from this pond is sent to the bottom ash system or the circulating water system. Hypalon liner installed during initial construction (1984), relined in mid-90's with High Density Polyethylene (HDPE)
Units 3 & 4 Wash Tray Pond	(85)/2,702,600	(8)/348,480	na	1983 - 1995	Clay In 1988 the bank on the southern half of the pond was covered with geotextile and baked shale to reduce bank erosion.	Originally served as a scrubber pond for the wash tray loop. This pond was abandoned in 1995 when a separate loop for the scrubber wash tray was determined to be unnecessary. The wash tray loop is now fed from the Units 3&4 EHP pond return water and the bleed goes to the scrubber recycle tank. The pond remains, but no longer utilized.
Units 3 & 4 Scrubber Drain Collection Pond. (DC Pond)	(72)/3,136,320	(6)/261,360	na	1983 - 1999	Clay	Received miscellaneous scrubber plant drains and washdown. This pond received scrubber slurry at times. In 1989, this pond was relined with 3" of clay and the east and south banks were shored up to address dredging and bank erosion issues. An access ramp was also added. In 1999, this pond was taken out of service and the scrubber drains/washdown was sent to the 3&4 EHP. In 2009 this pond was used to store the cleanup of materials from the 1&2 bottom ash secondary settling pond. The solids remain in this pond, but the water was pumped back to the 1&2 B Flyash pond. The pond remains, but not currently utilized.
Units 3 & 4 Bottom Ash Pond w/ Clearwell	(38.4)/1,672,704	(7.6)/331,050	Not Recorded	1983 - present	Clay	Collection area for bottom ash and main plant sumps. Clearwater flows into the clearwell section of this pond and is returned to the plant bottom ash system for re-use. In 1991, the initial settlement cells of this pond were relined with clay and reshaped. In 1999, a groundwater collection system was installed in this area. In 2002 and 2003, this groundwater collection system was expanded.
Units 3&4 Scrubber - EHP Pipeline	na	na	na	1983 - present	NA	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 (3), 1989, 1990 (2), 1992, 1993 (7), 1994 (2), 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.
Units 1 - 4 Sediment Retention Pond	(16)/696,960	(3.6)/156,816	Not Recorded	1975 - present	Originally Hypalon lined, then relined with High Density Polyethylene (HDPE) in 1989.	Receives plant storm water drainage and occasional scrubber overflow or cooling tower basin overflow. This water is pumped to the 1&2 Flyash Pond A or B side, depending on quality. In 1989, this pond was relined with HDPE to address gas bubbles that were causing the original hypalon liner to rise and risk its integrity. In 1995, a goundwater collection system was installed in this area.
Units 1 - 4 North Plant Sediment Retention Pond	(4)/174,240	(0.6)/26,136	Not Recorded	1975 - present	Clay	Receives surface drainage from north plant and warehouse areas. Lined with 3' clay during initial construction (1975).
Unit 4 Cooling Tower Canal	na	na	na	1985 - present	Concrete	Route circulating water from Unit 4 cooling tower to the circulating water pumphouse. In 1989, frost damage occurred to the concrete, resulting in replacement of the original canal to a pre-fabbed underground concrete structure.

(1) Design Capacity - To convert acre feet to cubic feet multiply by 43,560 square feet
(2) Area of pond footprint - top dimensions - multiply acres by 43,560 to get square feet
(3) Pond being rebuilt as of December 2014 and will be constructed as a concrete pond with a capacity of 2.05 Acre Feet/ 3,333 cubic feet
na - not applicable. Facility is no longer in service or facility is not parameterized by the dimension listed.
Not Recorded -- Facility is in operation but water level is not routinely monitored.

- Circulating water system – System of water used in the generation of electricity including raw water, makeup water, cooling water, bottom ash and flyash scrubber slurry, etc. The water is reused in various parts of the process.
- HDPE – High Density Polyethylene – a synthetic material that is a polyethylene thermoplastic. HDPE has a multitude of industrial uses including pipelines and liners to name a few. HDPE resists deterioration from chemicals, weather, heat, and oxygen. HDPE has been used to line some of the ponds at the Colstrip SES since it is flexible and does not crack.
- Hypalon – A synthetic material that is a registered trademark for a family of chlorosulfonated polyethylene synthetic rubbers. Hypalon resists deterioration from chemicals, weather, heat, and oxygen, and is flexible. Hypalon was has been used to line some of the ponds at the Colstrip SES.
- Leachate Collection – collection of fluids that has passed through a solid material such as liners, soil, or organic debris.
- Liner – An impermeable material (HDPE, Hypalon, reinforced polypropylene (RFP)), or material that exhibits very low permeability (clay, polymers, etc.) that is placed on the bottom of a pond, lake, canal, stream bed, etc. to retain water in the structure or to limit movement of fluids through the bottom of the structure.
- Plant Bottom Ash System – circulatory system used to collect and transport bottom ash to the bottom ash ponds.
- RFP – A synthetic material, sometimes referred to as reinforced polypropylene (RPP), that is light weight, heat weldable, ultraviolet resistant polypropylene sheeting reinforced by sandwiching reinforcing fiber between polypropylene sheets. The material is commonly used for lining ponds due to its light weight, strength, UV resistance, chemical resistance, flexibility, and low expansion and contraction characteristics. RFP has been used to line some of the ponds at Colstrip SES.
- Scrubber – Pollution control equipment that removes SO2, particulates, and other potential pollutants from the combustion flue gas.
- Wash Tray – a section of the scrubbers that helps remove SO2 and particulates from the flue gas.

2.1.2 Water Flow Description

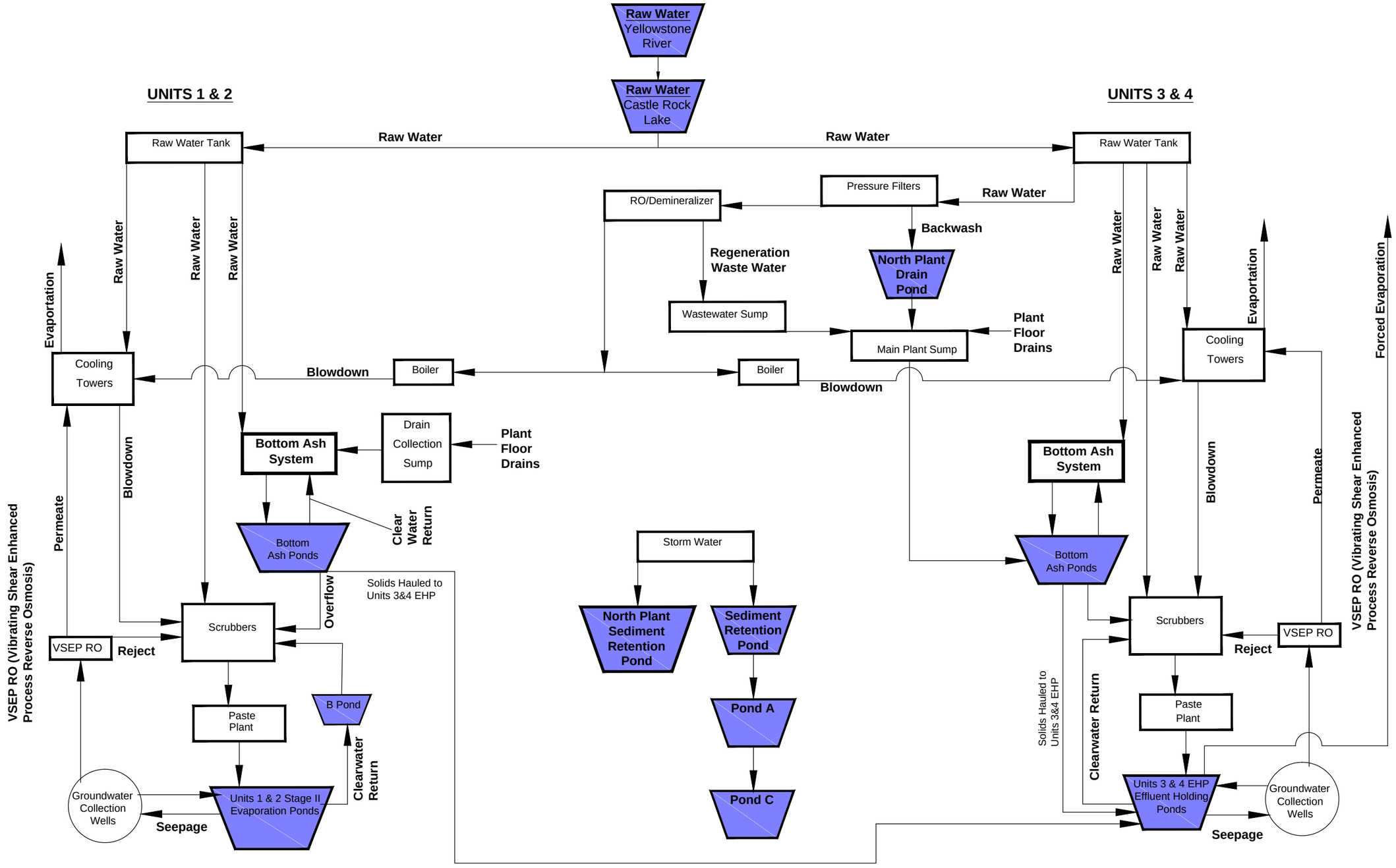
Figure 2-2 is a schematic illustrating process water flow at the Plant Site. Note only ponds that are part of the current process water circuit are shown on Figure 2-2. Ponds listed on Table 2-1 but not shown on Figure 2-2 are either no longer in use or have been removed.

Up to 69 cubic feet per second (CFS) of raw water is piped from the Yellowstone River to Castle Rock Lake (also known as the Surge Pond). Water can then be pumped to the holding tanks on the Plant Site. Water is then distributed for use in the boilers, cooling towers as makeup water, bottom ash systems, or the scrubbers. Raw water is treated by filtration, demineralization, and reverse-osmosis prior to being directed to the boilers. The majority of water used at the facility is in the cooling water systems. The cooling water systems are primarily used to condense the steam after it goes through the turbines so it can be sent back to the boiler to be re-used. The scrubbers are the Plant's main pollution control equipment, used to capture SO2, particulates, and other potential pollutants generated from the combustion of coal. Scrubber slurry is transported to paste plants at the STEP and 3&4 EHP through pipelines. The solids are deposited in the STEP and 3&4 EHP for final disposal and clear water is returned to the scrubbers for reuse.

The Colstrip SES burns coal in the boiler which generates steam from water contained in boiler tubes. The generated steam created is used to rotate turbines that generate electricity. Burning the coal generates exhaust and flue gas which is directed to the scrubbers. Burning the coal leaves two residuals; bottom ash and flyash.

Bottom ash is coarser grained than flyash (pebble sized (4-64 mm)). Bottom ash falls to the bottom of the boiler where it is collected and piped as a slurry to the bottom ash pond. The bottom ash settles out in the pond. Clear water decants into the adjacent Bottom Ash Clearwell (either Units 1&2 Bottom Ash Clearwell or Units 3&4 Bottom Ash Clearwell). Water from the clearwell's is normally routed back to the bottom ash system for reuse.

COLSTRIP WATER PROCESS DIAGRAM



PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT PLANT SITE REPORT	**COLSTRIP PROCESS WATER DIAGRAM**	FIGURE **2-2**

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Hydrometrics, Inc.
Consulting Scientists and Engineers

Flyash, which is lighter than bottom ash, is exhausted with flue gases through the scrubbers. Scrubbers remove the particulates creating a resultant scrubber slurry, which is directed to paste plants located at either the Units 1&2 STEP or Units 3&4 EHP. The paste plant removes water from the scrubber slurry, creating a "paste" that is piped to either the Units 1&2 STEP or Units 3&4 EHP. Water removed from the scrubber slurry in the paste plant is sent to lined clearwell's from which it is pumped back to the Plant for reuse in the scrubbers.

2.1.3 Water Use and Measurement Difficulties

As indicated in the previous section, water is pumped to the Surge Pond at a rate up to 69 CFS, depending on plant operation and season. The majority of this water is used at the Plant Site. A portion is also used for domestic water supply to the City of Colstrip. An estimate of water flows throughout the Plant process has been made, but detailed, accurate flow rates have not been determined because of difficulties with accurate flow measurement.

Difficulties in flow measurement throughout the process water circuit include the following.

- Some of the piping is not equipped with flow meters, some of the flow rates are estimated and general corrections, based on extensive site experience, professional judgment, and observations are made to some of the flow circuits.
- Where flow gages have been used, their accuracy has been limited due to scaling buildup, corrosion, and other maintenance issues.
    - Scale build up in pipes and flow meters reduces the accuracy. Scale reduces the pipe inside diameter causing velocities to be higher than in a pipe void of scale. Flows measured by externally mounted flow meters results in overestimation of pumping volumes.
    - Furthermore, scale buildup on in-line flow meters creates inefficiencies, typically resulting in lower flow readings.
- The large slurry flows can contain solids which range from 0 – 20%. This variability in solids can lead to a significant error in flow measurement.

- Reuse patterns- the process water circuit is not dynamic. That is, it is necessary to open and close values and redirect water during different processes which can introduce error in water balance calculations,
- The ponds have a large surface area, and therefore undergo relatively large amounts of evaporation. The amount of water being removed from the system through evaporation can be estimated but the margin of error is large,
- Similarly, the efficiency of forced evaporation used to reduce the amount of water in the process circuit, is highly variable due to humidity and temperature. This variability causes difficulty in making an accurate estimate of water being evaporated.
- Impacted groundwater collected from capture systems is estimated using local measurements at the pumps. Because of scaling problems and pressure differential caused by pumping uphill to the ponds, the accuracy of the flow estimate is limited.
    - Use of flow meters was attempted early in the groundwater capture process. Severe scaling resulted in continued maintenance of the flow meters, inaccurate measurements, or meter failure.
    - Volumetric flow measurements (time to fill a container of known volume) are used as an alternative to using flow meters. Inaccuracies arise with this method since the flows are measured at individual well head but pipeline pressures downstream of the capture wells vary. For example, flow may be measured at a well with a pipeline back pressure of 50 PSI, while the pressure at the well head is essentially zero. Flow in the pipeline is affected by the amount of back pressure. In this scenario, estimated pumping rates will be higher than those actually occurring in the pipeline.

As a result of these flow measurement difficulties, some of the current flow rates are not being measured, some of the flow rates are measured (possibly with correction), and some of the flow rates are estimated.

2.2 PLANT SITE PONDS

Table 2-1 lists process ponds located on the Plant Site, both current and past and the pond construction information. Process ponds at the Colstrip SES Plant Site have been referred by multiple names. Table 2-2 provides pond names and provides a correlation of other names that may be used, or have been used, to refer to these ponds.

All of the ponds contain some type of lining material, be it natural clay, or synthetic. Two ponds (Units 1&2 B Pond and Units 1&2 Bottom Ash Clearwell) were constructed with underdrain systems. The D4 Pond, which also had an underdrain system, was taken out of service in 2005, but the sump still serves to collect water, if present, under a portion of the pond that was used to dispose of solids within a lined and capped depository. Pond locations are shown on Figure 2-1.

2.2.1 Process Pond Storage and Water Management

2.2.1.1 Storage and Water Management

Process water is contained on the Plant Site in ponds to operate as a zero discharge facility. Water management is essential so an adequate amount of freeboard is maintained to account for upset conditions or to accommodate water introduced through precipitation. Management of the amount of water present in the ponds is complex because of plant operation and natural conditions. In some cases, it is necessary to direct process water to certain ponds to allow for maintenance or to deal with unforeseen occurrences in the operation of the plants.

Furthermore, because of the large area associated with the facility, a significant amount of water volume is added through precipitation. For example, Colstrip receives approximately 15 inches (1.25 feet) of precipitation of water each year. Water falling directly on ponds adds to pond volumes. Relatively large portions of water falling on portions of the Plant Site also enter the ponds through stormwater runoff control measures.

TABLE 2-2
COLSTRIP STEAM ELECTRIC STATION
ADMINSTRATIVE ORDER ON CONSENT (Comment #1 Response Table)
PROCESS POND NOMENCLATURE

Waste Water Facility	Also Known As
Units 1 & 2 Flyash Pond (no longer exists)	Units 1&2 Pond A; Units 1&2 Pond B; Units 1&2 A/B Fly Ash Pond Area; Units 1&2 Fly Ash A/B ponds; A/B Pond; Units 1&2 A/B pond; Units 1&2 A/B Pond Clearwell; Units 1&2 A and B Ponds
Clearwell	Units 1&2 Flyash (and Fly Ash) Clearwell, Fly Ash Clearwell; currently being used as Units 1 & 2 Bottom Ash Clearwell
Units 1 & 2 A Pond (west)	Units 1&2 Pond A; A pond and A Pond; Units 1&2 A Pond; Units 1&2 Fly Ash (and Flyash) Pond A; 1&2 A Pond
Units 1 & 2 B Pond (east)	Units 1&2 Pond B; Units 1&2 **B** Pond; Units 1&2 **"B"** Pond; B pond; Units 1&2 B Flyash Pond, Units 1&2 Flyash B Pond
1&2 Scrubber Pipeline	Scrubber Drain Pipeline
Units 1 & 2 Bottom Ash Pond w/ Clearwell	Units 1&2 Bottom Ash Clear Well; Units 1&2 Bottom Ash Clearwell; Units 1&2 Bottom Ash Ponds; Former Units 1&2 Bottom Ash Ponds; Bottom Ash Ponds; Units 1&2 Bottom Ash; 1&2 Bottom Ash Clearwell
Units 1 & 2 Brine Waste Disposal Ponds	Former Brine Ponds; Former Brine Pond Area; Brine Pond Area; 1&2 Brine Disposal Ponds; Units 1&2 Brine Ponds; Colstrip Units 1&2 Brine Ponds, Brine Pond
D1 - D3 ponds	D3 Brine Pond; D3 Pond Liner; Brine Ponds D1-D3, Brine Pond D-3; former D1-D3 ponds
D4 pond	D4 Brine Pond; D4 Sump; Former D4 Brine Pond; Brine Pond D4; former D4 pond
Units 1 & 2 Cooling Tower Blowdown Pond (Pond C)	Units 1&2 Cooling Water Blowdown Pond Area; Cooling Tower Blowdown Pond; South Cooling Tower Blowdown Pond; Blowdown Pond C; C Pond and Pond C
North pond C	Cooling Tower Blowdown Pond (North and South Pond C); Units 1&2 Cooling Tower Blowdown Pond C North
South pond C	South Cooling Tower Blowdown Pond C; Cooling Tower Blowdown Pond C South
Units 3 & 4 North Plant Area Drain Pond	North Plant Drain Pond; North Plant Area Drain Pond; North Drain Pond Liner; North Drain Pond
Units 3 & 4 Wash Tray Pond	Wash Tray Pond
Units 3 & 4 Auxiliary Scrubber Drain Pond (Duck Pond)	Auxiliary Scrubber Drain Pond; Units 3&4 Auxiliary Scrubber Drain Collection Pond
Units 3 & 4 Scrubber Drain Collection Pond. (DC Pond)	Units 3&4 Drain Collection Pond; Scrubber Drain Pond; Drain Collection Pond; Drain collection pond
Units 3 & 4 Bottom Ash Pond w/ Clearwell	Units 3&4 Bottom Ash Pond Area; Units 3&4 Bottom Ash Pond; Units 3&4 Clearwell; Units 3&4 Bottom Ash Clearwell
Units 3&4 Scrubber - EHP Pipeline	22" HDPE Return Line from 3&4 EHP Clearwell; Scrubber Drain Pipeline; Units 3&4 scrubbers
Units 1 - 4 Sediment Retention Pond (Thompson Lake)	Sediment Retention Pond; Sediment Retention Pond liner; North Sediment Pond
Units 1 - 4 North Plant Sediment Retention Pond	North Plant Sediment Pond; North Plant Sediment Retention Pond; North Plant Pond; North Sediment Retention Pond Area
Unit 4 Cooling Tower Canal	Unit 4 Cooling Tower Canal Break

Deposition of flyash and bottom ash (about 10% of the coal burned) is a continuous process during electric generation. Placement of the ash in the ponds reduces the amount of available storage for water. For this reason, it is necessary to reduce the amount of water at a rate faster than ash deposition and precipitation input rates to maintain sufficient storage. Colstrip SES uses best management practices (BMPs), to help manage water volumes.

2.2.1.2 BMP's for Water Management

PPLM institutes several BMP's to reduce water in the ponds. BMP's are upgraded when necessary to improve the methods used to reduce or contain water. In addition, new measures are periodically implemented to add new BMPs or improve existing facilities to improve water management. BMPs and site improvements are listed in the following bullets:

- Forced Evaporation;
- Weekly Pond Inventory;
- Multifunctional Water Management Team;
- Water Management Guidelines for Operation and Maintenance;
- Cooling Tower Water Management Cycle Optimization;
- On-going Water Reduction/Reuse Initiatives; and
- Review of current technologies with outside consultants.

2.2.2 Plant Site Pond Water Quality

Samples are collected from near the surface of the ponds at the approximate same location for each event. Actual sampling locations depend on site access, safety considerations, and pond levels. Grab samples are collected and the water sample preserved as needed, placed on ice, and transported to an analytical laboratory for analysis.

Metals within the pond samples are analyzed for dissolved phase concentrations in accordance with the MDEQ approved monitoring plan. Pond samples have been analyzed for both total recoverable and dissolved phases of metals in some cases. However, pond samples are generally analyzed for dissolved metals. The total analysis uses a digestion step to place both suspended and dissolved metals into solution. However, dissolved analysis is

considered more applicable for the ponds since water leaving the ponds as seepage will enter groundwater or unsaturated media. Groundwater velocities are typically extremely slow. The very low velocities and filtration characteristics of soil or clay liners make transport of solids from within the pond to groundwater unlikely. Furthermore, the Federal Ambient Water Quality Criteria are based upon aquatic toxicity testing of the dissolved form of the constituent. Therefore, dissolved phase of analysis is applicable to analysis of the pond water.

Select ponds, as listed in the project monitoring plan, are sampled at a minimum frequency of once every three years. Table 2-3 shows statistics for pond water quality including the most recent pond sample collected for each pond sampled at the site. Note that some of the data for pond water quality is for ponds that are not currently in use, or that have been closed. Additional parameters, including organic and inorganic parameters are periodically collected and analyzed. Graphs, showing concentrations of parameters versus time, and a disk containing pond water quality data are in Appendix B. Variation in the quality of process waters is illustrated by the graphs. Water quality in the ponds varies for a number of factors including, but not limited to:

- Changes in plant operations – A number of plant operation related activities can result in water quality variations. Uses of various ponds or the necessity of having the ponds, has changed in some cases due to changes in plant operations, experience with plant operations and ponds, changes in technology. Examples of changes in pond use or necessity include the Brine ponds, Units 3&4 Wash Tray Pond, Units 3&4 Scrubber Drain Collection Pond, Units 1&2 A/B Pond, Units 1&2 Cooling Tower Blowdown Pond (Pond C). These ponds have either been removed (Brine Ponds, Units 1&2 AB Pond Clearwell), taken out of service (Units 3&4 Wash Tray Pond, Units 3&4 Scrubber Drain Collection Pond), reconstructed (Units 1&2 A/B Pond, Units 1&2 Bottom Ash Clearwell), or the use has changed (Units 1&2 A Pond and B Pond), and therefore the routing of water has changed.

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

**** All Data Are Laboratory Analyses. No Field Data Are Included In This Table***

***** NA = Not Analyzed during most recent sampling event***

******Non-detects handled as 100% of the Reporting Limit in Statistical Calculations (i.e. mean, median).***

*******Results preceeded by "<" indicate value below reporting limit. Results preceeded by "<" for mean and median values indicate all results are below applicable reporting limit.***

SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
									4/22/2014
UNITS 1&2 B POND BETWEEN LINER	PH (LAB)	s.u.	7	7/7	6.9	8.4	7.51	7.3	**7.0**
Sample Period: March 2007 To April 2014	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	5	5/5	6470	18700	12474	13800	**13800**
	TDS (MEASURED AT 180 C)	mg/L	7	7/7	6910	30300	19153	20000	**14300**
Water between the upper and lower liners would be sourced from the	TOTAL HARDNESS AS CACO3	mg/L	1	1/1	9940	9940	9940	9940	**9940**
Units 1&2 Stage II Evaporation Ponds	CALCIUM (CA) DIS	mg/L	7	7/7	395	519	455	454	**427**
	CALCIUM (CA) TOT	mg/L	2	2/2	374	423	399	374	**NA**
	MAGNESIUM (MG) DIS	mg/L	7	7/7	731	4460	2711	2520	**2150**
	MAGNESIUM (MG) TOT	mg/L	2	2/2	3980	4750	4365	3980	**NA**
	SODIUM (NA) DIS	mg/L	7	7/7	462	1410	993	1180	**818**
	SODIUM (NA) TOT	mg/L	2	2/2	1160	1360	1260	1160	**NA**
	POTASSIUM (K) DIS	mg/L	7	7/7	17	78	46.6	56	**36**
	POTASSIUM (K) TOT	mg/L	2	2/2	53.2	63	58.1	53.2	**NA**
	TOTAL ALKALINITY AS CACO3	mg/L	7	7/7	103	366	240	315	**103**
	BICARBONATE (HCO3)	mg/L	7	7/7	126	446	292	383	**126**
	CARBONATE AS CO3	mg/L	7	1/7	<1	<4	<3	<4	**<4**
	SULFATE (SO4)	mg/L	7	7/7	4600	21300	13537	13500	**11800**
	CHLORIDE (CL)	mg/L	7	7/7	233	548	400	410	**410**
	FLUORIDE (F)	mg/L	2	2/2	0.94	0.97	0.955	0.94	**NA**
	BROMIDE (BR)	mg/L	4	3/4	11	146	58.5	27	**146**
	ALUMINUM (AL) DIS	mg/L	2	2/2	0.92	1.07	0.995	0.92	**NA**
	ALUMINUM (AL) TOT	mg/L	2	2/2	2.05	2.36	2.21	2.05	**NA**
	ANTIMONY (SB) DIS	mg/L	2	2/2	<0.006	<0.006	<0.006	<0.006	**NA**
	ANTIMONY (SB) TOT	mg/L	2	2/2	<0.005	0.007	0.006	0.005	**NA**
	ARSENIC (AS) DIS	mg/L	2	2/2	<0.003	0.01	0.007	0.003	**NA**
	ARSENIC (AS) TOT	mg/L	2	2/2	<0.003	0.011	0.007	0.003	**NA**
	BARIUM (BA) DIS	mg/L	2	2/2	0.054	0.064	0.059	0.054	**NA**
	BARIUM (BA) TOT	mg/L	2	2/2	0.056	0.061	0.059	0.056	**NA**
	BORON (B) DIS	mg/L	7	7/7	15.7	111	64.2	72.8	**40.8**
	BORON (B) TOT	mg/L	2	2/2	96	118	107	96	**NA**
	CADMIUM (CD) DIS	mg/L	2	2/2	<0.031	<0.031	<0.031	<0.031	**NA**
	CADMIUM (CD) TOT	mg/L	2	2/2	0.028	0.035	0.032	0.028	**NA**
	CHROMIUM (CR) DIS	mg/L	2	2/2	0.007	0.009	0.008	0.007	**NA**
	CHROMIUM (CR) TOT	mg/L	2	1/2	<0.01	<0.01	<0.01	<0.01	**NA**
	COPPER (CU) DIS	mg/L	2	2/2	0.17	0.191	0.181	0.17	**NA**
	COPPER (CU) TOT	mg/L	2	2/2	0.162	0.223	0.193	0.162	**NA**
	IRON (FE) DIS	mg/L	2	0/2	<0.05	<0.05	<0.05	<0.05	**NA**
	IRON (FE) TOT	mg/L	2	0/2	<0.05	<0.05	<0.05	<0.05	**NA**
	LEAD (PB) DIS	mg/L	2	1/2	<0.001	<0.001	<0.001	<0.001	**NA**
	LEAD (PB) TOT	mg/L	2	1/2	<0.001	<0.001	<0.001	<0.001	**NA**
	MANGANESE (MN) DIS	mg/L	2	2/2	70.3	71.6	71	70.3	**NA**
	MANGANESE (MN) TOT	mg/L	2	2/2	63.6	77.4	70.5	63.6	**NA**
	MERCURY (HG) DIS	mg/L	2	0/2	<0.00005	<0.00005	<0.00005	<0.00005	**NA**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

**** All Data Are Laboratory Analyses. No Field Data Are Included In This Table***

***** NA = Not Analyzed during most recent sampling event***

******Non-detects handled as 100% of the Reporting Limit in Statistical Calculations (i.e. mean, median).***

*******Results preceeded by "<" indicate value below reporting limit. Results preceeded by "<" for mean and median values indicate all results are below applicable reporting limit.***

SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 B POND BETWEEN LINER	MERCURY (HG) TOT	mg/L	2	0/2	<0.00005	<0.00005	<0.00005	<0.00005	**NA**
Sample Period: March 2007 To April 2014	MOLYBDENUM (MO) DIS	mg/L	2	2/2	<0.1	0.11	0.105	0.1	**NA**
(continued)	MOLYBDENUM (MO) TOT	mg/L	2	2/2	0.09	0.12	0.105	0.09	**NA**
	NICKEL (NI) DIS	mg/L	2	2/2	0.81	0.87	0.84	0.81	**NA**
	NICKEL (NI) TOT	mg/L	2	2/2	0.79	0.9	0.845	0.79	**NA**
	SELENIUM (SE) DIS	mg/L	7	5/7	0.005	0.172	0.072	0.068	**0.102**
	SELENIUM (SE) TOT	mg/L	2	2/2	0.128	0.191	0.16	0.128	**NA**
	ZINC (ZN) DIS	mg/L	2	2/2	0.65	0.66	0.655	0.65	**NA**
	ZINC (ZN) TOT	mg/L	2	2/2	0.59	0.74	0.665	0.59	**NA**
									4/25/2014
UNITS 1&2 B POND UNDERLINER	PH (LAB)	s.u.	12	12/12	6.9	7.6	7.28	7.2	**6.9**
Sample Period: September 2004 To April 2014	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	12	12/12	6790	9060	7570	7210	**7040**
	TDS (MEASURED AT 180 C)	mg/L	12	12/12	6600	10500	8119	7650	**7650**
Below the lower liner of the Units 1&2 Flyash B Pond	TOTAL HARDNESS AS CACO3	mg/L	1	1/1	4550	4550	4550	4550	**4550**
Intercepts groundwater from upgradient sources.	CALCIUM (CA) DIS	mg/L	12	12/12	458	515	483	479	**483**
	MAGNESIUM (MG) DIS	mg/L	12	12/12	740	1240	876	811	**811**
	SODIUM (NA) DIS	mg/L	12	12/12	487	592	521	491	**487**
	POTASSIUM (K) DIS	mg/L	12	12/12	18	24	20.9	20	**18**
	TOTAL ALKALINITY AS CACO3	mg/L	12	12/12	248	334	290	288	**334**
	BICARBONATE (HCO3)	mg/L	12	12/12	302	407	354	352	**407**
	CARBONATE AS CO3	mg/L	12	0/12	<1	<4	2.75	3	**<4**
	SULFATE (SO4)	mg/L	12	12/12	4750	6830	5305	5110	**5420**
	CHLORIDE (CL)	mg/L	12	12/12	174	306	229	223	**306**
	BROMIDE (BR)	mg/L	6	1/6	10	45	21.7	10	**45**
	BORON (B) DIS	mg/L	12	12/12	16	34.7	22.7	19.1	**16**
	MERCURY (HG) DIS	mg/L	1	0/1	<0.001	<0.001	0.001	0.001	**NA**
	SELENIUM (SE) DIS	mg/L	12	4/12	<0.005	0.025	0.011	0.005	**0.008**
									4/13/2008
UNITS 1&2 BOTTOM ASH CLEARWELL	PH (LAB)	s.u.	26	26/26	8	11.6	9.57	9.2	**9.5**
(Converted to secondary settling cell)	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	26	26/26	1550	9360	5219	4550	**4060**
Sample Period: January 1977 To April 2008	TDS (MEASURED AT 180 C)	mg/L	26	26/26	1310	12000	5892	4460	**3840**
	TOTAL HARDNESS AS CACO3	mg/L	20	20/20	1330	7720	3647	3180	**NA**
	CALCIUM (CA) DIS	mg/L	26	26/26	226	824	557	557	**639**
Water sample now collected from the New Units 1&2 Bottom	MAGNESIUM (MG) DIS	mg/L	26	24/26	<1	1530	501	297	**8**
Ash Pond	SODIUM (NA) DIS	mg/L	26	26/26	126	717	297	251	**385**
Received decant water from Units 1&2 Bottom Ash Pond.	POTASSIUM (K) DIS	mg/L	22	22/22	8	40	17.9	17	**19**
This pond has been removed.	TOTAL ALKALINITY AS CACO3	mg/L	22	22/22	0	353	323	110	**39**
	TOTAL ACIDITY AS CACO3	mg/L	1	0/1	<1	<1	<1	<1	**NA**
	BICARBONATE (HCO3)	mg/L	22	20/22	0	160	50.9	23	**23**
	CARBONATE AS CO3	mg/L	4	4/4	0	78	35.5	12	**12**
	SULFATE (SO4)	mg/L	26	26/26	775	7970	3758	2990	**2450**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

**** All Data Are Laboratory Analyses. No Field Data Are Included In This Table***

***** NA = Not Analyzed during most recent sampling event***

******Non-detects handled as 100% of the Reporting Limit in Statistical Calculations (i.e. mean, median).***

*******Results preceeded by "<" indicate value below reporting limit. Results preceeded by "<" for mean and median values indicate all results are below applicable reporting limit.***

SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 BOTTOM ASH CLEARWELL	CHLORIDE (CL)	mg/L	26	26/26	27	257	68.6	54	**71**
(Converted to secondary settling cell)	FLUORIDE (F)	mg/L	18	18/18	0.13	3.1	1.09	0.91	**NA**
Sample Period: January 1977 To April 2008	BROMIDE (BR)	mg/L	2	2/2	1.6	1.6	1.6	1.6	**NA**
(continued)	NITRATE + NITRITE AS N	mg/L	21	21/21	0.73	18.4	6.93	6.2	**NA**
	NITRITE (NO2-N)	mg/L	1	1/1	0.11	0.11	0.11	0.11	**NA**
	ORTHOPHOSPHATE (PO4-P)	mg/L	14	11/14	<0.01	0.28	0.044	0.03	**NA**
	PHOSPHORUS (P) TOT	mg/L	1	1/1	<0.04	<0.04	<0.04	0.04	**NA**
	SIGMA	mg/L	1	1/1	2.61	2.61	2.61	0.1	**NA**
	ALUMINUM (AL) DIS	mg/L	14	7/14	<0.1	2	0.343	0.1	**NA**
	ALUMINUM (AL) TOT	mg/L	2	1/2	<0.1	1.5	0.8	0.1	**NA**
	ANTIMONY (SB) TOT	mg/L	1	0/1	<0.05	<0.05	<0.05	0.05	**NA**
	ARSENIC (AS) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**NA**
	BARIUM (BA) TOT	mg/L	1	1/1	<0.3	<0.3	<0.3	0.3	**NA**
	BERYLLIUM (BE) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	BORON (B) DIS	mg/L	23	23/23	1.9	52.7	41.7	20.6	**31.9**
	BORON (B) TOT	mg/L	1	1/1	1.4	2.4	1.4	1.4	**2.4**
	CADMIUM (CD) DIS	mg/L	15	1/15	<0.002	0.005	0.004	0.005	**NA**
	CADMIUM (CD) TOT	mg/L	2	1/2	<0.001	0.003	0.002	0.001	**NA**
	CHLORINE (CL) TOT	mg/L	1	0/1	<0.1	<0.1	<0.1	<0.1	**NA**
	CHROMIUM (CR+6) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	<0.01	**NA**
	CHROMIUM (CR+3) DIS	mg/L	1	1/1	<0.02	<0.02	<0.02	<0.02	**NA**
	CHROMIUM (CR) TOT	mg/L	1	1/1	<0.02	<0.02	<0.02	<0.02	**NA**
	COBALT (CO) TOT	mg/L	1	0/1	<0.01	<0.01	<0.01	<0.01	**NA**
	COPPER (CU) DIS	mg/L	12	5/12	<0.01	0.5	0.066	0.02	**NA**
	COPPER (CU) TOT	mg/L	2	1/2	<0.01	<0.01	<0.01	0.01	**NA**
	IRON (FE) DIS	mg/L	19	8/19	<0.05	0.15	0.06	0.05	**NA**
	IRON (FE) TOT	mg/L	2	0/2	<0.03	<0.03	<0.03	0.03	**NA**
	LEAD (PB) DIS	mg/L	15	5/15	0.02	0.5	0.078	0.02	**NA**
	LEAD (PB) TOT	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	MANGANESE (MN) DIS	mg/L	17	16/17	<0.05	6.07	1.53	0.75	**NA**
	MANGANESE (MN) TOT	mg/L	2	1/2	<0.01	3.64	1.83	0.01	**NA**
	MERCURY (HG) DIS	mg/L	2	0/2	<0.001	<0.001	<0.001	<0.001	**<0.001**
	MERCURY (HG) TOT	mg/L	2	0/2	<0.001	<0.001	<0.001	<0.001	**NA**
	MOLYBDENUM (MO) TOT	mg/L	1	1/1	0.091	0.091	0.091	0.091	**NA**
	NICKEL (NI) DIS	mg/L	3	2/3	<0.02	0.22	0.097	0.05	**NA**
	NICKEL (NI) TOT	mg/L	2	2/2	<0.01	0.06	0.035	0.01	**NA**
	SELENIUM (SE) DIS	mg/L	24	11/24	<0.005	0.054	0.016	0.005	**<0.005**
	SELENIUM (SE) TOT	mg/L	2	2/2	0.009	0.043	0.026	0.009	**NA**
	SILVER (AG) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**NA**
	THALLIUM (TL) TOT	mg/L	1	0/1	<0.1	<0.1	<0.1	<0.1	**NA**
	VANADIUM (V) DIS	mg/L	12	1/12	0.08	1	0.482	0.2	**NA**
	VANADIUM (V) TOT	mg/L	2	0/2	<0.1	<0.1	<0.1	0.1	**NA**
	ZINC (ZN) DIS	mg/L	19	9/19	<0.01	0.45	0.058	0.02	**NA**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

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***** NA = Not Analyzed during most recent sampling event***

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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 BOTTOM ASH CLEARWELL	ZINC (ZN) TOT	mg/L	2	0/2	<0.01	<0.01	<0.01	<0.01	**NA**
(Converted to secondary settling cell)	BENZENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
Sample Period: January 1977 To April 2008	BENZENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
(continued)	ETHYLENE GLYCOL	mg/L	1	1/1	<10	<10	<10	<10	**NA**
	ETHYLBENZENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	ETHYLBENZENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	TOTAL XYLENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	TOTAL XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	M-P XYLENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	M-P XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	O-XYLENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	O-XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	METHYL ETHYL KETONE VOC	mg/L	1	0/1	<0.02	<0.02	<0.02	<0.02	**NA**
	METHYL TERT-BUTYL ETHER VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	TOLUENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	TOLUENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	HEXACHLOROBENZENE	mg/L	1	0/1	<0.01	<0.01	<0.01	<0.01	**NA**
	NAPHTHALENE (VPH)	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	DIESEL RANGE ORGANICS AS DIESEL	mg/L	1	0/1	<0.32	<0.32	<0.32	<0.32	**NA**
	DIESEL RANGE ORGANICS	mg/L	1	0/1	<0.32	<0.32	<0.32	<0.32	**NA**
	C9-C10 AROMATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	<0.02	**NA**
	C9 TO C12 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	<0.02	**NA**
	OIL & GREASE TRC	mg/L	1	1/1	<0.1	<0.1	<0.1	<0.1	**NA**
	TOTAL EXTRACTABLE HYDROCARBONS	mg/L	1	0/1	<0.3	<0.3	<0.3	<0.3	**NA**
	TOTAL PURGEABLE HYDROCARBONS	mg/L	1	0/1	<0.02	<0.02	<0.02	<0.02	**NA**
	TOT EXTRACTABLE HYDROCARBON(EPH scr)	mg/L	1	1/1	<0.3	<0.3	<0.3	<0.3	**NA**
	CYANIDE (CN) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	<0.005	**NA**
	C5-C8 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	<0.02	**NA**
									7/19/2012
UNITS 1&2 BOTTOM ASH CLEARWELL	PH (LAB)	s.u.	6	6/6	8.3	9.1	8.86	8.9	**8.3**
(NEW)	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	6	6/6	3780	5830	5194	5540	**5830**
Sample Period: June 2007 To July 2012	TDS (MEASURED AT 180 C)	mg/L	6	6/6	3540	5700	5098	5590	**5700**
	TOTAL HARDNESS AS CACO3	mg/L	1	1/1	3610	3610	3610	3610	**3610**
Received decant water from Units 1&2 Bottom Ash Pond.	CALCIUM (CA) DIS	mg/L	6	6/6	350	664	532	580	**350**
Water from direct precipitation	MAGNESIUM (MG) DIS	mg/L	6	6/6	167	665	317	258	**665**
	SODIUM (NA) DIS	mg/L	6	6/6	0.01	535	361	464	**0.01**
	POTASSIUM (K) DIS	mg/L	6	6/6	16	33	25.4	30	**16**
	TOTAL ALKALINITY AS CACO3	mg/L	6	6/6	99	158	131	142	**158**
	BICARBONATE (HCO3)	mg/L	6	6/6	50	193	90.6	60	**193**
	CARBONATE AS CO3	mg/L	6	4/6	<4	60	35	35	**<4**
	SULFATE (SO4)	mg/L	6	6/6	2170	3990	3242	3310	**3990**
	CHLORIDE (CL)	mg/L	6	6/6	106	181	147	160	**126**

TABLE 2 - 3
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PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 BOTTOM ASH CLEARWELL	FLUORIDE (F)	mg/L	1	1/1	1	1	1	1	**1**
(NEW)	BROMIDE (BR)	mg/L	4	1/4	<5	29	20	26	**29**
Sample Period: June 2007 To July 2012	NITRATE + NITRITE AS N	mg/L	1	1/1	0.56	0.56	0.56	0.56	**0.56**
(continued)	NITRITE (NO2-N)	mg/L	1	0/1	<0.05	<0.05	<0.05	0.05	**<0.05**
	ORTHOPHOSPHATE (PO4-P)	mg/L	1	1/1	0.013	0.013	0.013	0.013	**0.013**
	PHOSPHORUS (P) TOT	mg/L	1	1/1	0.06	0.06	0.06	0.06	**0.06**
	ALUMINUM (AL) TOT	mg/L	1	1/1	0.13	0.13	0.13	0.13	**0.13**
	ANTIMONY (SB) TOT	mg/L	1	1/1	0.001	0.001	0.001	0.001	**0.001**
	ARSENIC (AS) TOT	mg/L	1	1/1	0.002	0.002	0.002	0.002	**0.002**
	BARIUM (BA) TOT	mg/L	1	1/1	0.11	0.11	0.11	0.11	**0.11**
	BERYLLIUM (BE) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	BORON (B) DIS	mg/L	4	4/4	8.8	14.6	11.5	10.8	**NA**
	BORON (B) TOT	mg/L	1	1/1	15	15	15	15	**15**
	CADMIUM (CD) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	CHLORINE (CL) TOT	mg/L	1	0/1	<0.1	<0.1	<0.1	0	**<0.1**
	CHROMIUM (CR+6) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
	CHROMIUM (CR+3) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
	CHROMIUM (CR) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**<0.005**
	COBALT (CO) TOT	mg/L	1	1/1	0.01	0.01	0.01	0.01	**0.009**
	COPPER (CU) TOT	mg/L	1	1/1	0.009	0.009	0.009	0.009	**0.009**
	IRON (FE) TOT	mg/L	1	1/1	0.1	0.1	0.1	0.1	**0.1**
	MANGANESE (MN) TOT	mg/L	1	1/1	2.37	2.37	2.37	2.37	**2.37**
	MERCURY (HG) DIS	mg/L	3	0/3	<0.001	<0.001	<0.001	0.001	**NA**
	MERCURY (HG) TOT	mg/L	1	0/1	<0.0001	<0.0001	<0.0001	0	**<0.0001**
	MOLYBDENUM (MO) TOT	mg/L	1	1/1	0.033	0.033	0.033	0.033	**0.033**
	NICKEL (NI) TOT	mg/L	1	1/1	0.045	0.045	0.045	0.045	**0.045**
	SELENIUM (SE) DIS	mg/L	5	5/5	0.009	0.016	0.012	0.011	**NA**
	SELENIUM (SE) TOT	mg/L	1	1/1	0.024	0.024	0.024	0.024	**0.024**
	SILVER (AG) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	STRONTIUM (SR) DIS	mg/L	1	1/1	16.4	16.4	16.4	16.4	**NA**
	THALLIUM (TL) TOT	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	VANADIUM (V) TOT	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
	ZINC (ZN) TOT	mg/L	1	1/1	0.02	0.02	0.02	0.02	**0.02**
	BENZENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	ETHYLENE GLYCOL	mg/L	1	0/1	<250	<250	<250	250	**<250**
	ETHYLBENZENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	TOTAL XYLENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	M-P XYLENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	O-XYLENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	METHYL ETHYL KETONE VOC	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	METHYL TERT-BUTYL ETHER VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	NAPHTHALENE (VOL)	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	TOLUENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
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PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

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UNITS 1&2 BOTTOM ASH CLEARWELL	HEXACHLOROBENZENE	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
(NEW)	DIESEL RANGE ORGANICS	mg/L	1	0/1	<0.31	<0.31	<0.31	0.31	**<0.31**
Sample Period: June 2007 To July 2012	C9-C10 AROMATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
(continued)	C9 TO C12 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	OIL & GREASE	mg/L	1	0/1	<1	<1	<1	1	**<1**
	PURGEABLE HYDROCARBONS TOT	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	TOT EXTRACTABLE HYDROCARBON(EPH)	mg/L	1	0/1	<0.31	<0.31	<0.31	0.31	**<0.31**
	TOT EXTRACTABLE HYDROCARBON(EPH scr)	mg/L	1	0/1	<0.309	<0.309	<0.309	0.309	**<0.309**
	CYANIDE (CN) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**<0.005**
	C5-C8 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
									4/11/2011
UNITS 1&2 BOTTOM ASH CLEARWELL	PH (LAB)	s.u.	5	5/5	8.8	9.7	9.28	9.4	**9.1**
UNDERDRAIN	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	5	5/5	3700	4700	4298	4320	**4200**
Sample Period: August 2007 To April 2011	TDS (MEASURED AT 180 C)	mg/L	5	5/5	3180	4170	3686	3730	**3730**
	CALCIUM (CA) DIS	mg/L	5	5/5	490	579	540	549	**579**
Below Units 1&2 Bottom Ash Pond Clearwell	MAGNESIUM (MG) DIS	mg/L	5	5/5	4	109	33.2	15	**11**
	SODIUM (NA) DIS	mg/L	5	5/5	415	545	512	536	**536**
	POTASSIUM (K) DIS	mg/L	5	5/5	42	52	45.4	45	**52**
	TOTAL ALKALINITY AS CACO3	mg/L	5	5/5	37	69	53.2	52	**37**
	BICARBONATE (HCO3)	mg/L	5	2/5	1	29	11.6	4	**20**
	CARBONATE AS CO3	mg/L	5	5/5	12	29	23	25	**12**
	SULFATE (SO4)	mg/L	5	5/5	1960	2520	2268	2290	**2290**
	CHLORIDE (CL)	mg/L	5	5/5	138	239	195	199	**195**
	BROMIDE (BR)	mg/L	2	2/2	20	24	22	20	**24**
	BORON (B) DIS	mg/L	5	5/5	5.6	16	9.8	8.5	**5.6**
	MERCURY (HG) DIS	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	SELENIUM (SE) DIS	mg/L	5	2/5	<0.005	0.025	0.01	0.005	**0.012**
									4/21/2005
UNITS 1&2 FLYASH AB POND CLEARWELL	PH (LAB)	s.u.	6	6/6	5.3	9.1	7.35	7.4	**8.1**
(A side and B side)	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	6	6/6	2800	20100	10238	8970	**12600**
Sample Period: September 1996 To April 2005	TDS (MEASURED AT 180 C)	mg/L	6	6/6	2470	28900	14398	16000	**16300**
	TOTAL HARDNESS AS CACO3	mg/L	2	2/2	2690	17500	10095	2690	**NA**
Decant water from Units 1&2 AB Ponds, SRP area groundwater	CALCIUM (CA) DIS	mg/L	6	6/6	291	508	430	420	**508**
capture wells.	MAGNESIUM (MG) DIS	mg/L	6	6/6	176	3940	1887	1970	**2140**
Water from direct precipitation	SODIUM (NA) DIS	mg/L	6	5/6	<0.01	1130	618	662	**842**
	POTASSIUM (K) DIS	mg/L	3	3/3	22	53	39.3	43	**43**
	TOTAL ALKALINITY AS CACO3	mg/L	3	3/3	7	138	89	122	**122**
	TOTAL ACIDITY AS CACO3	mg/L	1	1/1	217	217	217	217	**NA**
	BICARBONATE (HCO3)	mg/L	3	3/3	9	160	106	148	**148**
	CARBONATE AS CO3	mg/L	3	2/3	0	4	2.33	3	**3**
	SULFATE (SO4)	mg/L	6	6/6	1680	18100	9250	10200	**10300**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

**** All Data Are Laboratory Analyses. No Field Data Are Included In This Table***

***** NA = Not Analyzed during most recent sampling event***

******Non-detects handled as 100% of the Reporting Limit in Statistical Calculations (i.e. mean, median).***

*******Results preceeded by "<" indicate value below reporting limit. Results preceeded by "<" for mean and median values indicate all results are below applicable reporting limit.***

SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 FLYASH AB POND CLEARWELL	CHLORIDE (CL)	mg/L	6	6/6	69	312	202	211	**287**
(A side and B side)	FLUORIDE (F)	mg/L	2	2/2	1.36	2.59	1.98	1.36	**NA**
Sample Period: September 1996 To April 2005	BROMIDE (BR)	mg/L	1	1/1	2	2	2	2	**NA**
(continued)	NITRATE + NITRITE AS N	mg/L	2	2/2	1.28	15.4	8.34	1.28	**NA**
	NITRITE (NO2-N)	mg/L	1	1/1	0.11	0.11	0.11	0.11	**NA**
	ORTHOPHOSPHATE (PO4-P)	mg/L	1	1/1	0.04	0.04	0.04	0.04	**NA**
	PHOSPHORUS (P) TOT	mg/L	1	1/1	0.09	0.09	0.09	0.09	**NA**
	ALUMINUM (AL) TOT	mg/L	1	1/1	0.2	0.2	0.2	0.2	**NA**
	ANTIMONY (SB) TOT	mg/L	1	0/1	<0.05	<0.05	<0.05	0.05	**NA**
	ARSENIC (AS) TOT	mg/L	1	1/1	0.006	0.006	0.006	0.006	**NA**
	BARIUM (BA) TOT	mg/L	1	1/1	0.2	0.2	0.2	0.2	**NA**
	BERYLLIUM (BE) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	BORON (B) DIS	mg/L	5	5/5	4.2	89.5	55.1	57.4	**57.4**
	BORON (B) TOT	mg/L	1	1/1	10.1	10.1	10.1	10.1	**NA**
	CADMIUM (CD) TOT	mg/L	1	1/1	0.001	0.001	0.001	0.001	**NA**
	CHROMIUM (CR+6) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	CHROMIUM (CR+3) DIS	mg/L	1	1/1	0.02	0.02	0.02	0.02	**NA**
	CHROMIUM (CR) TOT	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	COBALT (CO) TOT	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	COPPER (CU) TOT	mg/L	1	1/1	0.02	0.02	0.02	0.02	**NA**
	IRON (FE) DIS	mg/L	1	0/1	0.03	0.03	0.03	0.03	**NA**
	IRON (FE) TOT	mg/L	1	1/1	0.09	0.09	0.09	0.09	**NA**
	MANGANESE (MN) DIS	mg/L	1	1/1	26.8	26.8	26.8	26.8	**NA**
	MANGANESE (MN) TOT	mg/L	1	1/1	2.36	2.36	2.36	2.36	**NA**
	MERCURY (HG) TOT	mg/L	1	0/1	<0.0001	<0.0001	<0.0001	0	**NA**
	MOLYBDENUM (MO) TOT	mg/L	1	1/1	0.151	0.151	0.151	0.151	**NA**
	NICKEL (NI) TOT	mg/L	1	1/1	0.06	0.06	0.06	0.06	**NA**
	SELENIUM (SE) DIS	mg/L	5	5/5	0.007	0.106	0.063	0.068	**0.071**
	SELENIUM (SE) TOT	mg/L	1	1/1	0.016	0.016	0.016	0.016	**NA**
	SILVER (AG) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**NA**
	THALLIUM (TL) TOT	mg/L	1	0/1	<0.1	<0.1	<0.1	0.1	**NA**
	VANADIUM (V) TOT	mg/L	1	0/1	<0.1	<0.1	<0.1	0.1	**NA**
	ZINC (ZN) DIS	mg/L	1	1/1	0.23	0.23	0.23	0.23	**NA**
	ZINC (ZN) TOT	mg/L	1	1/1	0.02	0.02	0.02	0.02	**NA**
	BENZENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	BENZENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	ETHYLENE GLYCOL	mg/L	1	0/1	<10	<10	<10	10	**NA**
	ETHYLBENZENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	ETHYLBENZENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	TOTAL XYLENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	TOTAL XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	M-P XYLENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	M-P XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

**** All Data Are Laboratory Analyses. No Field Data Are Included In This Table***

***** NA = Not Analyzed during most recent sampling event***

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*******Results preceeded by "<" indicate value below reporting limit. Results preceeded by "<" for mean and median values indicate all results are below applicable reporting limit.***

SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 FLYASH AB POND CLEARWELL	O-XYLENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
(A side and B side)	O-XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
Sample Period: September 1996 To April 2005	METHYL ETHYL KETONE VOC	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**NA**
(continued)	METHYL TERT-BUTYL ETHER VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	TOLUENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	TOLUENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	HEXACHLOROBENZENE	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	NAPHTHALENE (VPH)	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	DIESEL RANGE ORGANICS AS DIESEL	mg/L	1	0/1	<0.31	<0.31	<0.31	0.31	**NA**
	DIESEL RANGE ORGANICS	mg/L	1	0/1	<0.31	<0.31	<0.31	0.31	**NA**
	C9-C10 AROMATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**NA**
	C9 TO C12 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**NA**
	OIL & GREASE TRC	mg/L	1	1/1	<0.1	<0.1	<0.1	0.1	**NA**
	PURGEABLE HYDROCARBONS TOT	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**NA**
	TOTAL EXTRACTABLE HYDROCARBONS	mg/L	1	0/1	<0.3	<0.3	<0.3	0.3	**NA**
	TOT EXTRACTABLE HYDROCARBON(EPHscr)	mg/L	1	0/1	<0.31	<0.31	<0.31	0.31	**NA**
	CYANIDE (CN) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**NA**
	C5-C8 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**NA**
									7/19/2012
UNITS 3&4 BOTTOM ASH CLEARWELL	PH (LAB)	s.u.	5	5/5	9.8	11.4	10.8	10.9	**10.9**
Sample Period: December 2002 To July 2012	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	5	5/5	2470	5210	3772	3830	**3510**
	TDS (MEASURED AT 180 C)	mg/L	5	5/5	1970	4220	3094	3150	**2650**
Decant water form the Units 3&4 Bottom Ash Ponds	TOTAL HARDNESS AS CACO3	mg/L	2	2/2	825	1200	1013	825	**1200**
Water from direct precipitation	CALCIUM (CA) DIS	mg/L	5	5/5	326	631	497	497	**480**
	MAGNESIUM (MG) DIS	mg/L	5	4/5	<1	13	3.8	2	**2**
	SODIUM (NA) DIS	mg/L	5	5/5	0.01	603	363	403	**0.01**
	POTASSIUM (K) DIS	mg/L	5	5/5	15	24	19	19	**17**
	HYDRAZINE	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**NA**
	TOTAL ALKALINITY AS CACO3	mg/L	5	5/5	53	151	95.4	105	**62**
	BICARBONATE (HCO3)	mg/L	5	1/5	<2	5	3.2	3	**4**
	CARBONATE AS CO3	mg/L	5	5/5	28	57	37.2	31	**31**
	SULFATE (SO4)	mg/L	5	5/5	1370	2570	2018	1940	**1860**
	CHLORIDE (CL)	mg/L	5	5/5	55	115	75.2	71	**72**
	FLUORIDE (F)	mg/L	2	2/2	0.47	0.7	0.585	0.47	**0.7**
	BROMIDE (BR)	mg/L	4	2/4	<0.5	21	8.88	5	**9**
	NITRATE + NITRITE AS N	mg/L	2	2/2	0.45	0.64	0.545	0.45	**0.64**
	NITRITE (NO2-N)	mg/L	2	2/2	0.3	0.31	0.305	0.3	**0.31**
	ORTHOPHOSPHATE (PO4-P)	mg/L	2	1/2	0.008	0.01	0.009	0.008	**0.008**
	PHOSPHORUS (P) TOT	mg/L	2	2/2	0.06	0.31	0.185	0.06	**0.06**
	ALUMINUM (AL) TOT	mg/L	2	2/2	0.2	1.95	1.08	0.2	**1.95**
	ANTIMONY (SB) TOT	mg/L	2	1/2	0.004	0.05	0.027	0.004	**0.004**
	ARSENIC (AS) TOT	mg/L	2	1/2	0.002	0.005	0.004	0.002	**0.002**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 3&4 BOTTOM ASH CLEARWELL	BARIUM (BA) TOT	mg/L	2	2/2	0.12	0.3	0.21	0.12	**0.12**
Sample Period: December 2002 To July 2012	BERYLLIUM (BE) TOT	mg/L	2	0/2	<0.001	<0.001	<0.001	0.001	**<0.001**
(continued)	BORON (B) DIS	mg/L	3	3/3	2.1	4.4	2.9	2.2	**NA**
	BORON (B) TOT	mg/L	2	2/2	1.2	2.98	2.09	1.2	**2.98**
	CADMIUM (CD) TOT	mg/L	2	0/2	<0.001	<0.001	<0.001	0.001	**<0.001**
	CHLORINE (CL) TOT	mg/L	1	0/1	<0.1	<0.1	<0.1	<0.1	**<0.1**
	CHROMIUM (CR+6) DIS	mg/L	2	0/2	<0.01	<0.01	<0.01	<0.01	**<0.01**
	CHROMIUM (CR+3) DIS	mg/L	2	0/2	<0.01	<0.01	<0.01	<0.01	**<0.01**
	CHROMIUM (CR) TOT	mg/L	2	1/2	<0.005	0.02	0.013	0.005	**<0.005**
	COBALT (CO) TOT	mg/L	2	0/2	<0.005	0.01	0.008	0.005	**<0.005**
	COPPER (CU) TOT	mg/L	2	0/2	<0.005	0.01	0.008	0.005	**<0.005**
	IRON (FE) TOT	mg/L	2	2/2	0.05	0.06	0.055	0.05	**0.06**
	MANGANESE (MN) TOT	mg/L	2	1/2	0.006	0.01	0.008	0.006	**0.006**
	MERCURY (HG) DIS	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	MERCURY (HG) TOT	mg/L	2	0/2	<0.0001	<0.0002	<0.0001	<0.0001	**<0.0001**
	MOLYBDENUM (MO) TOT	mg/L	2	2/2	0.194	0.301	0.248	0.194	**0.194**
	NICKEL (NI) TOT	mg/L	2	1/2	<0.005	0.01	0.008	0.005	**<0.005**
	SELENIUM (SE) DIS	mg/L	3	2/3	<0.005	0.013	0.01	0.013	**NA**
	SELENIUM (SE) TOT	mg/L	2	2/2	<0.005	0.007	0.006	0.005	**0.005**
	SILVER (AG) TOT	mg/L	2	0/2	<0.001	0.005	0.003	0.001	**<0.001**
	STRONTIUM (SR) DIS	mg/L	1	1/1	10.7	10.7	10.7	10.7	**NA**
	THALLIUM (TL) TOT	mg/L	2	0/2	<0.0005	0.1	0.05	0.001	**<0.0005**
	VANADIUM (V) TOT	mg/L	2	1/2	0.04	0.1	0.07	0.04	**0.04**
	ZINC (ZN) TOT	mg/L	2	0/2	<0.01	<0.01	<0.01	0.01	**<0.01**
	BENZENE VPH	mg/L	1	0/1	<0.0005	<0.001	<0.001	0.001	**<0.0005**
	ETHYLENE GLYCOL	mg/L	4	0/4	<10	<250	<130	10	**<250**
	ETHYLBENZENE VPH	mg/L	2	0/2	<0.0005	<0.001	<0.001	0.001	**<0.0005**
	M-P XYLENE VPH	mg/L	1	0/1	<0.0005	<0.001	<0.001	0.001	**<0.0005**
	O-XYLENE VPH	mg/L	4	0/4	<0.0005	<0.001	<0.001	0.001	**<0.0005**
	METHYL ETHYL KETONE VOC	mg/L	1	0/1	<0.02	<0.02	<0.02	<0.02	**<0.02**
	METHYL TERT-BUTYL ETHER VPH	mg/L	4	0/4	<0.001	<1	<0.334	0.001	**<1**
	NAPHTHALENE (VOL)	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**<0.001**
	TOLUENE VPH	mg/L	4	0/4	<0.0005	<0.001	<0.001	<0.001	**<0.0005**
	2-METHYLNAPHTHALENE	mg/L	1	0/1	<0.011	<0.011	<0.011	<0.011	**NA**
	ACENAPHTHENE	mg/L	4	0/4	<0.011	<0.011	<0.011	<0.011	**NA**
	ACENAPHTHYLENE	mg/L	2	0/2	<0.011	<0.011	<0.011	<0.011	**NA**
	ANTHRACENE	mg/L	4	0/4	<0.011	<0.011	<0.011	<0.011	**NA**
	BENZO (A) ANTHRACENE	mg/L	3	0/3	<0.011	<0.011	<0.011	<0.011	**NA**
	BENZO (A) PYRENE	mg/L	1	0/1	<0.011	<0.011	<0.011	<0.011	**NA**
	BENZO (B) FLUORANTHENE	mg/L	4	0/4	<0.011	<0.011	<0.011	<0.011	**NA**
	BENZO (GHI) PERYLENE	mg/L	2	0/2	<0.011	<0.011	<0.011	<0.011	**NA**
	BENZO (K) FLUORANTHENE	mg/L	1	0/1	<0.011	<0.011	<0.011	<0.011	**NA**
	CHRYSENE	mg/L	1	0/1	<0.011	<0.011	<0.011	<0.011	**NA**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
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PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 3&4 BOTTOM ASH CLEARWELL	DIBENZ (A,H) ANTHRACENE	mg/L	1	0/1	<0.011	<0.011	<0.011	<0.011	**NA**
Sample Period: December 2002 To July 2012	FLUORENE	mg/L	1	0/1	<0.011	<0.011	<0.011	<0.011	**NA**
(continued)	HEXACHLOROBENZENE	mg/L	1	0/1	<0.01	<0.01	<0.01	<0.01	**NA**
	INDENO (1,2,3-CD) PYRENE	mg/L	1	0/1	<0.011	<0.011	<0.011	<0.011	**NA**
	NAPHTHALENE (SEMI-VOL)	mg/L	1	0/1	<0.011	<0.011	<0.011	<0.011	**NA**
	NAPHTHALENE (VPH)	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**NA**
	PHENANTHRENE	mg/L	1	0/1	<0.011	<0.011	<0.011	<0.011	**NA**
	PYRENE	mg/L	1	0/1	<0.011	<0.011	<0.011	<0.011	**NA**
	DIESEL RANGE ORGANICS AS DIESEL	mg/L	1	0/1	<0.32	<0.32	<0.32	<0.32	**NA**
	DIESEL RANGE ORGANICS	mg/L	1	0/1	0.31	<0.32	0.315	0.31	**0.31**
	C9-C10 AROMATICS	mg/L	2	0/2	<0.02	<0.02	<0.02	<0.02	**<0.02**
	C9 TO C12 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	<0.02	**<0.02**
	OIL & GREASE	mg/L	1	0/1	<1	30	10.7	1	**<1**
	PURGEABLE HYDROCARBONS TOT	mg/L	1	0/1	<0.02	<0.02	<0.02	0.1	**<0.02**
	TOTAL EXTRACTABLE HYDROCARBONS	mg/L	1	0/1	<0.28	<0.28	<0.28	<0.28	**NA**
	TOTAL PURGEABLE HYDROCARBONS	mg/L	1	0/1	<0.02	<0.02	<0.02	<0.02	**<0.02**
	TOT EXTRACTABLE HYDROCARBON(EPH)	mg/L	1	0/1	0.78	3.87	2.33	0.78	**0.78**
	TOT EXTRACTABLE HYDROCARBON(EPHscr)	mg/L	2	1/2	0.316	4.55	1.45	0.34	**0.588**
	CYANIDE (CN) TOT	mg/L	4	0/4	<0.005	0.062	0.034	0.005	**0.062**
	C5-C8 ALIPHATICS	mg/L	4	0/4	<0.02	<0.02	<0.02	0.02	**<0.02**
	C11-C22 AROMATICS	mg/L	3	1/3	0.263	0.263	0.263	0.263	**NA**
	C19-C36 ALIPHATICS	mg/L	1	0/1	3.55	3.55	3.55	3.55	**NA**
	C9-C18 ALIPHATICS	mg/L	4	0/4	0.325	0.325	0.325	0.325	**NA**
									3/19/2003
UNITS 1&2 AB POND	PH (LAB)	s.u.	28	28/28	3.9	9.2	5.63	5	**9.2**
(A Side and B Side)	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	28	28/28	2200	20400	10864	9970	**2200**
Sample Period: January 1977 To March 2003	TDS (MEASURED AT 180 C)	mg/L	28	28/28	1810	29400	15292	14640	**1810**
	TOTAL HARDNESS AS CACO3	mg/L	21	21/21	7400	17900	11131	10473	**NA**
Replaced with Units 1&2 A Pond and B Pond. Formerly received	CALCIUM (CA) DIS	mg/L	28	28/28	243	667	505	493	**243**
scrubber water, clearwater return from Units 1&2 Flyash Evaporation	MAGNESIUM (MG) DIS	mg/L	28	28/28	81	4070	2125	2010	**81**
Ponds. Flyash removed during construction of Units 1&2 B B Pond.	SODIUM (NA) DIS	mg/L	28	28/28	10.8	1090	388	320	**180**
Water from direct precipitation	POTASSIUM (K) DIS	mg/L	21	21/21	8	56	23	18	**NA**
	TOTAL ALKALINITY AS CACO3	mg/L	21	20/21	0	65	14	5	**NA**
	TOTAL ACIDITY AS CACO3	mg/L	2	2/2	278	286	282	278	**NA**
	BICARBONATE (HCO3)	mg/L	22	22/22	0	79	16.4	5	**NA**
	CARBONATE AS CO3	mg/L	2	2/2	0	0	0	0	**NA**
	SULFATE (SO4)	mg/L	28	28/28	1250	20000	10420	10100	**1250**
	CHLORIDE (CL)	mg/L	28	28/28	24	331	109	73	**53**
	FLUORIDE (F)	mg/L	19	19/19	0.65	8.5	2.97	2.42	**NA**
	NITRATE + NITRITE AS N	mg/L	22	22/22	9.56	34.7	19.1	17.8	**NA**
	ORTHOPHOSPHATE (PO4-P)	mg/L	13	13/13	0.01	0.35	0.072	0.05	**NA**
	ALUMINUM (AL) DIS	mg/L	15	14/15	<0.1	59	20.5	7.7	**NA**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

**** All Data Are Laboratory Analyses. No Field Data Are Included In This Table***

***** NA = Not Analyzed during most recent sampling event***

******Non-detects handled as 100% of the Reporting Limit in Statistical Calculations (i.e. mean, median).***

*******Results preceeded by "<" indicate value below reporting limit. Results preceeded by "<" for mean and median values indicate all results are below applicable reporting limit.***

SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 AB POND	BORON (B) DIS	mg/L	25	25/25	2.1	111	71.9	77.8	**2.1**
(A Side and B Side)	CADMIUM (CD) DIS	mg/L	16	8/16	<0.002	0.22	0.023	0.005	**NA**
Sample Period: January 1977 To March 2003	COPPER (CU) DIS	mg/L	13	11/13	<0.03	0.54	0.205	0.15	**NA**
(continued)	IRON (FE) DIS	mg/L	22	16/22	<0.03	0.97	0.252	0.08	**NA**
	LEAD (PB) DIS	mg/L	16	4/16	<0.01	0.7	0.099	0.02	**NA**
	MANGANESE (MN) DIS	mg/L	19	19/19	7.23	71.9	26.4	25.5	**NA**
	MERCURY (HG) DIS	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	NICKEL (NI) DIS	mg/L	5	4/5	<0.02	0.53	0.272	0.31	**NA**
	SELENIUM (SE) DIS	mg/L	28	17/28	<0.005	0.175	0.034	0.012	**0.006**
	VANADIUM (V) DIS	mg/L	13	1/13	<0.02	1	0.498	0.2	**NA**
	ZINC (ZN) DIS	mg/L	22	22/22	0.03	1.05	0.312	0.26	**NA**
									9/16/2009
UNITS 1&2 BOTTOM ASH POND	PH (LAB)	s.u.	2	2/2	8.8	9.3	9.05	8.8	**9.3**
Sample Period: April 2008 To September 2009	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	2	2/2	5040	5670	7875	5040	**5040**
	TDS (MEASURED AT 180 C)	mg/L	2	2/2	4820	5610	7625	4820	**4820**
Water from Units 1&2 Drain Collection Sump. Raw water.	CALCIUM (CA) DIS	mg/L	2	2/2	592	692	642	592	**692**
Clearwater return from Units 1&2 Bottom Ash Pond Clearwell.	MAGNESIUM (MG) DIS	mg/L	2	2/2	165	256	211	165	**165**
Water from direct precipitation	SODIUM (NA) DIS	mg/L	2	2/2	497	536	517	497	**497**
	POTASSIUM (K) DIS	mg/L	2	2/2	31	34	32.5	31	**31**
	TOTAL ALKALINITY AS CACO3	mg/L	2	2/2	69	126	97.5	69	**69**
	BICARBONATE (HCO3)	mg/L	2	2/2	11	85	48	11	**11**
	CARBONATE AS CO3	mg/L	2	2/2	33	36	34.5	33	**36**
	SULFATE (SO4)	mg/L	2	2/2	3240	3320	3280	3240	**3240**
	CHLORIDE (CL)	mg/L	2	2/2	181	183	182	181	**181**
	BROMIDE (BR)	mg/L	1	0/1	<5	<5	<5	5	**<5**
	BORON (B) DIS	mg/L	2	2/2	9.1	11	10.1	9.1	**11**
	MERCURY (HG) DIS	mg/L	2	0/2	<0.001	<0.001	<0.001	0.001	**<0.001**
	SELENIUM (SE) DIS	mg/L	2	2/2	0.006	0.012	0.009	0.006	**0.006**
									9/16/2009
UNITS 3&4 BOTTOM ASH POND	PH (LAB)	s.u.	15	15/15	6.4	11.8	10.1	10.9	**11**
Sample Period: February 1984 To September 2009	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	15	15/15	2740	9280	4079	3970	**3970**
	TDS (MEASURED AT 180 C)	mg/L	15	15/15	1760	5180	3133	3260	**3500**
Water from Units 3&4 Bottom Ash Collecction System, Main Plant	TOTAL HARDNESS AS CACO3	mg/L	9	9/9	643	1540	1004	791	**NA**
Sump, Raw water. Water from direct precipitation	CALCIUM (CA) DIS	mg/L	15	15/15	188	647	401	373	**562**
	MAGNESIUM (MG) DIS	mg/L	15	10/15	1	202	36.2	3	**2**
	SODIUM (NA) DIS	mg/L	15	15/15	187	1200	511	444	**394**
	POTASSIUM (K) DIS	mg/L	11	11/11	7	31	17.4	19	**20**
	TOTAL ALKALINITY AS CACO3	mg/L	12	12/12	41	1160	253	113	**113**
	TOTAL ACIDITY AS CACO3	mg/L	1	0/1	<1	<1	<1	1	**NA**
	BICARBONATE (HCO3)	mg/L	12	10/12	0	326	60.5	1	**<4**
	CARBONATE AS CO3	mg/L	7	7/7	0	101	37	27	**26**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 3&4 BOTTOM ASH POND	SULFATE (SO4)	mg/L	15	15/15	872	2830	1899	2000	**2190**
Sample Period: February 1984 To September 2009	CHLORIDE (CL)	mg/L	15	15/15	22	90	46.9	41	**71**
(continued)	FLUORIDE (F)	mg/L	9	9/9	0.29	0.9	0.529	0.47	**4.9**
	BROMIDE (BR)	mg/L	1	0/1	<5	<5	<5	5	**<5**
	NITRATE + NITRITE AS N	mg/L	9	8/9	<0.05	1.02	0.319	0.25	**NA**
	ORTHOPHOSPHATE (PO4-P)	mg/L	6	3/6	<0.01	0.14	0.048	0.01	**NA**
	ALUMINUM (AL) DIS	mg/L	6	4/6	<0.1	1.8	0.45	0.1	**NA**
	BORON (B) DIS	mg/L	15	15/15	0.4	6.5	2.7	2.3	**4.9**
	CADMIUM (CD) DIS	mg/L	6	3/6	<0.001	0.005	0.003	0.002	**NA**
	COPPER (CU) DIS	mg/L	6	1/6	<0.01	0.03	0.015	0.01	**NA**
	IRON (FE) DIS	mg/L	9	4/9	<0.03	0.11	0.049	0.04	**NA**
	LEAD (PB) DIS	mg/L	6	0/6	<0.01	0.02	0.013	0.01	**NA**
	MANGANESE (MN) DIS	mg/L	9	2/9	<0.01	0.12	0.033	0.02	**NA**
	MERCURY (HG) DIS	mg/L	4	0/4	<0.001	<0.001	<0.001	0.001	**NA**
	NICKEL (NI) DIS	mg/L	6	0/6	<0.01	0.03	0.023	0.02	**NA**
	SELENIUM (SE) DIS	mg/L	15	9/15	<0.005	0.025	0.011	0.01	**0.01**
	VANADIUM (V) DIS	mg/L	6	1/6	0.09	0.2	0.115	0.1	**NA**
	ZINC (ZN) DIS	mg/L	9	4/9	<0.01	0.2	0.036	0.01	**NA**
UNITS 1&2 COOLING TOWER BLOWDOWN									**7/19/2012**
POND C - SOUTH POND	PH (LAB)	s.u.	10	10/10	8.1	8.7	8.39	8.3	**8.6**
(Cooling Tower Blowdown Pond South Side)	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	10	10/10	1120	7700	3934	3590	**7700**
Sample Period: April 1993 To July 2012	TDS (MEASURED AT 180 C)	mg/L	10	10/10	834	7730	3898	3330	**7730**
	TOTAL HARDNESS AS CACO3	mg/L	3	3/3	521	4580	1999	897	**4580**
Formerly received Units 1&2 Cooling Tower Blowdown Pond water.	CALCIUM (CA) DIS	mg/L	10	10/10	94	589	331	368	**589**
Now primarily recieves water from storm water runoff collection,	MAGNESIUM (MG) DIS	mg/L	10	10/10	37	754	270	160	**754**
minor groundwater capture system water, transfer from Units 1&2	SODIUM (NA) DIS	mg/L	10	9/10	<0.01	611	270	379	**0.01**
A Pond and Units 1-4 Sediment Retention Pond.	POTASSIUM (K) DIS	mg/L	6	6/6	7	30	18.3	17	**30**
Water from direct precipitation	TOTAL ALKALINITY AS CACO3	mg/L	6	6/6	118	267	168	157	**168**
	BICARBONATE (HCO3)	mg/L	6	6/6	128	326	197	179	**179**
	CARBONATE AS CO3	mg/L	5	2/5	<1	12	4.2	3	**12**
	SULFATE (SO4)	mg/L	10	10/10	407	5540	2463	2090	**5540**
	CHLORIDE (CL)	mg/L	10	10/10	20	231	118	127	**231**
	FLUORIDE (F)	mg/L	3	2/3	0.93	1.81	1.45	1.6	**1.6**
	BROMIDE (BR)	mg/L	3	1/3	1	8	4.67	5	**8**
	NITRATE + NITRITE AS N	mg/L	2	0/2	<0.01	0.62	0.227	0.05	**<0.01**
	NITRITE (NO2-N)	mg/L	3	2/3	<0.05	<0.05	<0.05	0.05	**<0.05**
	ORTHOPHOSPHATE (PO4-P)	mg/L	2	2/2	<0.005	0.1	0.042	0.02	**<0.005**
	ALUMINUM (AL) DIS	mg/L	1	0/1	<0.03	<0.1	<0.065	0.1	**<0.03**
	ALUMINUM (AL) TOT	mg/L	2	0/2	<0.03	0.1	0.065	0.03	**0.03**
	ANTIMONY (SB) TOT	mg/L	2	0/2	<0.001	<0.05	<0.026	0.001	**<0.001**
	ARSENIC (AS) TOT	mg/L	2	2/2	0.01	0.017	0.014	0.01	**0.01**
	BARIUM (BA) TOT	mg/L	2	0/2	<0.05	<0.1	<0.075	0.05	**<0.05**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 COOLING TOWER BLOWDOWN	BERYLLIUM (BE) TOT	mg/L	2	0/2	<0.001	<0.001	<0.001	0.001	**<0.001**
POND C - SOUTH POND	BORON (B) DIS	mg/L	8	8/8	0.3	13.2	3.74	1.2	**NA**
(Cooling Tower Blowdown Pond South Side)	BORON (B) TOT	mg/L	2	2/2	0.7	11.8	6.25	0.7	**11.8**
Sample Period: April 1993 To July 2012	CADMIUM (CD) DIS	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
(continued)	CADMIUM (CD) TOT	mg/L	2	0/2	<0.001	<0.001	<0.001	0.001	**<0.001**
	CHROMIUM (CR+6) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	CHROMIUM (CR+6) TOT	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
	CHROMIUM (CR+3) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	CHROMIUM (CR+3) TOT	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
	CHROMIUM (CR) TOT	mg/L	2	0/2	<0.005	<0.01	<0.008	0.005	**<0.005**
	COBALT (CO) TOT	mg/L	2	0/2	<0.005	<0.01	<0.008	0.005	**<0.005**
	COPPER (CU) DIS	mg/L	1	1/1	0.11	0.11	0.11	0.11	**NA**
	COPPER (CU) TOT	mg/L	2	2/2	0.01	0.012	0.011	0.011	**0.012**
	IRON (FE) DIS	mg/L	1	0/1	<0.03	<0.03	<0.03	0.03	**NA**
	IRON (FE) TOT	mg/L	2	1/2	<0.04	0.07	0.055	0.04	**<0.04**
	LEAD (PB) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	MANGANESE (MN) DIS	mg/L	1	1/1	0.02	0.02	0.02	0.02	**NA**
	MANGANESE (MN) TOT	mg/L	2	2/2	0.03	0.152	0.091	0.03	**0.152**
	MERCURY (HG) DIS	mg/L	3	0/3	<0.001	<0.001	<0.001	0.001	**NA**
	MERCURY (HG) TOT	mg/L	2	0/2	<0.0001	<0.0001	<0.0001	0	**<0.0001**
	MOLYBDENUM (MO) TOT	mg/L	2	2/2	0.007	0.066	0.037	0.007	**0.066**
	NICKEL (NI) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	NICKEL (NI) TOT	mg/L	2	1/2	<0.01	0.031	0.021	0.01	**0.031**
	SELENIUM (SE) DIS	mg/L	8	4/8	<0.005	0.026	0.011	0.005	**NA**
	SELENIUM (SE) TOT	mg/L	2	2/2	0.005	0.007	0.006	0.005	**0.005**
	SILVER (AG) TOT	mg/L	2	0/2	<0.001	<0.005	<0.003	0.001	**<0.001**
	THALLIUM (TL) TOT	mg/L	2	0/2	<0.0005	<0.1	<0.0502	0.001	**<0.0005**
	VANADIUM (V) DIS	mg/L	1	0/1	<0.1	<0.1	<0.1	0.1	**NA**
	VANADIUM (V) TOT	mg/L	2	0/2	<0.01	<0.1	<0.055	0.01	**<0.01**
	ZINC (ZN) DIS	mg/L	1	1/1	0.02	0.02	0.02	0.02	**NA**
	ZINC (ZN) TOT	mg/L	2	2/2	0.02	1.99	1.01	0.02	**1.99**
	BENZENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	BENZENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	ETHYLENE GLYCOL	mg/L	2	0/2	<10	<250	<130	10	**<250**
	ETHYLBENZENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	ETHYLBENZENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	TOTAL XYLENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	TOTAL XYLENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	M-P XYLENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	M-P XYLENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	O-XYLENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	O-XYLENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	METHYL ETHYL KETONE VOC	mg/L	2	0/2	<0.02	<0.02	<0.02	0.02	**<0.02**

TABLE 2 - 3
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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 COOLING TOWER BLOWDOWN	METHYL TERT-BUTYL ETHER VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
POND C - SOUTH POND	NAPHTHALENE (VOL)	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
(Cooling Tower Blowdown Pond South Side)	TOLUENE	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
Sample Period: April 1993 To July 2012	TOLUENE VOC	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
(continued)	HEXACHLOROBENZENE	mg/L	2	0/2	<0.01	<0.01	<0.01	0.01	**<0.01**
	DIESEL RANGE ORGANICS	mg/L	1	0/1	<0.31	<0.31	<0.31	0.31	**<0.31**
	C9-C10 AROMATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	C9 TO C12 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	OIL & GREASE	mg/L	1	0/1	<1	<1	<1	1	**<1**
	PURGEABLE HYDROCARBONS TOT	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	TOT EXTRACTABLE HYDROCARBON(EPH)	mg/L	1	0/1	<0.31	<0.31	<0.31	0.31	**<0.31**
	TOT EXTRACTABLE HYDROCARBON(EPHscr)	mg/L	1	0/1	0.309	0.309	0.309	0.309	**0.309**
	CYANIDE (CN) TOT	mg/L	2	0/2	<0.005	<0.005	<0.005	0.005	**<0.005**
	C5-C8 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
									9/16/2009
UNITS 1&2 COOLING TOWER BLOWDOWN	PH (LAB)	s.u.	4	4/4	8	8.6	8.25	8.2	**8.6**
POND C - NORTH POND	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	4	4/4	4250	7420	5625	4250	**7420**
(Cooling Tower Blowdown Pond South Side)	TDS (MEASURED AT 180 C)	mg/L	4	4/4	5160	7810	6268	5160	**7810**
Sample Period: May 2004 To September 2009	CALCIUM (CA) DIS	mg/L	4	4/4	270	449	356	270	**449**
	MAGNESIUM (MG) DIS	mg/L	4	4/4	496	704	569	496	**704**
Formerly received Units 1&2 Cooling Tower Blowdown Pond water.	SODIUM (NA) DIS	mg/L	4	4/4	470	591	512	470	**591**
Now primarily recieves water from storm water runoff collection,	POTASSIUM (K) DIS	mg/L	4	4/4	29	30	29.5	29	**29**
minor groundwater capture system water, transfer from Units 1&2	TOTAL ALKALINITY AS CACO3	mg/L	4	4/4	147	257	211	184	**147**
A Pond and Units 1-4 Sediment Retention Pond.	BICARBONATE (HCO3)	mg/L	4	4/4	152	313	251	225	**152**
Water from direct precipitation	CARBONATE AS CO3	mg/L	4	2/4	0	14	4	1	**14**
	SULFATE (SO4)	mg/L	4	4/4	3360	5260	4060	3360	**5260**
	CHLORIDE (CL)	mg/L	4	4/4	214	227	223	226	**227**
	BROMIDE (BR)	mg/L	1	0/1	<10	<10	<10	10	**<10**
	BORON (B) DIS	mg/L	4	4/4	4	10.6	6.83	4	**10.6**
	MERCURY (HG) DIS	mg/L	2	0/2	<0.001	<0.001	<0.001	0.001	**<0.001**
	SELENIUM (SE) DIS	mg/L	4	3/4	<0.005	0.013	0.007	0.005	**0.013**
									5/7/2014
UNITS 1&2 POND A	PH (LAB)	s.u.	6	6/6	8.3	9	8.52	8.4	**8.7**
Sample Period: April 2005 To May 2014	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	6	6/6	4440	6990	6093	5810	**4440**
	TDS (MEASURED AT 180 C)	mg/L	5	5/5	4080	7200	5994	5930	**4080**
Primarily recieves water from storm water runoff collection via the	TOTAL HARDNESS AS CACO3	mg/L	2	2/2	2350	4180	3265	2350	**2350**
Units 1-4 Sediment Retention Pond	CALCIUM (CA) DIS	mg/L	6	6/6	408	517	444	430	**420**
Water from direct precipitation	MAGNESIUM (MG) DIS	mg/L	6	6/6	316	740	572	568	**316**
Contains some residual flyash from Units 1&2 Scrubbers	SODIUM (NA) DIS	mg/L	6	6/6	366	513	450	449	**366**
	POTASSIUM (K) DIS	mg/L	6	6/6	17	27	22.7	22	**17**
	TOTAL ALKALINITY AS CACO3	mg/L	6	6/6	92	163	139	143	**92**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

**** All Data Are Laboratory Analyses. No Field Data Are Included In This Table***

***** NA = Not Analyzed during most recent sampling event***

******Non-detects handled as 100% of the Reporting Limit in Statistical Calculations (i.e. mean, median).***

*******Results preceeded by "<" indicate value below reporting limit. Results preceeded by "<" for mean and median values indicate all results are below applicable reporting limit.***

SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 POND A	BICARBONATE (HCO3)	mg/L	6	6/6	82	199	149	173	**87**
Sample Period: April 2005 To May 2014	CARBONATE AS CO3	mg/L	6	2/6	<1	48	11.7	4	**12**
(continued)	SULFATE (SO4)	mg/L	6	6/6	2650	4870	3988	3850	**2650**
	CHLORIDE (CL)	mg/L	6	6/6	145	207	174	158	**145**
	FLUORIDE (F)	mg/L	1	1/1	1.6	1.6	1.6	1.6	**NA**
	BROMIDE (BR)	mg/L	3	2/3	<5	24	16	19	**19**
	NITRATE + NITRITE AS N	mg/L	1	1/1	<0.02	<0.02	<0.02	0.02	**NA**
	NITRITE (NO2-N)	mg/L	1	0/1	<0.05	<0.05	<0.05	0.05	**NA**
	ORTHOPHOSPHATE (PO4-P)	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**NA**
	PHOSPHORUS (P) TOT	mg/L	1	1/1	<0.07	<0.07	<0.07	0.07	**NA**
	ALUMINUM (AL) TOT	mg/L	1	0/1	<0.03	<0.03	<0.03	0.03	**NA**
	ANTIMONY (SB) TOT	mg/L	1	1/1	<0.002	<0.002	<0.002	0.002	**NA**
	ARSENIC (AS) TOT	mg/L	1	1/1	<0.002	<0.002	<0.002	0.002	**NA**
	BARIUM (BA) TOT	mg/L	1	1/1	<0.07	<0.07	<0.07	0.07	**NA**
	BERYLLIUM (BE) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	BORON (B) DIS	mg/L	5	5/5	7.6	16.5	13.2	14.7	**7.6**
	BORON (B) TOT	mg/L	1	1/1	15.1	15.1	15.1	15.1	**NA**
	CADMIUM (CD) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	CHROMIUM (CR+6) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	CHROMIUM (CR+3) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	CHROMIUM (CR) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**NA**
	COBALT (CO) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**NA**
	COPPER (CU) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**NA**
	IRON (FE) TOT	mg/L	1	0/1	<0.04	<0.04	<0.04	0.04	**NA**
	MANGANESE (MN) TOT	mg/L	1	1/1	0.182	0.182	0.182	0.182	**NA**
	MERCURY (HG) DIS	mg/L	2	0/2	<0.001	<0.001	<0.001	0.001	**NA**
	MERCURY (HG) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0	**NA**
	MOLYBDENUM (MO) TOT	mg/L	1	1/1	0.065	0.065	0.065	0.065	**NA**
	NICKEL (NI) TOT	mg/L	1	1/1	0.022	0.022	0.022	0.022	**NA**
	SELENIUM (SE) DIS	mg/L	5	5/5	0.006	0.024	0.016	0.014	**0.006**
	SELENIUM (SE) TOT	mg/L	1	1/1	0.007	0.007	0.007	0.007	**NA**
	SILVER (AG) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	THALLIUM (TL) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	VANADIUM (V) TOT	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	ZINC (ZN) TOT	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	BENZENE VPH (LAB)	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	ETHYLENE GLYCOL	mg/L	1	0/1	<250	<250	<250	250	**NA**
	ETHYLBENZENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	TOTAL XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	M-P XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	O-XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	METHYL ETHYL KETONE VOC	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**NA**
	METHYL TERT-BUTYL ETHER VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

**** All Data Are Laboratory Analyses. No Field Data Are Included In This Table***

***** NA = Not Analyzed during most recent sampling event***

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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 POND A	NAPHTHALENE (VOL)	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
Sample Period: April 2005 To May 2014	TOLUENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
(continued)	HEXACHLOROBENZENE	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	DIESEL RANGE ORGANICS	mg/L	1	0/1	<0.32	<0.32	<0.32	0.32	**NA**
	C9-C10 AROMATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**NA**
	C9 TO C12 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**NA**
	OIL & GREASE	mg/L	1	0/1	<1	<1	<1	1	**NA**
	PURGEABLE HYDROCARBONS TOT	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**NA**
	TOT EXTRACTABLE HYDROCARBON(EPH)	mg/L	1	1/1	<0.39	<0.39	<0.39	0.39	**NA**
	TOT EXTRACTABLE HYDROCARBON(EPH scr)	mg/L	1	0/1	<306	<306	<306	306	**NA**
	CYANIDE (CN) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**NA**
	C5-C8 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**NA**
									7/19/2012
UNITS 1&2 POND-B	PH (LAB)	s.u.	4	4/4	6.9	7.9	7.4	7.3	**7.5**
Sample Period: June 2005 To July 2012	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	4	4/4	15000	21700	18250	17500	**18800**
	TDS (MEASURED AT 180 C)	mg/L	4	4/4	19400	27500	22700	19900	**19400**
Replaced Pond B side of the Units 1&2 AB Ponds.	TOTAL HARDNESS AS CACO3	mg/L	1	1/1	16600	16600	16600	16600	**16600**
Recieves water from the Units 1&2 Stage II Evaporation Pond	CALCIUM (CA) DIS	mg/L	4	4/4	426	442	434	429	**439**
Clearwell.	MAGNESIUM (MG) DIS	mg/L	4	4/4	2410	4060	3395	3350	**3760**
Water from direct precipitation	SODIUM (NA) DIS	mg/L	4	4/4	905	1320	1146	1080	**1280**
	POTASSIUM (K) DIS	mg/L	4	4/4	43	59	52.8	54	**54**
	TOTAL ALKALINITY AS CACO3	mg/L	4	4/4	49	201	116	86	**129**
	BICARBONATE (HCO3)	mg/L	4	4/4	60	245	142	104	**157**
	CARBONATE AS CO3	mg/L	4	0/4	<1	<4	<3	3	**<4**
	SULFATE (SO4)	mg/L	4	4/4	11900	19600	16625	16500	**19600**
	CHLORIDE (CL)	mg/L	4	4/4	314	564	448	380	**564**
	FLUORIDE (F)	mg/L	1	1/1	3	3	3	3	**3**
	BROMIDE (BR)	mg/L	2	2/2	12	218	115	12	**218**
	NITRATE + NITRITE AS N	mg/L	1	1/1	10.9	10.9	10.9	10.9	**10.9**
	NITRITE (NO2-N)	mg/L	1	1/1	0.08	0.08	0.08	0.08	**0.08**
	ORTHOPHOSPHATE (PO4-P)	mg/L	1	1/1	0.046	0.046	0.046	0.046	**0.046**
	PHOSPHORUS (P) TOT	mg/L	1	1/1	0.08	0.08	0.08	0.08	**0.08**
	ALUMINUM (AL) TOT	mg/L	1	1/1	1.17	1.17	1.17	1.17	**1.17**
	ANTIMONY (SB) TOT	mg/L	1	1/1	0.003	0.003	0.003	0.003	**0.003**
	ARSENIC (AS) TOT	mg/L	1	1/1	0.006	0.006	0.006	0.006	**0.006**
	BARIUM (BA) TOT	mg/L	1	1/1	0.15	0.15	0.15	0.15	**0.15**
	BERYLLIUM (BE) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	BORON (B) DIS	mg/L	3	3/3	62.4	114	92	99.6	**NA**
	BORON (B) TOT	mg/L	1	1/1	87	87	87	87	**87**
	CADMIUM (CD) TOT	mg/L	1	1/1	0.025	0.025	0.025	0.025	**0.025**
	CHROMIUM (CR+6) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	<0.01	**<0.01**
	CHROMIUM (CR+3) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 POND-B	CHROMIUM (CR) TOT	mg/L	1	1/1	0.008	0.008	0.008	0.008	**0.008**
Sample Period: June 2005 To July 2012	COBALT (CO) TOT	mg/L	1	1/1	0.239	0.239	0.239	0.239	**0.239**
(continued)	COPPER (CU) TOT	mg/L	1	1/1	0.144	0.144	0.144	0.144	**0.144**
	IRON (FE) TOT	mg/L	1	1/1	0.17	0.17	0.17	0.17	**0.17**
	MANGANESE (MN) TOT	mg/L	1	1/1	55.9	55.9	55.9	55.9	**55.9**
	MERCURY (HG) DIS	mg/L	2	0/2	<0.001	<0.001	<0.001	0.001	**<0.001**
	MOLYBDENUM (MO) TOT	mg/L	1	1/1	0.098	0.098	0.098	0.098	**0.098**
	NICKEL (NI) TOT	mg/L	1	1/1	0.709	0.709	0.709	0.709	**0.709**
	SELENIUM (SE) DIS	mg/L	3	3/3	0.099	0.188	0.139	0.131	**NA**
	SELENIUM (SE) TOT	mg/L	1	1/1	0.25	0.25	0.25	0.25	**0.25**
	SILVER (AG) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	THALLIUM (TL) TOT	mg/L	1	1/1	0.003	0.003	0.003	0.003	**0.003**
	VANADIUM (V) TOT	mg/L	1	1/1	0.02	0.02	0.02	0.02	**0.02**
	ZINC (ZN) TOT	mg/L	1	1/1	0.6	0.6	0.6	0.6	**0.6**
	BENZENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	ETHYLENE GLYCOL	mg/L	1	0/1	<250	<250	<250	250	**<250**
	ETHYLBENZENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	TOTAL XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	M-P XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	O-XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	METHYL ETHYL KETONE VOC	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	METHYL TERT-BUTYL ETHER VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	NAPHTHALENE (VOL)	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	TOLUENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.01**
	HEXACHLOROBENZENE	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**NA**
	PROPANE	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**NA**
	DIESEL RANGE ORGANICS	mg/L	1	1/1	0.42	0.42	0.42	0.42	**0.42**
	C9-C10 AROMATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	C9 TO C12 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	OIL & GREASE	mg/L	1	0/1	<1	<1	<1	1	**<1**
	PURGEABLE HYDROCARBONS TOT	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	TOT EXTRACTABLE HYDROCARBON(EPH)	mg/L	1	1/1	0.79	0.79	0.79	0.79	**0.79**
	TOT EXTRACTABLE HYDROCARBON(EPHscr)	mg/L	1	1/1	0.649	0.649	0.649	0.649	**0.649**
	CYANIDE (CN) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**<0.005**
	C5-C8 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
									9/29/2011
UNITS 3&4 WASH TRAY POND (3&4 WTP)	PH (LAB)	s.u.	13	13/13	4.2	9.4	6.28	5.1	**8**
Sample Period: February 1984 To September 2011	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	13	13/13	5440	21300	12082	12700	**16500**
	TDS (MEASURED AT 180 C)	mg/L	13	13/13	5400	44200	17680	18300	**21900**
Removed from service in 1996. Samples collected after that time	TOTAL HARDNESS AS CACO3	mg/L	12	12/12	3140	16069	9780	9930	**13400**
represent precipitation water.	CALCIUM (CA) DIS	mg/L	13	13/13	107	618	455	499	**107**
Formerly received water from the Units 3&4 Wash Trays.	MAGNESIUM (MG) DIS	mg/L	13	13/13	465	5130	2299	2520	**2850**
Water from direct precipitation	SODIUM (NA) DIS	mg/L	13	13/13	381	2780	933	830	**1650**
Contains residual flyash from the Units 3&4 Scrubber System.	POTASSIUM (K) DIS	mg/L	11	11/11	13	100	53.4	67	**91**
Currently only recives water from direct precipitation	TOTAL ALKALINITY AS CACO3	mg/L	12	12/12	NA	142	40.3	6	**106**
	TOTAL ACIDITY AS CACO3	mg/L	2	2/2	62	250	156	62	**62**
	BICARBONATE (HCO3)	mg/L	12	12/12	NA	129	21.8	4	**129**
	CARBONATE AS CO3	mg/L	6	5/6	0	83	16.2	0	**<4**
	SULFATE (SO4)	mg/L	13	13/13	3840	27800	12202	12910	**15900**
	CHLORIDE (CL)	mg/L	13	13/13	48	868	236	185	**535**
	FLUORIDE (F)	mg/L	11	11/11	1.8	15	4.68	4.38	**NA**
	BROMIDE (BR)	mg/L	1	0/1	<50	<50	<50	50	**<50**
	HYDROXIDE (OH)	mg/L	1	0/1	<4	<4	<4	4	**NA**
	TOTAL AMMONIA (NH3+NH4 AS N)	mg/L	1	0/1	<0.05	<0.05	<0.05	0.05	**NA**
	NITRATE + NITRITE AS N	mg/L	11	10/11	<0.01	18.8	6.78	7.2	**NA**
	ORTHOPHOSPHATE (PO4-P)	mg/L	6	6/6	<0.01	0.13	0.053	0.04	**NA**
	PHOSPHORUS (P) TOT	mg/L	1	1/1	0.209	0.209	0.209	0.209	**NA**
	ALUMINUM (AL) DIS	mg/L	6	5/6	<0.1	49.9	17.8	7.6	**NA**
	BORON (B) DIS	mg/L	13	13/13	15.6	112	54.5	50.5	**85.6**
	CADMIUM (CD) DIS	mg/L	6	4/6	0.004	0.017	0.009	0.005	**NA**
	COPPER (CU) DIS	mg/L	6	5/6	<0.01	0.24	0.082	0.03	**NA**
	IRON (FE) DIS	mg/L	10	8/10	<0.03	0.53	0.211	0.17	**NA**
	LEAD (PB) DIS	mg/L	6	1/6	<0.01	0.41	0.08	0.01	**NA**
	MANGANESE (MN) DIS	mg/L	10	8/10	<0.02	18.9	9.87	11.9	**NA**
	MERCURY (HG) DIS	mg/L	2	0/2	<0.001	<0.001	<0.001	0.001	**NA**
	NICKEL (NI) DIS	mg/L	6	3/6	<0.02	0.15	0.06	0.03	**NA**
	SELENIUM (SE) DIS	mg/L	13	10/13	<0.005	0.14	0.065	0.06	**0.03**
	VANADIUM (V) DIS	mg/L	6	2/6	<0.1	0.14	0.112	0.1	**NA**
	ZINC (ZN) DIS	mg/L	10	8/10	<0.01	0.9	0.309	0.26	**NA**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

**** All Data Are Laboratory Analyses. No Field Data Are Included In This Table***

***** NA = Not Analyzed during most recent sampling event***

******Non-detects handled as 100% of the Reporting Limit in Statistical Calculations (i.e. mean, median).***

*******Results preceeded by "<" indicate value below reporting limit. Results preceeded by "<" for mean and median values indicate all results are below applicable reporting limit.***

SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
									6/1/1999
UNITS 1&2 CONCENTRATOR DISPOSAL	PH	s.u.	22	22/22	6.5	7.9	7.46	7.6	**7.8**
POND D4	SC (UMHOS/CM AT 25 C)	umhos/cm	22	22/22	52800	97000	70573	71200	**64400**
CLOSED in 2005	TDS (MEASURED AT 180 C)	mg/L	22	22/22	111500	272000	187725	175000	**186000**
Sample Period: June 1979 To June 1999	TOTAL HARDNESS AS CACO3	mg/L	21	21/21	11670	121063	75704	78500	**NA**
	CALCIUM (CA) DIS	mg/L	22	22/22	197	1426	737	776	**502**
Oringally recived water from the Units 1&2 Brine Water.	MAGNESIUM (MG) DIS	mg/L	22	22/22	8740	30300	19083	18600	**21500**
Also received excess water for water management.	SODIUM (NA) DIS	mg/L	22	22/22	13800	34600	23097	21760	**34600**
Water from direct precipitation	POTASSIUM (K) DIS	mg/L	21	21/21	560	6280	3082	2920	**NA**
	TOTAL ALKALINITY AS CACO3	mg/L	20	20/20	248	3590	977	798	**NA**
Materials encapsulated at southwest corner of former pond in 2006.	BICARBONATE (HCO3)	mg/L	22	22/22	303	4380	1156	916	**NA**
Liner removed in 2006. Th depression currently recieves water from	CARBONATE AS CO3	mg/L	1	1/1	0	0	0	0	**124000**
direct precipitation. Salt laden soil remains in the depression that once	SULFATE (SO4)	mg/L	22	22/22	62400	159000	115129	117000	**23700**
held the pond. These solids were removed in late 2014.	CHLORIDE (CL)	mg/L	22	22/22	4250	31900	12810	10300	**NA**
	FLUORIDE (F)	mg/L	20	20/20	17.1	234	115	122	**NA**
	TOTAL AMMONIA (NH3+NH4 AS N)	mg/L	1	1/1	0.9	0.9	0.9	0.9	**NA**
	NITRATE + NITRITE AS N	mg/L	20	20/20	0.1	43.8	10.6	4.31	**NA**
	ORTHOPHOSPHATE (PO4-P)	mg/L	13	13/13	0.13	227	49.5	42.2	**NA**
	ALUMINUM (AL) DIS	mg/L	15	8/15	0.1	4106	284	0.3	**405**
	BORON (B) DIS	mg/L	20	20/20	162	854	367	276	**NA**
	CADMIUM (CD) DIS	mg/L	15	10/15	0.002	0.233	0.054	0.019	**NA**
	COPPER (CU) DIS	mg/L	13	13/13	0.05	88	25.3	21.6	**NA**
	IRON (FE) DIS	mg/L	20	18/20	0.02	40.8	9.11	0.79	**NA**
	LEAD (PB) DIS	mg/L	15	11/15	0.02	2	0.408	0.12	**NA**
	MANGANESE (MN) DIS	mg/L	18	18/18	1.4	79.6	26.3	24.7	**NA**
	MERCURY (HG) DIS	mg/L	1	0/1	0.001	0.001	0.001	0.001	**NA**
	NICKEL (NI) DIS	mg/L	5	4/5	0.02	4.57	1.36	0.89	**1.05**
	SELENIUM (SE) DIS	mg/L	22	11/22	0.005	1.05	0.158	0.005	**NA**
	VANADIUM (V) DIS	mg/L	13	4/13	0.02	20	2.4	0.8	**NA**
	ZINC (ZN) DIS	mg/L	19	19/19	0.09	15.4	5.41	4.5	**NA**
									4/2/2013
UNITS 1&2 BRINE WASTE DISPOSAL POND	PH (LAB)	s.u.	6	6/6	7	7.9	7.6	7.6	**7.4**
UNDERDRAIN SUMP	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	6	6/6	46300	77900	61900	59100	**69200**
Sample Period: May 2008 To April 2013	TDS (MEASURED AT 180 C)	mg/L	6	6/6	64500	332000	185750	161000	**218000**
	CALCIUM (CA) DIS	mg/L	6	6/6	178	394	329	350	**350**
Collects water from the former Pond D4 Underdrain	MAGNESIUM (MG) DIS	mg/L	6	6/6	9460	57900	27093	21000	**28900**
system which is no longer in service. Water collected at this site	SODIUM (NA) DIS	mg/L	6	6/6	8300	33600	18750	15500	**18000**
is the result of precipitation.	POTASSIUM (K) DIS	mg/L	6	6/6	456	2340	1326	1150	**1380**
	TOTAL ALKALINITY AS CACO3	mg/L	6	6/6	400	1890	1138	1110	**1320**
	BICARBONATE (HCO3)	mg/L	6	6/6	488	2300	1387	1360	**1610**
	CARBONATE AS CO3	mg/L	6	0/6	1	4	3.5	4	**<4**
	SULFATE (SO4)	mg/L	6	6/6	59200	277000	149500	114000	**156000**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1&2 BRINE WASTE DISPOSAL POND	CHLORIDE (CL)	mg/L	6	6/6	1410	4990	3000	2150	**3800**
UNDERDRAIN SUMP	BROMIDE (BR)	mg/L	4	0/4	1	200	75.5	1	**<1**
Sample Period: May 2008 To April 2013	BORON (B) DIS	mg/L	6	6/6	35.1	186	114	91.3	**138**
(continued)	MERCURY (HG) DIS	mg/L	1	0/1	0.001	0.001	0.001	0.001	**NA**
	SELENIUM (SE) DIS	mg/L	6	6/6	0.021	0.109	0.064	0.066	**0.078**
									11/19/2009
UNITS 3&4 SCRUBBER DRAIN	PH (LAB)	s.u.	14	14/14	5	9.4	7.98	8.2	**9**
COLLECTION POND (DC POND)	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	14	14/14	3490	17900	10226	10100	**6550**
Sample Period: February 1984 To November 2009	TDS (MEASURED AT 180 C)	mg/L	14	14/14	2740	23600	13702	14300	**6940**
Removed from Service in 1996	TOTAL HARDNESS AS CACO3	mg/L	10	10/10	3680	13000	9122	9383	**NA**
Received water from miscellaneous Units 3&4 scrubber plant drains,	CALCIUM (CA) DIS	mg/L	14	14/14	114	745	497	505	**553**
washdown water, and Units 3&4 Scrubber Slurry. No longer used and	MAGNESIUM (MG) DIS	mg/L	14	14/14	67	3530	1772	1950	**624**
receives water from direct precipitation and coal pile runoff.	SODIUM (NA) DIS	mg/L	14	14/14	448	1290	733	681	**506**
	POTASSIUM (K) DIS	mg/L	11	11/11	12	176	56.8	46	**29**
Pond bottom contains some flyash from Units 3&4 scrubbers	TOTAL ALKALINITY AS CACO3	mg/L	12	12/12	5	442	203	147	**NA**
	TOTAL ACIDITY AS CACO3	mg/L	1	0/1	1	1	1	1	**NA**
	BICARBONATE (HCO3)	mg/L	11	11/11	0	539	176	93	**92**
	CARBONATE AS CO3	mg/L	4	3/4	0	142	48.8	1	**52**
	SULFATE (SO4)	mg/L	14	14/14	1580	14000	8940	10000	**4240**
	CHLORIDE (CL)	mg/L	14	14/14	12	375	149	136	**4240**
	FLUORIDE (F)	mg/L	11	11/11	0	13.7	904	5.9	**NA**
	BROMIDE (BR)	mg/L	1	0/1	10	10	10	10	**<10**
	NITRATE + NITRITE AS N	mg/L	11	9/11	0.05	12.4	3.74	2.64	**NA**
	ORTHOPHOSPHATE (PO4-P)	mg/L	6	5/6	0.01	0.1	0.042	0.04	**NA**
	ALUMINUM (AL) DIS	mg/L	6	4/6	0.1	2.9	0.717	0.1	**NA**
	BORON (B) DIS	mg/L	14	14/14	0.5	112	48	45.7	**18.9**
	CADMIUM (CD) DIS	mg/L	6	3/6	0.001	0.012	0.006	0.005	**NA**
	COPPER (CU) DIS	mg/L	6	3/6	0.01	0.04	0.022	0.01	**NA**
	IRON (FE) DIS	mg/L	10	8/10	0.03	0.26	0.126	0.09	**NA**
	LEAD (PB) DIS	mg/L	6	2/6	0.01	0.07	0.025	0.01	**NA**
	MANGANESE (MN) DIS	mg/L	10	9/10	0.02	13.1	5.92	4.6	**NA**
	MERCURY (HG) DIS	mg/L	6	0/6	0.001	0.001	0.001	0.001	**NA**
	NICKEL (NI) DIS	mg/L	6	3/6	0.02	0.67	0.14	0.03	**NA**
	SELENIUM (SE) DIS	mg/L	14	10/14	0.005	0.287	0.085	0.06	**0.025**
	VANADIUM (V) DIS	mg/L	6	2/6	0.1	0.2	0.127	0.1	**NA**
	ZINC (ZN) DIS	mg/L	10	4/10	0.01	0.56	0.11	0.01	**NA**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
									7/19/2012
UNITS 3&4 NORTH PLANT AREA DRAIN	PH (LAB)	s.u.	8	8/8	7.4	8.4	7.84	7.8	**8**
POND (NORTH POND)	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	8	8/8	1740	4730	3079	2930	**3560**
Sample Period: May 1996 To July 2012	TDS (MEASURED AT 180 C)	mg/L	8	8/8	1170	4350	2596	2370	**2370**
	TOTAL HARDNESS AS CACO3	mg/L	1	1/1	904	904	904	904	**904**
Recieves water from storm water. Also receives water	CALCIUM (CA) DIS	mg/L	8	8/8	141	434	259	206	**202**
from direct precipitation.	MAGNESIUM (MG) DIS	mg/L	8	8/8	54	185	119	97	**97**
	SODIUM (NA) DIS	mg/L	8	8/8	134	520	263	227	**450**
	POTASSIUM (K) DIS	mg/L	5	5/5	12	30	19	14	**14**
	TOTAL ALKALINITY AS CACO3	mg/L	5	5/5	103	249	169	137	**103**
	BICARBONATE (HCO3)	mg/L	5	5/5	126	303	206	167	**126**
	CARBONATE AS CO3	mg/L	5	0/5	<1	4	2.6	3	**<4**
	SULFATE (SO4)	mg/L	8	8/8	477	2560	1454	1300	**1300**
	CHLORIDE (CL)	mg/L	8	8/8	71	439	170	119	**439**
	FLUORIDE (F)	mg/L	1	1/1	2.1	2.1	2.1	2.1	**2.1**
	BROMIDE (BR)	mg/L	2	1/2	<1	2	1.5	1	**2**
	NITRATE + NITRITE AS N	mg/L	1	1/1	0.38	0.38	0.38	0.38	**0.38**
	NITRITE (NO2-N)	mg/L	1	0/1	<0.05	<0.05	<0.05	0.05	**<0.05**
	ORTHOPHOSPHATE (PO4-P)	mg/L	1	1/1	0.253	0.253	0.253	0.253	**0.253**
	PHOSPHORUS (P) TOT	mg/L	1	1/1	0.46	0.46	0.46	0.46	**0.46**
	ALUMINUM (AL) TOT	mg/L	1	1/1	0.17	0.17	0.17	0.17	**0.17**
	ANTIMONY (SB) TOT	mg/L	1	1/1	0.001	0.001	0.001	0.001	**0.001**
	ARSENIC (AS) TOT	mg/L	1	1/1	0.032	0.032	0.032	0.032	**0.032**
	BARIUM (BA) TOT	mg/L	1	1/1	0.16	0.16	0.16	0.16	**0.16**
	BERYLLIUM (BE) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	BORON (B) DIS	mg/L	7	7/7	0.4	1.9	1.09	1.1	**NA**
	BORON (B) TOT	mg/L	1	1/1	0.7	0.7	0.7	0.7	**0.7**
	CADMIUM (CD) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	CHLORINE (CL) TOT	mg/L	1	1/1	0.1	0.1	0.1	0.1	**0.1**
	CHROMIUM (CR+6) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
	CHROMIUM (CR+3) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
	CHROMIUM (CR) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**<0.005**
	COBALT (CO) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**<0.005**
	COPPER (CU) TOT	mg/L	1	1/1	0.009	0.009	0.009	0.009	**0.009**
	IRON (FE) TOT	mg/L	1	1/1	3.54	3.54	3.54	3.54	**3.54**
	MANGANESE (MN) TOT	mg/L	1	1/1	0.112	0.112	0.112	0.112	**0.112**
	MERCURY (HG) DIS	mg/L	2	0/2	<0.001	<0.001	<0.001	0.001	**NA**
	MERCURY (HG) TOT	mg/L	1	0/1	<0.0001	<0.0001	<0.0001	0	**<0.0001**
	MOLYBDENUM (MO) TOT	mg/L	1	1/1	0.005	0.005	0.005	0.005	**0.005**
	NICKEL (NI) TOT	mg/L	1	1/1	0.01	0.01	0.01	0.01	**0.01**
	SELENIUM (SE) DIS	mg/L	7	5/7	0.005	0.02	0.009	0.007	**NA**
	SELENIUM (SE) TOT	mg/L	1	1/1	0.011	0.011	0.011	0.011	**0.011**
	SILVER (AG) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**

TABLE 2 - 3
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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 3&4 NORTH PLANT AREA DRAIN	THALLIUM (TL) TOT	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
POND (NORTH POND)	VANADIUM (V) TOT	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
Sample Period: May 1996 To July 2012	ZINC (ZN) TOT	mg/L	1	1/1	0.01	0.01	0.01	0.01	**0.01**
(continued)	BENZENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	ETHYLENE GLYCOL	mg/L	1	0/1	<250	<250	<250	250	**<250**
	ETHYLBENZENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	TOTAL XYLENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	M-P XYLENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	O-XYLENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	METHYL ETHYL KETONE VOC	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	METHYL TERT-BUTYL ETHER VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	NAPHTHALENE (VOL)	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	TOLUENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	HEXACHLOROBENZENE	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
	DIESEL RANGE ORGANICS	mg/L	1	1/1	<0.38	<0.38	<0.38	0.38	**<0.38**
	C9-C10 AROMATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	C9 TO C12 ALIPHATICS	mg/L	1	1/1	<0.034	<0.034	<0.034	0.034	**<0.034**
	OIL & GREASE	mg/L	1	0/1	<1	<1	<1	1	**<1**
	TOTAL PURGEABLE HYDROCARBONS	mg/L	1	1/1	<0.041	<0.041	<0.041	0.041	**<0.041**
	TOT EXTRACTABLE HYDROCARBON(EPH)	mg/L	1	1/1	<0.73	<0.73	<0.73	0.73	**<0.73**
	TOT EXTRACTABLE HYDROCARBON(EPHscr)	mg/L	1	1/1	<0.375	<0.375	<0.375	0.375	**<0.375**
	CYANIDE (CN) TOT	mg/L	1	1/1	<0.006	<0.006	<0.006	0.006	**<0.006**
	C5-C8 ALIPHATICS	mg/L	1	1/1	<0.024	<0.024	<0.024	0.024	**<0.024**
									7/19/2012
UNITS 1-4 NORTH PLANT SEDIMENT	PH (LAB)	s.u.	14	14/14	6.7	9.3	7.83	7.7	**7.6**
RETENTION POND	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	14	14/14	619	5130	1975	1320	**1290.0**
Sample Period: June 1984 To July 2012	TDS (MEASURED AT 180 C)	mg/L	14	14/14	396	4780	1647	968	**932.0**
Recieves water from north plant and warehouse areas. Also receives	TOTAL HARDNESS AS CACO3	mg/L	10	10/10	283	2320	1028	596	**585.0**
water from direct precipitation.	CALCIUM (CA) DIS	mg/L	14	14/14	55	555	185	116	**101.0**
	MAGNESIUM (MG) DIS	mg/L	14	14/14	25	226	82.7	52	**81.0**
	SODIUM (NA) DIS	mg/L	14	14/14	12	615	189	112	**43.0**
	POTASSIUM (K) DIS	mg/L	12	12/12	6	37	16.1	11	**9.0**
	TOTAL ALKALINITY AS CACO3	mg/L	12	12/12	44	170	107	105	**105.0**
	TOTAL ACIDITY AS CACO3	mg/L	2	0/2	1	1	1	1	**NA**
	BICARBONATE (HCO3)	mg/L	12	12/12	54	207	130	129	**129.0**
	CARBONATE AS CO3	mg/L	6	2/6	0	4	2	1	**<4**
	SULFATE (SO4)	mg/L	14	14/14	119	3140	979	554	**479.0**
	CHLORIDE (CL)	mg/L	14	14/14	29	162	73.8	67	**98.0**
	FLUORIDE (F)	mg/L	9	9/9	0.15	4.1	1.4	0.85	**0.4**
	BROMIDE (BR)	mg/L	2	1/2	0.5	0.8	0.65	0.5	**0.8**
	NITRATE + NITRITE AS N	mg/L	9	8/9	0.01	4.13	0.865	0.4	**<0.01**
	NITRITE (NO2-N)	mg/L	1	0/1	0.05	0.05	0.05	0.05	**<0.05**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

**** All Data Are Laboratory Analyses. No Field Data Are Included In This Table***

***** NA = Not Analyzed during most recent sampling event***

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*******Results preceeded by "<" indicate value below reporting limit. Results preceeded by "<" for mean and median values indicate all results are below applicable reporting limit.***

SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1-4 NORTH PLANT SEDIMENT	ORTHOPHOSPHATE (PO4-P)	mg/L	6	6/6	0.014	0.51	0.199	0.14	**0.014**
RETENTION POND	PHOSPHORUS (P) TOT	mg/L	1	1/1	0.14	0.14	0.14	0.14	**0.14**
Sample Period: June 1984 To July 2012	ALUMINUM (AL) DIS	mg/L	5	1/5	0.1	0.6	0.2	0.1	**NA**
(continued)	ALUMINUM (AL) TOT	mg/L	1	1/1	4.14	4.14	4.14	4.14	**4.140**
	ANTIMONY (SB) TOT	mg/L	1	0/1	0.001	0.001	0.001	0.001	**<0.001**
	ARSENIC (AS) TOT	mg/L	1	1/1	0.014	0.014	0.014	0.014	**0.014**
	BARIUM (BA) TOT	mg/L	1	1/1	0.39	0.39	0.39	0.39	**0.390**
	BERYLLIUM (BE) TOT	mg/L	1	0/1	0.001	0.001	0.001	0.001	**<0.001**
	BORON (B) DIS	mg/L	14	14/14	0.2	1.4	0.668	0.6	**NA**
	BORON (B) TOT	mg/L	1	1/1	0.96	0.96	0.96	0.96	**0.96**
	CADMIUM (CD) DIS	mg/L	5	2/5	0.001	0.005	0.003	0.004	**0.005**
	CADMIUM (CD) TOT	mg/L	1	1/1	0.001	0.001	0.001	0.001	**0.001**
	CHLORINE (CL) TOT	mg/L	1	0/1	<0.1	<0.1	<0.1	0	**<0.1**
	CHROMIUM (CR+6) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
	CHROMIUM (CR+3) DIS	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
	CHROMIUM (CR) TOT	mg/L	1	1/1	0.012	0.012	0.012	0.012	**0.012**
	COBALT (CO) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**<0.005**
	COPPER (CU) DIS	mg/L	5	3/5	<0.01	0.14	0.07	0.06	**NA**
	COPPER (CU) TOT	mg/L	1	1/1	0.017	0.017	0.017	0.017	**0.017**
	IRON (FE) DIS	mg/L	9	6/9	<0.03	0.14	0.074	0.05	**NA**
	IRON (FE) TOT	mg/L	1	1/1	5.82	5.82	5.82	5.82	**5.820**
	LEAD (PB) DIS	mg/L	5	0/5	<0.01	0.02	0.014	0.01	**NA**
	MANGANESE (MN) DIS	mg/L	8	8/8	0.03	0.17	0.079	0.07	**NA**
	MANGANESE (MN) TOT	mg/L	1	1/1	0.868	0.868	0.868	0.868	**0.868**
	MERCURY (HG) DIS	mg/L	4	0/4	<0.001	<0.001	<0.001	0.001	**NA**
	MERCURY (HG) TOT	mg/L	1	0/1	<0.0001	<0.0001	<0.0001	0	**<0.0001**
	MOLYBDENUM (MO) TOT	mg/L	1	1/1	0.006	0.006	0.006	0.006	**0.006**
	NICKEL (NI) DIS	mg/L	5	0/5	<0.01	0.05	0.026	0.02	**NA**
	NICKEL (NI) TOT	mg/L	1	1/1	<0.01	0.01	0.01	0.01	**0.01**
	SELENIUM (SE) DIS	mg/L	13	3/13	<0.005	0.02	0.007	0.005	**NA**
	SELENIUM (SE) TOT	mg/L	1	1/1	0.001	0.001	0.001	0.001	**0.001**
	SILVER (AG) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	THALLIUM (TL) TOT	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	0.001	**<0.0005**
	VANADIUM (V) DIS	mg/L	5	2/5	0.02	0.1	0.082	0.1	**NA**
	VANADIUM (V) TOT	mg/L	1	1/1	0.01	0.01	0.01	0.01	**0.01**
	ZINC (ZN) DIS	mg/L	8	8/8	0.02	0.97	0.287	0.13	**NA**
	ZINC (ZN) TOT	mg/L	1	1/1	0.16	0.16	0.16	0.16	**0.160**
	BENZENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	ETHYLENE GLYCOL	mg/L	1	0/1	<250	<250	<250	250	**<250**
	ETHYLBENZENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	TOTAL XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	M-P XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	O-XYLENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE UNITS 1 THROUGH 4 PROCESS POND CHEMICAL PROFILES

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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1-4 NORTH PLANT SEDIMENT	METHYL ETHYL KETONE VOC	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
RETENTION POND	METHYL TERT-BUTYL ETHER VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
Sample Period: June 1984 To July 2012	NAPHTHALENE (VOL)	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
(continued)	TOLUENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	HEXACHLOROBENZENE	mg/L	1	0/1	<0.01	<0.01	<0.01	0.01	**<0.01**
	DIESEL RANGE ORGANICS	mg/L	1	1/1	<0.51	<0.51	<0.51	0.51	**<0.51**
	C9-C10 AROMATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	C9 TO C12 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	OIL & GREASE	mg/L	1	0/1	1	1	1	1	**1**
	PURGEABLE HYDROCARBONS TOT	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
	TOT EXTRACTABLE HYDROCARBON(EPH)	mg/L	1	1/1	<1.4	<1.4	<1.4	1.4	**<1.4**
	TOT EXTRACTABLE HYDROCARBON(EPHscr)	mg/L	1	1/1	<0.493	<0.493	<0.493	0.493	**<0.493**
	CYANIDE (CN) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**<0.005**
	C5-C8 ALIPHATICS	mg/L	1	0/1	<0.02	<0.02	<0.02	0.02	**<0.02**
									7/19/2012
UNITS 1-4 SEDIMENT RETENTION POND	PH (LAB)	s.u.	11	11/11	7.75	8.8	7.75	8.1	**8.2**
Sample Period: February 1985 To July 2012	SC (UMHOS/CM AT 25 C) (LAB)	umhos/cm	11	11/11	6640	14800	7871	6640	**12400**
	TDS (MEASURED AT 180 C)	mg/L	11	11/11	7110	19900	8800	7110	**10900**
Recieveds plant storm water drainage water and occassional scubber	TOTAL HARDNESS AS CACO3	mg/L	5	5/5	6414	12400	6414	7690	**8000**
overflow. Also recieves water from direct precipitation	CALCIUM (CA) DIS	mg/L	11	11/11	426	1030	458	426	**771**
	MAGNESIUM (MG) DIS	mg/L	11	11/11	525	2700	983	525	**1470**
	SODIUM (NA) DIS	mg/L	11	11/11	558	1560	590	558	**1040**
	POTASSIUM (K) DIS	mg/L	8	8/8	31	55	33.3	31	**48**
	TOTAL ALKALINITY AS CACO3	mg/L	8	8/8	129	211	129	147	**168**
	TOTAL ACIDITY AS CACO3	mg/L	2	1/2	0	1	0.5	0	**NA**
	BICARBONATE (HCO3)	mg/L	8	8/8	14	257	147	113	**205**
	CARBONATE AS CO3	mg/L	7	4/7	<3	41	7.43	3	**<4**
	SULFATE (SO4)	mg/L	12	12/12	2350	12800	5219	2350	**9320**
	CHLORIDE (CL)	mg/L	11	11/11	181	2050	333	181	**498**
	FLUORIDE (F)	mg/L	4	4/4	2.1	4.51	2.61	2.1	**2.2**
	BROMIDE (BR)	mg/L	2	2/2	35	47	41	35	**47**
	NITRATE + NITRITE AS N	mg/L	5	3/5	1.16	3.3	1.48	1.16	**<0.01**
	NITRITE (NO2-N)	mg/L	1	0/1	<0.05	<0.05	<0.05	0.05	**<0.05**
	ORTHOPHOSPHATE (PO4-P)	mg/L	3	2/3	0.022	0.05	0.031	0.022	**0.022**
	PHOSPHORUS (P) TOT	mg/L	1	1/1	0.09	0.09	0.09	0.09	**0.09**
	ALUMINUM (AL) DIS	mg/L	2	2/2	0.1	0.22	0.16	0.1	**NA**
	ALUMINUM (AL) TOT	mg/L	1	1/1	0.12	0.12	0.12	0.12	**0.12**
	ANTIMONY (SB) TOT	mg/L	1	1/1	0.002	0.002	0.002	0.002	**0.002**
	ARSENIC (AS) TOT	mg/L	1	1/1	0.006	0.006	0.006	0.006	**0.006**
	BARIUM (BA) DIS	mg/L	1	0/1	<10	<10	<10	10	**NA**
	BARIUM (BA) TOT	mg/L	1	1/1	0.09	0.09	0.09	0.09	**0.09**
	BERYLLIUM (BE) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**

TABLE 2 - 3
COLSTRIP STEAM ELECTRIC STATION
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SITE	PARAMETER	UNITS	NO. OF SAMPLES	NO. ABV DETECT	MIN	MAX	MEAN	MEDIAN	DATE AND ANALYSES OF MOST RECENT RESULT
UNITS 1-4 SEDIMENT RETENTION POND	BORON (B) DIS	mg/L	10	10/10	10.8	67	22.5	10.8	**NA**
Sample Period: February 1985 To October 2013	BORON (B) TOT	mg/L	2	2/2	0.183	27.9	14	0.183	**27.9**
(continued)	CADMIUM (CD) DIS	mg/L	2	0/2	<0.003	<0.005	<0.001	0.001	**NA**
	CADMIUM (CD) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	0.001	**<0.001**
	CHLORINE (CL) TOT	mg/L	1	0/1	<0.1	<0.1	<0.1	<0.1	**<0.1**
	CHROMIUM (CR+6) DIS	mg/L	1	0/1	<0.1	<0.1	<0.1	0.01	**<0.1**
	CHROMIUM (CR+3) DIS	mg/L	1	0/1	<0.1	<0.1	<0.1	0.01	**<0.1**
	CHROMIUM (CR) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**<0.005**
	COBALT (CO) TOT	mg/L	1	0/1	<0.005	<0.005	<0.005	0.005	**<0.005**
	COPPER (CU) DIS	mg/L	2	1/2	0.105	0.2	<0.01	0.01	**NA**
	COPPER (CU) TOT	mg/L	1	1/1	0.007	0.007	0.007	0.007	**0.007**
	IRON (FE) DIS	mg/L	3	1/3	<0.03	1.2	0.42	0.03	**NA**
	IRON (FE) TOT	mg/L	1	0/1	<0.08	<0.08	<0.08	0.08	**<0.08**
	LEAD (PB) DIS	mg/L	2	1/2	<0.01	0.06	0.035	0.01	**NA**
	MANGANESE (MN) DIS	mg/L	3	2/3	0.71	35.2	12.8	2.53	**NA**
	MANGANESE (MN) TOT	mg/L	1	1/1	3.32	3.32	3.32	3.32	**3.32**
	MERCURY (HG) DIS	mg/L	4	0/4	<0.001	<0.001	<0.001	0.001	**NA**
	MERCURY (HG) TOT	mg/L	1	0/1	<0.0001	<0.0001	<0.0001	<0.0001	**<0.0001**
	MOLYBDENUM (MO) TOT	mg/L	1	1/1	0.019	0.019	0.019	0.019	**0.019**
	NICKEL (NI) DIS	mg/L	1	1/1	0.05	0.05	0.05	0.05	**NA**
	NICKEL (NI) TOT	mg/L	1	1/1	0.051	0.051	0.051	0.051	**0.051**
	SELENIUM (SE) DIS	mg/L	9	8/9	0.026	0.125	0.013	0.013	**NA**
	SELENIUM (SE) TOT	mg/L	1	1/1	0.01	0.01	0.01	0.01	**0.01**
	SILVER (AG) TOT	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**<0.001**
	THALLIUM (TL) TOT	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	<0.0005	**<0.0005**
	VANADIUM (V) TOT	mg/L	1	0/1	<0.01	<0.01	<0.01	<0.01	**<0.01**
	ZINC (ZN) DIS	mg/L	3	3/3	0.14	0.23	0.17	0.17	**NA**
	ZINC (ZN) TOT	mg/L	1	1/1	0.06	0.06	0.06	0.06	**0.06**
	BENZENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	<0.0005	**<0.0005**
	ETHYLENE GLYCOL	mg/L	1	0/1	<250	<250	<250	<250	**<250**
	ETHYLBENZENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	<0.0005	**<0.0005**
	TOTAL XYLENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	<0.0005	**<0.0005**
	M-P XYLENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	<0.0005	**<0.0005**
	O-XYLENE VPH	mg/L	1	0/1	<0.0005	<0.0005	<0.0005	<0.0005	**<0.0005**
	METHYL ETHYL KETONE VOC	mg/L	1	0/1	<0.02	<0.02	<0.02	<0.02	**<0.02**
	METHYL TERT-BUTYL ETHER VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**<0.001**
	NAPHTHALENE (VOL)	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**<0.001**
	TOLUENE VPH	mg/L	1	0/1	<0.001	<0.001	<0.001	<0.001	**<0.001**
	HEXACHLOROBENZENE	mg/L	2	0/2	<0.03	<0.05	<0.01	<0.01	**<0.01**

- Routing of process waters may change for short periods for operational reasons. For example if a pond is going to be relined or rebuilt, the water from that pond has to be placed in different ponds. Water quality of the receiving pond may change following the transfer,
- Evaporation of water from the pond surface results in a concentration of the remaining water,
- Precipitation results in dilution of waters in the ponds. All other things being equal, this results in a lowering of SC in ponds. Colstrip receives about 1.25 feet of precipitation that falls directly on the ponds or that flows to the ponds as runoff.

At the request of the MDEQ Major Facilities Siting Program, PPLM conducted a more detailed sampling of six ponds in December 2002. The six ponds were those that were most likely to receive chemical constituents in the event of on-site releases or upset conditions in containment features (oil/water separators). Samples were analyzed an extensive list of parameters including major constituents, hydrazine, nutrients, an extended metals list, volatile organic constituents, semi-volatiles constituents, diesel range organics, diesel range organics as diesel, total extractable hydrocarbons, total purgeable hydrocarbons, hydrocarbon fractions (aliphatic & aromatics), cyanide, oil and grease, ethylene glycol, and residual chlorine.

PPLM conducted sampling of the same ponds for similar parameters in July 2012. Results of the analysis are included in data routinely submitted to the MDEQ Major Facilities Siting Program.

Extended metals analyses were conducted on select ponds in March 2007. This sampling was voluntarily conducted by PPLM. Samples were analyzed for an extended list of metals using dissolved and total recoverable sampling and analytical methods.

In some cases, PPLM collects samples from the ponds in response to actual or suspected releases or to evaluate current pond water conditions. For example, the Units 1-4 Sediment Retention Pond was sampled (7/9/2013 & 10/7/2013) for expanded metals, petroleum hydrocarbons (Volatile Petroleum Hydrocarbons, Extractable Petroleum Hydrocarbons, Semi-Volatiles), and cyanide to obtain recent data from the ponds to examine current process water conditions. This pond receives water draining from a portion of the Plant Site and organic constituents may enter the pond if upset conditions exist or if small releases occur that could result in hydrocarbons entering the pond. Organics may also be collected based on requests from MDEQ or for operational purposes to obtain period pond water quality conditions. However, analysis of process water in response to releases or suspected releases is typically not conducted since the pond chemistry is well understood and relatively consistent. Rather, groundwater quality is extensively monitored in response to releases and additional monitoring wells installed downgradient if warranted. Ponds have been sampled and analyzed for hydrogen and oxygen isotopes, in some cases, in association with investigations of changes in groundwater quality and are not necessarily associated with specific releases.

2.2.2.1 Units 1 & 2 B Pond Underliner, and Units 1 & 2 Bottom Ash Clearwell Underdrain

The Units 1&2 B Pond and Units 1&2 Bottom Ash Clearwell are constructed with a double liner system with leakage collection between the liners and under both liners. Water collected between the liners is sampled and identified as “Between Liner”. Water captured below the bottom liner is called “Underliner”. Water quality data for samples collected from both sites is presented in Table 2-3. Examination of these data shows that concentrations of TDS and SC between the liners (average 19,153 mg/L & 12,474 µmhos/cm) are considerably higher than those detected under the liners (average 8,119 mg/L & 7,570 µmhos/cm). The underliner drain intersects shallow groundwater in this area, creating a sink, or low spot, in the groundwater table. There is a difference in water quality compared to samples between the liners and underliners.

2.2.2.2 Bromide

Calcium bromide has been added to the combustion process as part of the mercury control system since 2010. This calcium bromide causes the mercury to be oxidized and is captured in the scrubbers. Typically, ponds that are directly connected to the scrubbers will have higher bromide concentrations. However, bromide concentration can be affected by factors other than the scrubber process. The amount of inventory in a pond also has an effect on the bromide concentrations in the ponds. Higher bromide concentrations result with more evaporation. Conversely, lower concentrations result from periods of high precipitation or if a substantial amount of raw water is added to the system.

2.2.2.3 Reporting Limits and Method Detection Limits

Water quality samples collected at the facility are submitted to commercial laboratories for analysis of parameters listed on a table referenced from the site monitoring plan. Reporting limits are also referenced in the Water Resources Monitoring Plan (Appendix E). This includes pond water, samples from the creek, and from groundwater monitoring wells. Reporting limits (RL) and method detection limits (MDL) are described in this section and apply for surface water and groundwater analysis, but would also hold true for other types of laboratory analysis.

Reporting limits are typically the lowest concentrations that a particular analyte that can be detected by a laboratory and the concentration reported with a reasonable degree of accuracy and precision. These values are often the lowest standard on the calibration curve. RL's are generally driven client or regulatory guidelines and as such have changed over time. Less accurate methods in the past produce a greater variance in the curves which may produce an artificial upward trend. Matrix interferences, caused by the presence of other chemical constituents may raise the level at which the concentration of a given analyte can be detected for reporting purposes. A simple, easy to use, protocol to evaluate the effects of matrix interferences and variations with reporting limits over time is not possible and a substantial amount of interpretation is required. For this reason, any trends that are potentially artificial

and may be associated with variations in laboratory analysis should be looked at on a case by case basis.

MDLs are the lowest concentrations that an analyte can be detected in a sample that does not cause matrix interferences using a particular analytical method. Detected has been defined as a value where you are almost positive that the analyte you are analyzing is not background, also called the critical level. The MDL is essentially equal to the critical level. The critical level is where detection is considered positive, with an allowable false positive result of less than 1%. So the MDL is a value at which an analyte can be detected with at least 99% accuracy. MDL's are evaluated using pure water blanks (water that contains extremely low or no analytes). In other words, MDL's are evaluated using the purest water available under the most ideal conditions. At no time is the MDL higher than the RL.

Water occurring in the environment, whether it be process or natural waters are generally far from pure. A relatively high number of false positives occur when analyzing a sample because of the additional analytes. This reduces the confidence level, and raises the MDL for a particular value. Actual detection levels then for water quality samples from ponds, surface water and wells are just above the point where a sample distribution barely intersects the blank sample distribution. Water with a high concentration of analytes tend to broaden the sample distribution and raise the level at which individual analytes can accurately be detected. This is referred to as matrix interference. The higher the degree of matrix interferences, the higher the detection limit will be for a given sample.

Practical quantitation limits (PQL) are the lowest level that can be consistently achieved during routine laboratory conditions. The PQL is typically about two to five times the MDL (Van Buuren, B.H., 2011). The PQL may also be set at a level up to 10 times (one order of magnitude) higher than the MDL. A table listing available reporting limits through time, and recent MDL's evaluated at the analytical laboratory are contained in Appendix F.

Water samples from the Colstrip SES exhibit a wide degree of concentrations of chemical constituents which frequently result in variations in the MDL and the RL. Samples that

exhibit elevated levels of constituents may require a dilution. Dilutions are prepared by mixing the sample water with a known quantity of deionized water. Laboratory sample dilution raises the reporting limit.

2.3 POND SEEPAGE ESTIMATES

An estimate of seepage to groundwater was made for 13 ponds on the Plant Site. These ponds are listed in Table 2-4 and include only those ponds that are currently in operation or have the potential to impound stormwater that may result in seepage. In several cases, specific Plant Site ponds have been removed from service or their designated service or function has changed. For example, the Units 1&2 Wash Tray Pond served as a scrubber pond from 1975 to 1980; it was abandoned in 1980 after a separate loop for the scrubber wash tray was determined to be unnecessary. The area occupied by the abandoned pond was converted to the 1&2 Bottom Ash Pond in 1988. A complete list of Plant Site ponds, including those that have been abandoned was presented previously in Table 2-1.

The list of current Plant Site ponds, for which seepage estimates were made (Table 2-4), includes ponds lined with either earthen materials (i.e. clay) or geo-synthetic liners (geomembranes). Geomembrane liners in place at Plant Site ponds are constructed of Hypalon, high density polyethylene (HDPE), or reinforced polypropylene (RPP). Further, geomembrane-lined ponds on the Plant Site consist of either a single liner or a double-liner system. Practical engineering methods specific to each liner type (earthen or geomembrane) were used to make a head-dependent calculation of seepage to groundwater from each pond. Analytical methods presented by Bouwer (1982) were used to estimate seepage from ponds lined with earthen materials (i.e. clay); and empirical equations developed by Giroud et. al. (1992, 1994, and 1997) were used to estimate seepage from ponds with single or double geomembrane liners. Parameter input for the three methods/liner types is variable; thus, seepage estimates for Plant Site ponds are listed in Table 2-5A for earthen-lined ponds, Table 2-5B for ponds with double liner systems, and Table 2-5C for ponds with single composite geomembrane liners. Pond dimensions, water levels, and parameter assignments used in the seepage estimates are included in the tables.

TABLE 2-4
COLSTRIP STEAM ELECTRIC STATION
ADMINSTRATIVE ORDER ON CONSENT
PLANT SITE PONDS USED IN SEEPAGE ESTIMATES

Waste Water Facility	Years in-service	Liner Type
Units 1&2 Flyash Pond A side (west)	1975 - present	Clay
Units 1 & 2 Bottom Ash Pond	1975 - present	Clay
Units 1 & 2 Cooling Tower Blowdown North Pond (Pond C North)	1978 - present	Clay
Units 1 & 2 Cooling Tower Blowdown South Pond (Pond C South)	1978 - present	Clay
Units 3 & 4 Wash Tray Pond	1983 - 1995	Clay
Units 3 & 4 Scrubber Drain Collection Pond. (DC Pond)	1983 - 1999	Clay
Units 3 & 4 Bottom Ash Pond w/ Clearwell	1983 - present	Clay
Units 1 - 4 North Plant Sediment Retention Pond	1975 - present	Clay
Units 1&2 Flyash Pond, B Pond	1975 - present	Geomembrane -- Double Liner
Units 1 & 2 Bottom Ash Pond Clearwell	1975 - present	Geomembrane -- Double Liner
Units 3 & 4 Auxiliary Scrubber Drain Pond (Duck Pond)	1983 - present	Geomembrane - Single Composite
Units 3 & 4 North Plant Area Drain Pond	1984 - present	Geomembrane - Single Composite
Units 1 - 4 Sediment Retention Pond (Thompson Lake)	1975 - present	Geomembrane - Single Composite

TABLE 2-5A
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
SEEPAGE ESTIMATES FROM PLANT SITE PONDS WITH EARTHEN (CLAY) LINERS

Waste Water Facility	Years in-service	Total Capacity	[1]Area	Total Capacity	Area	Head on Liner (H_w)	[2]K_c	K_c	L_c	h_i	v_i	[3]Q
		(acre-feet)	(acres)	(ft^3)	(ft^2)	(ft)	ft/yr	ft/day	(ft)	(feet)	ft/day	(gpm)
Units 1&2 Flyash Pond A side (west)	1975 - present	245	14	10,672,200	609,840	14.5	0.525	0.00144	3	0	0.008	27
Units 1 & 2 Bottom Ash Pond	1975 - present	12	2	522,720	87,120	6	0.525	0.00144	3	0	0.004	2
Units 1 & 2 Cooling Tower Blowdown North Pond (Pond C North)	1978 - present	195	10	8,494,200	435,600	11.6	0.525	0.00144	3	0	0.007	16
Units 1 & 2 Cooling Tower Blowdown South Pond (Pond C South)	1978 - present	205	10.5	8,929,800	457,380	16.6	0.525	0.00144	3	0	0.009	22
Units 3 & 4 Wash Tray Pond	1983 - 1995	85	8	3,702,600	348,480	1	0.525	0.00144	3	0	0.002	3
Units 3 & 4 Scrubber Drain Collection Pond. (DC Pond)	1983 - 1999	72	6	3,136,320	261,360	1	0.525	0.00144	3	0	0.002	3
Units 3 & 4 Bottom Ash Pond w/ Clearwell	1983 - present	38.4	7.6	1,672,704	331,056	5	0.525	0.00144	3	0	0.004	7
Units 1 - 4 North Plant Sediment Retention Pond	1975 - present	4	0.6	174,240	26,136	6.66	0.525	0.00144	3	0	0.005	1
											Q_{total}	***80***

Notes:

[1]For all cells, area is assumed to be all area within impoundment berm.

[2]Hydraulic conductivity of 0.525 ft/yr is conservative estimate to account for unknown variables in pond liner construction and increases in hydraulic conductivity due fractures and/or reduced clay swelling by high TDS water. Lab results ranged from 0.01 to 0.05 ft/year; thus, assignment of 0.525 ft/yr to hydraulic conductivity parameter will result in conservative (large) estimate of seepage.

[3]Calculated using equation of Bouwer (1982) to obtain seepage velocity. Volumetric rate is product of seepage velocity and pond area.

Units 1&2 Flyash Pond A side (west): Pond constructed with minimum clay thickness of 3' in portions of pond bottom. Alluvial channels in pond bottom removed and replaced with clay. Estimated 25 feet of siltstone/shal beneath pond. This section of the pond was removed from scrubber service in May of 2005. It is currently being used as a clean water storage pond (stormwater runoff, etc). Pond water level is measured weekly. Average water level elevation in 2014 is 3257 feet. Maximum fill elevation is 3260 feet. Pond maximum depth is 17.5 feet; thus, head on pond liner is 14.5 feet in 2014. Initial seepage estimate made for this pond was 1 gpm (Botz, 1978) and included Pond A, Pond B, the Clearwell, and the Units 1&2 Wash Tray Pond.

Units 1&2 Bottom Ash Pond: Head in pond assumed to be 6 feet based on pond capacity and area. Minimum of three feet of clay liner specified in construction.

Units 1 & 2 Cooling Tower Blowdown Pond (Pond C): Initial seepage estimate of 15 gpm included seepage from north and south ponds (Botz, 1978).

Pond C North: Pond constructed on compacted silt/clay. Thickness unknown; assumed to be 3 feet. Pond water level is measured weekly. Average water level elevation in 2014 is 3261.1 feet (January through October). Maximum fill elevation is 3269 feet. Pond maximum depth is 19.5 feet; thus, head on pond liner is 11.6 feet in 2014.

Pond C South: Pond constructed on compacted silt/clay. Thickness unknown; assumed to be 3 feet. Pond water level is measured weekly. Average water level elevation in 2014 is 3266 feet (January through October). Maximum fill elevation is 3269 feet. Pond maximum depth is 19.5 feet; thus, head on pond liner is 16.55 feet in 2014.

Units 3 & 4 Wash Tray Pond: Originally served as a scrubber pond for the wash tray loop. This pond was abandoned in 1995 when a separate loop for the scrubber wash tray was determined to be unnecessary. The pond remains, but is no longer utilized. Seepage estimate based on Bouwer (1982). Permeability of clay liner from Bechtel (1976). Head on liner assumed to be one foot, as some standing water almost always present in this pond.

Units 3 & 4 Scrubber Drain Collection Pond. (DC Pond): Received miscellaneous scrubber plant drains, washdown, and scrubber slurry at times. In 1989, three inches of clay were added to the existing three-foot clay liner and the east and south banks were shored up to address dredging and bank erosion issues. In 1999, this pond was abandoned and the scrubber drains/washdown was sent to the 3&4 EHP. The pond remains, bu is no longer utilized, except to store runoff from the coal pile and surrounding area. Pond is typically dry but may contain approximately one foot of head following periods of heavy precipitation.

Units 3 & 4 Bottom Ash Pond w/ Clearwell: Collection area for bottom ash and main plant sumps. Clearwater flows into the clearwell section of this pond and is returned to the plant bottom ash system for re-use. In 1991 the initial settlement cells of this pond were relined with clay and reshaped.

Units 1 - 4 North Plant Sediment Retention Pond: Receives surface drainage from north plant and warehouse areas. Head in pond estimated to be 6.66 feet based on capacity divided by area.

Equations:

$$v_i = K_c \frac{H_w + L_c - h_i}{L_c}$$ *leakage rate through liner, assumes rectangular geometry (most conservative)*

$$Q_{cell} = v_i * A$$ *volumetric leakage rate per cell/pond (ft^3/day); converted to gpm.*

where:
vi = seepage rate (ft/day)
Kc = hydraulic conductivity of clay liner (ft/day)
Hw = head, water depth on top of clay liner (ft)
hi = head at bottome of clay layer (ft), assumed to be zero
Lc= thickness of clay liner (ft)
A = area of pond (ft^2)

Example (for Units 1&2 Flyash Pond A):

$$v_i = K_c \frac{H_w + L_c - h_i}{L_c} = 0.00144 \frac{ft}{day} * \frac{14.5ft + 3ft - 0ft}{3ft} = 0.0084 ft/day$$

$$Q_{cell} = v_i * A = 0.0084 \frac{ft}{day} * 609{,}840 ft^2 = 5122.7 \frac{ft^3}{day}$$

(convert Q_{cell} to gpm);

$$5122.7 \frac{ft^3}{day} * \frac{7.48 gallon}{ft^3} * \frac{1 day}{1440 minutes} = \mathbf{26.6 gpm}$$

TABLE 2-5B
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
SEEPAGE ESTIMATES FROM PLANT SITE PONDS WITH DOUBLE GEOMEMBRANE LINER SYSTEMS

Pond Parameters/Dimensions								Seepage Estimates by Liquid Permeation through primary liner		Seepage Calculations through Defects in Primary Liner. Preliminary calculations to evaluate head on secondary liner.									
Waste Water Facility	Years in-service	Total Capacity (acre-feet)	Area (acres)[1]	Total Capacity (ft^3)	Area (ft^2)[1]	Head (ft)	Head (m)	Water Vapor Permeance (Perms)[2] (grain/ft^2*hour*inHg)	Qp gal/min	a (in^2)	a (m^2)	^{3}Qd m^3/s	^{3}Qd ft^3/s	F m^{-2}	qi m/s	L m	k_2 m/s	β deg.	$^4h_2$ m
Units 1&2 Flyash Pond, B Pond	1975 - present	196	10	8,537,760	435,600	24	7.32	0.12	0.32	0.155	1.0E-04	7.19E-04	2.5E-02	2.5E-03	2.E-06	390	0.1	1	2.3E-03
Units 1 & 2 Bottom Ash Pond Clearwell	1975 - present	49	3	2,134,440	130,680	16	4.88	0.12	0.06	0.155	1.0E-04	5.87E-04	2.1E-02	2.5E-03	1.E-06	100	0.1	1	4.7E-04

Pond Parameters/Dimensions								Seepage Estimates by Liquid Permeation through secondary liner		Seepage Calculations through Defects in Secondary Liner. Final Seepage calculations for double-lined ponds.											
Waste Water Facility	Years in-service	Total Capacity (acre-feet)	Area (acres)[1]	Total Capacity (ft^3)	Area (ft^2)[1]	Head (h_2) (ft)	Head (h_2) (m)	Water Vapor Permeance (Perms)[2] (grain/ft^2*hour*inHg)	Qp gal/min	K_s (ft/yr)	K_s (m/s)	a^5 (m^2)	^{6}ts (ft)	^{6}ts (m)	$I_{avg}{}^2$ --	**Q_d (m^3/sec)	**Q_d (ft^3/sec)	n^5 10 / 43,055.6 ft^2	**Q_{cell} (ft^3/sec)	**Q_{cell} (gpm)	**Qtotal (gpm)
Units 1&2 Flyash Pond, B Pond	1975 - present	196	10	8,537,760	435,600	2.25E-03	6.9E-04	0.12	3.0E-05	0.525	5.1E-09	1.0E-04	3	0.91	1.0	4.74E-10	1.67E-08	101	1.69E-06	7.60E-04	**7.9E-04**
Units 1 & 2 Bottom Ash Pond Clearwell	1975 - present	49	3	2,134,440	130,680	4.71E-04	1.4E-04	0.12	1.9E-06	0.525	5.1E-09	1.0E-04	3	0.91	1.0	1.16E-10	4.09E-09	30	1.24E-07	5.58E-05	**5.76E-05**
									3.15E-05	--	--	--	--	--	--	--	--	--	--	--	***8.5E-04***

Notes on Pond and/or Seepage Estimate

Units 1&2 Flyash Pond B Pond: Pond was originally clay-lined; double-lined RPP with leachate collection system installed in 2004. Seepage estimate is for double liner system underlain by clay soil. Water level measured on a weekly basis at this pond. Average water level elevation for 2014 (January - October 2014) is 3259.879. Maximum water level elevation is 3260 feet. PPL assumes 360,962 ft^3/ft of vertical pond elevation; total pond capacity divided by 360,962 ft^3/ft is 24 feet of head at max.

Units 1 & 2 Bottom Ash Pond Clearwell: Pond was clay-lined originally, double-lined RPP with leachate collection system installed in 2006. Seepage estimate is for double liner system underlain by clay soil. Head is based on max fill level calculated by dividing total pond capacity by pond area.

[1]For all cells, area is assumed to be all area within impoundment berm.
[2]Permeance of RPP liners typically 0.05 to 0.1 perms. Conservative valuve of 0.12 perms assigned to calculation.
[3]Calculated using Bernoulli's equation for free flow through orifice. Most conservative flow assumption for upper liner layer. Giroud et al. (1997)
[4]Calculated using equations of Giroud et al. (1997) for adjusted head on secondary liner.
[5]Assumes ten 1 cm^2 diameter defects per 4,000 m^2 (43,066.6 ft^2). Two defects per 4000 cm^2 is conservative estimate for landfill liner evaluation (Giroud et al. 1994).
[6]Assumes 3 feet of low permeability silt/clay beneath each pond liner.
**Assumes quality of liner contact is poor for all estimates. Factor C_q = 1.15

Conversion factors

gc1	density	gc2	gc3
grains/lb	lb/gal	inHg/ft $H_2$0	hour/min
7000	8.34	0.88265	0.0167

Equations for Seepage through Liner Defects:

$Q_d = 0.6*a\sqrt{2gh}$ — *Free flow through orifice (Bernoulli's Equation)*

$q_i = F * Qd$ — *unit rate of leachate migration through primary liner defect*

$h_2 = \frac{q_i * L}{2k_2 tan\beta}$ — *Adjusted head on secondary liner, Giroud et al. (1997)*

$i_{avg} = 1 + 0.1\left(\frac{h}{t_s}\right)^{0.95}$ — *analytical expression for average hydraulic gradient for ponds with head ≤ 3 m (~10 ft); Giroud et al (1997)*

$Q_d = C_q * i_{avg} * a^{0.1} * h^{0.9} * K_s{}^{0.74}$ — *Seepage through single circular liner defect, Giroud (1997)*

$Q_{cell} = Q_d * n$ — *Total seepage through all pond defects*

Calculation of Seepage Liquid Permeation through Liner:

$$Q_p = 0.12(grain/ft^2 * hour * inHg) \div 7000\left(\frac{gr}{lb}\right) \div 8.34\left(\frac{lb}{gal}\right) * 0.88265\left(\frac{inHg}{ftH_2O}\right) * 0.0167\left(\frac{hour}{min}\right) * A(ft^2) * h(ft)$$

$$Q_{total} = Q_{cell} + Q_p$$

where:

Qd = leakage rate per defect (applies to both primary and secondary liners)
qi = unit rate of seepage through defects
g = gravitational acceleration (9.81 m/s^2)
L = horizontal projection of length of liner system in direction of slope (m)
K_2 = hydraulic conductivity of between liner leachate collection system
β = slope angle of the liner system (assumed to be 1 degree)
F = frequency of liner defects (10/4,000 m^2 = 0.0025/m^2)

Qcell = leakage rate per lined cell/pond
n = number of defects per cell, assumes 10 defects per 4,000 m^2 (43,066.6 ft^2)
i_{avg} = average hydraulic gradient (unitless). i_{avg} = one, where head on liner is less than thickness of underlying clay layer.
h = head above liner (m), refers to either primary liner in Bernoulli's equation and secondary liner in Giroud's equation
ts = thickness of low permeability soil beneath liner (m)
a = area of defect (m^2)
C_q = Contact quality factor (assumed to be 1.15 for poor contact)
K_s = hydraulic conductivity of clay soil beneath liner

Qp = seepage by permeation (gpm)
A =Area of cell or pond (ft^2)
h=head on liner (ft)
Qtotal = total seepage through cell by permeation and defects.

Example (for Units 1 & 2 Flyash Pond B):

A = 10 Acres; 435,600 ft^2
Ks = 0.525 ft/day (5.1E-9 m/sec)
K_2 = 0.1 m/s
h = 24 ft, 7.32 m
Cq = 1.15

n=10 *a = 0.155 in^2 (1.0 x 10^{-4} m^2)* *Permeance = 0.12(grain/ft^2 *hour*inHg)*
ts = 3 ft (0.91 m)
b = 0.564 cm (0.00564 m)
i_{avg} = 1

$Q_d = 0.6*a\sqrt{2gh}$ = $0.6*0.0001m^2\sqrt{2 * 9.81\frac{m}{s^2} * 7.34m}$ =7.19 x 10^{-4} m^3/s

$q_i = F * Qd = \frac{0.0025}{m^2} * 7.19x\ 10^{-4}$ m^3/s = 2 x 10^{-6} m/s

$h_2 = \frac{q_i * L}{2k_2 tan\beta} = \frac{2\text{ x }10\text{–}6\text{ m/s} * 390\ m}{2 * \frac{0.1m}{s} * tan(1^0)}$ = 2.3 x 10^{-3} m

$Q_d = 1.15 * 1 * (1e-4)^{0.1} m^2 * (2.3x10^{-3})^{0.9} m * 5.1E^{-9}\ m/\sec = 4.74x10^{-10}\ \frac{m^3}{sec} x\ \frac{35.31ft^3}{m^3} = 1.67e^{-8}\frac{ft^3}{s}$

$Q_{cell} = Q_d * n = 1.67E^{-8}\frac{ft^3}{sec} * 10\frac{defect}{40{,}066\ ft^2} * 435{,}600\ ft^2 = 1.69E^{-6}\frac{ft^3}{sec}$

(convert Q_{cell} to gpm);

$1.69E^{-6}\frac{ft^3}{sec} * \frac{60\ sec}{1\ min} * \frac{7.48gallon}{1ft^3}$ = 7.6 x 10^{-4} gpm

$$Q_p = 0.12(grain/ft^2 * hour * inHg) \div 7000\left(\frac{gr}{lb}\right) \div 8.34\left(\frac{lb}{gal}\right) * 0.88265\left(\frac{inHg}{ftH_2O}\right) * 0.0167\left(\frac{hour}{min}\right) * 435{,}600ft^2 * 2.25\ x10-3ft = 3\ x\ 10-5\ gpm$$

$Q_{total} = 3\ x\ 10-5\ gpm + 7.6$ x 10 –4 $gpm =$ **7.9 x 10^{-4}**

TABLE 2-5C
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
SEEPAGE ESTIMATES FROM PLANT SITE PONDS WITH SINGLE COMPOSITE GEOMEMBRANE LINERS

Pond Parameters/Dimensions								Seepage Estimates by Liquid Permeation[2]		Seepage Calculations through Defects in Geomembrane Liner[4]											
Waste Water Facility	Years in-service	Total Capacity (acre-feet)	Area (acres)[1]	Total Capacity (ft^3)	Area (ft^2)[1]	Head (ft)	Head (m)	Water Vapor Permeance (Perms)[2] (grain/ft^2*hour*inHg)	Qp gal/min	K_s (ft/yr)	K_s (m/s)	a (in^2)	a (m^2)	ts[4] (ft)	ts (m)	I_{avg}[5] --	**Q_d (m^3/sec)	**Q_d (ft^3/sec)	n[3] / 43,055.6	**Q_{cell} (ft^3/sec)	**Q_{cell} (gpm)	**Qtotal (gpm)
Units 3 & 4 Auxiliary Scrubber Drain Pond (Duck Pond)	1983 - present	0.51	0.23	22,216	10,019	2.2	0.67	0.12	0.001	0.525	5.1E-09	0.155	1.0E-04	3	0.91	1.07	2.50E-07	8.83E-06	2	2.05E-05	9.22E-03	9.88E-03
Units 3 & 4 North Plant Area Drain Pond	1984 - present	4.5	1.0	196,020	43,560	4.5	1.37	0.12	0.006	0.525	5.1E-09	0.155	1.0E-04	3	0.91	1.15	5.08E-07	1.79E-05	10	1.82E-04	0.08	0.09
Units 1 - 4 Sediment Retention Pond (Thompson Lake)	1975 - present	16	3.6	696,960	156,816	4.5	1.37	0.12	0.021	0.525	5.1E-09	0.155	1.0E-04	3	0.91	1.15	5.08E-07	1.79E-05	36	6.53E-04	0.29	0.31
			4.8					Q_{total}	***0.028***				--	--	--	--	--	--	--	--	***0.384***	***0.412***

Notes on Pond and/or Seepage Estimate

Units 3 & 4 Auxiliary Scrubber Drain Pond (Duck Pond) Liner is Hypalon. Seepage estimate is for composite liner consisting of single geomembrane layer underlain by clay soil. Head is based on capacity divided by pond area.

Units 3 & 4 North Plant Area Drain Pond: Pond was originally lined with Hypalon; pond is now lined with High Density Polyethylene (HDPE). Seepage estimate is for composite liner consisting of single geomembrane layer underlain by clay soil. Head is based on pond capacity divided by pond area.

Units 1 - 4 Sediment Retention Pond (Thompson Lake): Originally Hypalon lined, then relined with High Density Polyethylene (HDPE) in 1989. Seepage estimate is for composite liner consisting of single geomembrane layer underlain by clay soil. Head is based on pond capacity divided by pond area.

[1]For all cells, area is assumed to be all area within impoundment berm.

[2]Permeance of RPP liners typically 0.05 to 0.1 perms. Conservative valuve of 0.12 perms assigned to calculation.
[3]Assumes ten 1 cm^2 diameter defects per 4,000 m^2 (43,066.6 ft^2). Two defects per 4000 cm^2 is conservative estimate for landfill liner evaluation (Giroud et al. 1994).
[4]Assumes 3 feet of low permeability silt/clay beneath each pond liner.
[5]Calculated using equations of Giroud (1997).
**Assumes quality of liner contact is poor. Factor C_q = 1.15

Conversion factors perms to gpm

gc1	density	gc2	gc3
grains/lb	lb/gal	inHg/ft H_2O	hour/min
7000	8.34	0.88265	0.01667

Equations for Seepage through Liner Defects:

$$i_{avg} = 1 + 0.1\left(\frac{h}{t_s}\right)^{0.95}$$ *analytical expression for average hydraulic gradient for ponds with head ≤ 3 m (~10 ft); Giroud et al (1997)*

$$Q_d = C_q * i_{avg} * a^{0.1} * h^{0.9} * K_s{}^{0.74}$$ *volumetric leakage rate per circular defect, m^3/sec. Giroud et al (1992 and 1997)*

$$Q_{cell} = Q_d * n$$ *volumetric leakage rate per cell (from defects)*

Equations for Seepage by Liquid Permeation through Liner:

$$Q_p = 0.12(grain/ft^2 * hour * inHg) \div 7000\left(\frac{gr}{lb}\right) \div 8.34\left(\frac{lb}{gal}\right) * 0.88265\left(\frac{inHg}{ftH_2O}\right) * 0.0167\left(\frac{hour}{min}\right) * A(ft^2) * h(ft)$$

$$Q_{total} = Q_{cell} + Q_p$$

where

i_{avg} = average hydraulic gradient (unitless)
h = head above liner (m)
ts = thickness of low permeability soil beneath liner (m)
b = diameter of defect (m)
ε = Giroud parameter (unitless); from Giroud et al. (1992)
R = wetted radius beneath defect (m)
K_s = hydraulic conductivity of clay soil beneath liner
Qd = leakage rate per defect
n = number of defects per cell, assumes 10 defects per 4,000 m^2 (43,066.6 ft^2)
Qcell = leakage rate per lined cell/pond
C_q = Contact quality factor (1.15 for poor)
A = area of pond (ft^2)
h = hydraulic head on pond liner (ft)
Qtotal = total seepage through liner by permeation and defects.

Example (for Units 1 -4 Sediment Retention Pond):

A = 3.6 Acres; 156,816 ft^2 *h = 4.5 ft, 1.37 m* *n=10* *a = 0.155 in^2 (1.0 x 10^{-4} m^2)* *Permeance = 0.12(grain/ft^2 *hour*inHg)*
Ks = 0.525 ft/day (5.1E-9 m/sec) *Cq = 1.15* *ts = 3 ft (0.91 m)*

$$i_{avg} = 1 + 0.1\left(\frac{1.37}{0.91}\right) = 1.15$$

$$Q_d = 1.15 * 1.15 * (1e-4)^{0.1} m^2 * 1.37^{0.9} m * 5.1E^{-9}\ m/\sec = 5.08x10^{-7}\ \frac{m^3}{sec} x \frac{35.31 ft^3}{m^3} = 1.79x10-5 \frac{ft^3}{s}$$

$$Q_{cell} = Q_d * n = 1.79x10^{-5}\ \frac{ft^3}{sec} * 10 \frac{defect}{40{,}066\ ft^2} * 156{,}816\ ft^2 = 6.53x10^{-4}\ \frac{ft^3}{sec}$$

(convert Q_{cell} to gpm);

$$6.53x10^{-4}\ \frac{ft^3}{sec} * \frac{60\ sec}{1\ min} * \frac{7.48 gallon}{1 ft^3} = \textbf{0.29 gpm}$$

$$Q_p = 0.12(grain/ft^2 * hour * inHg) \div 7000\left(\frac{gr}{lb}\right) \div 8.34\left(\frac{lb}{gal}\right) * 0.88265\left(\frac{inHg}{ftH_2O}\right) * 0.0167\left(\frac{hour}{min}\right) * 156{,}816(ft^2) * 4.5(ft) = 0.021 \text{ gpm}$$

$$Q_{total} = 0.29\ gpm + 0.021\ gpm = \textbf{0.31 gpm}$$

Seepage estimates for all ponds are dependent on the amount of head (hydrostatic pressure) on the liner. PPLM monitors water levels in the Units 1&2 Flyash A Pond and B Pond and the Units 1&2 Cooling Tower Blowdown Ponds (Pond C North and South) on a weekly basis to maintain an inventory of available storage capacity in ponds that actively service plant operations. The ponds that are monitored weekly are not only the largest ponds on the Plant Site but also those with the highest operating head; thus, they have the greatest potential for seepage. Average water levels recorded in 2014 (January 1 through October 31) were assigned to seepage calculations for these four ponds. Head and water level elevations for Pond C North and South, and A Pond are included in Table 2-5A. Head in the Units 1&2 Flyash B Pond are included in Table 2-5B.

The remainder of the Plant Site ponds that are currently in operation were assumed to be full for the sake of the seepage calculations; and heads were estimated by dividing pond capacity by pond area. For example, head in the Units 3&4 North Plant Area Drain Pond was estimated to be 4.5 feet based on the total capacity of 4.5 acre-feet and the area of 1 acre (Table 2-5C). The Units 3&4 Wash Tray Pond and Scrubber Drain Collection Pond are no longer in service but are still present on the Plant Site. Although they are not used to store process water, the potential exists for stormwater to percolate through the bottom of these clay-lined ponds. Water levels in the Units 3&4 Scrubber Drain Collection Pond (DC Pond) typically range from dry to isolated puddles of standing water at low points in the bottom of the pond. A head of one foot was assumed uniformly distributed over the entire DC Pond area to obtain a conservative estimate of seepage from this pond. The distribution of standing water in the Units 3&4 Wash Tray Pond is similar to that of the DC Pond; but the Wash Tray Pond typically contains at least some water (i.e. is never completely dry). For the seepage calculation, one foot of head was assumed in the Units 3&4 Wash Tray Pond.

In general, parameters assigned to seepage calculations for clay-lined or geomembrane-lined ponds were chosen to obtain conservative estimates of seepage rates. As often implied in engineering, conservative estimates are made to intentionally predict the extreme outcome within a reasonable range of results. It is appropriate to assign values of parameters that will

result in conservative estimates when there is uncertainty in the actual value of a parameter needed for a given calculation/equation. In this evaluation of Plant Site ponds, conservative assumptions were made to predict seepage rates that are on the high end of potential results. Parameterization of pond seepage calculations, a discussion of parameter uncertainty, and results of seepage calculations for clay-lined and geomembrane-lined ponds are presented as follows.

Clay-Lined Ponds

Seepage from clay-lined ponds was estimated using the form of the Darcian flow equation presented by Bouwer (1982). Under seeping conditions, the clay liner itself is saturated and the following equation applies:

$$v_{i=K_c}\frac{H_w+L_c-h_i}{L_c}$$

where

v_i = seepage rate (length/time)

H_w = water depth above liner (length)

K_c = saturated hydraulic conductivity of earthen liner (length/time)

L_c = thickness of earthen liner (length)

h_i = pressure head of water at bottom of liner (length)

In addition to the equation presented above, Bouwer (1982) submits two alternative equations for seepage through ponds that consider: 1.) trapezoidal pond dimensions; and 2.) accumulation of sediment or other materials on the pond bottom. Neither of these equations are appropriate for the current seepage evaluation for the reasons discussed as follows.

1. The form of the equation that considers trapezoidal geometry introduces more parameter uncertainty into the seepage calculation and is contrary to the objective of providing a conservative seepage estimate. If a given pond is sufficiently wide compared to the depth of water it contains, most of the seepage will occur through the pond bottom. In this case, the form of the equation presented above will yield essentially the same result as seepage for the entire pond (Bouwer, 1982). All of the

ponds considered in this seepage evaluation have widths that far exceed their depth. In the current seepage estimate (Table 2-5A), the entire area of the pond—not just the pond bottom—is included.

2. The form of the equation that considers accumulation of sediment in ponds was developed to account for materials that have a sufficiently low hydraulic conductivity to further restrict seepage beyond control offered by material (clay) used to construct the pond bottom (Bouwer, 1982). The ponds considered in this seepage evaluation do not accumulate sediment or other materials that are less or equivalently hydraulically conductive than the clay liners themselves. The only clay-lined ponds that contain flyash are the Units 3&4 Wash Tray Pond and Scrubber Drain Collection Pond. The hydraulic conductivity of the clay liner in these ponds is assumed to be 0.525 ft/year (0.0014 ft/day, or 5 x 10^{-7} cm/sec) in the seepage calculations. The hydraulic conductivity of coal flyash is well documented (EPRI, 1992) and typically ranges between 1 x 10^{-4} and 1x10^{-7} cm/sec. Bottom ash is accumulated in the Units 3&4 Bottom Ash Pond; but bottom ash has an even greater hydraulic conductivity than flyash. Because the hydraulic conductivity of flyash and bottom ash is equal to or greater than that of the clay liner, the liner and not the ash, controls the rate of seepage through the ponds.

In the equation presented above (Bouwer, 1982), the seepage velocity is a function of hydraulic conductivity of the clay liner, head on the clay liner, and pressure head in the unsaturated soil at the base of the clay liner. In a cyclical relationship, soil water pressure in the unsaturated soil is dependent on the amount of seepage that flows through the liner. When conditions at the base of the liner are dry (such as during the initial period of pond operation), pressure head is negative. Negative soil water pressure results in an increase in the overall head term in the equation presented above; however, the unsaturated hydraulic conductivity of the underlying soil declines to a rate that is very small compared to its saturated hydraulic conductivity under very dry conditions (Bouwer, 1982). The actual relationship between soil moisture and soil water pressure for a given soil is typically determined experimentally by creating a soil water characteristic curve. Soil water characteristic curves are not available for strata underlying the Plant Site ponds. However,

after many years of operation, the most likely condition present at the Plant Site ponds is that soil water pressure has become negligible as sediments have been increasingly wetted due to assumed percolation during pond operation. In attempt to make a steady-state estimate of seepage, pressure head of the soil beneath the clay lined ponds was assumed to be zero; thus, the overall seepage of a given pond is a function of the hydraulic conductivity of the clay liner and the ratio of head above the liner to total liner thickness.

The hydraulic conductivity and thickness of materials used in the construction of clay-lined ponds were parameterized in seepage calculations based on early construction drawings (Bechtel, 1974) and the description of Botz (1978). A locally derived silt/clay material was used to line the clay-lined Plant Site ponds. Laboratory results indicated that the coefficient of permeability (hydraulic conductivity) of material used in the clay liner was 0.01 to 0.05 ft/year (9.6×10^{-9} to 8.4×10^{-8} cm/sec). The range of hydraulic conductivities reported for the soils is consistent with typical values for either unconsolidated clay or siltstone bedrock. K values for unconsolidated clay and siltstone sedimentary bedrock range from 1×10^{-9} to 1×10^{-6} cm/sec (Duffield 2007). Other factors that may influence the hydraulic conductivity of the earthen-lined ponds include the potential for desiccation cracks, fracturing in native bedrock, and/or reduced swelling of clay liners caused by increased concentrations of dissolved ionic constituents. None of these factors are well parameterized in the current understanding of pond liner construction. To make a conservative seepage estimate, hydraulic conductivity of the silt/clay liner material was assigned a value in the calculation that is at least an order of magnitude higher than laboratory results. A K value of 0.525 ft/year (5×10^{-7} cm/sec) was assigned to the clay liners in the seepage estimates for all ponds.

A pond liner thickness of three feet was assigned to each of the clay-lined ponds constructed on the Plant Site to service Units 1&2, as this was the minimum specified thickness used in construction of the original Units 1&2 Bottom Ash Pond (and Clearwell), Units 1&2 Flyash Ponds (A and B Ponds), and Units 1&2 Wash Tray Pond (Bechtel, 1974). The Units 1&2 Flyash Pond (A and B Ponds) was not uniformly covered with the three-foot clay layer. The three-foot minimum liner was installed on the sides of the pond; and ancestral alluvial channels that were present in the pond bottom were removed and backfilled with compacted

clay. Where siltstone/shale was already present on the pond bottom, it was compacted and left in place but not covered with additional clay materials. The estimated thickness of the siltstone layer was 25 feet (Botz 1978). The Units 1&2 Cooling Tower Blowdown Ponds (north and south) were constructed on compacted native silt-clay soil/sedimentary bedrock. The exact thickness of the underlying siltstone is unknown; but well logs for wells completed around the perimeter of the pond (e.g. 6D and 9M) suggest a minimum of 15 feet of siltstone. Thus, a conservative seepage estimate is made by assuming a thickness of only three feet.

The Units 3&4 Wash Tray Pond and Scrubber Drain Collection Pond were originally constructed to service the Units 3&4 scrubber loop. Each of these ponds is still in existence but has since been removed from service. As noted above, a minimal amount of head is present in the unused ponds. Each of these ponds was constructed using a minimum three-foot clay liner, as specified in the final as-built drawings (Bechtel, 1993). A thickness of three feet was included in the seepage calculation. As noted in Table 2-1, an additional three inches of clay were added to the DC pond in 1989.

Similar to the construction of the Units 1&2 Colling Tower Blowdown Pond, The Units 3&4 Bottom Ash Ponds and the Units 1-4 North Plant Sediment Retention Pond were constructed on compacted native fill; so values of thickness and hydraulic conductivity consistent with the rest of the earthen-lined ponds were assumed.

Estimates of seepage velocity made using the equation and parameters listed above for clay-lined ponds on the Plant Site are presented in Table 2-5A. To convert the seepage velocity to a volumetric flow rate, the result for each pond was multiplied by pond area. Seepage estimates for clay-lined ponds range from 1 gpm at the 0.6-acre Units 1-4 North Plant Sediment Retention Pond to 27 gpm at the Units 1&2 Flyash Pond A. The cumulative estimate of seepage from clay-lined ponds in 2014 is 80 gpm.

Geomembrane-Lined Ponds

A geomembrane is a thin, flexible, low permeability material that is used as a fluid barrier (Giroud and Bonaparte, 1989). Ponds that have a geomembrane or dual geomembrane

components have a much lower seepage potential than ponds constructed of earthen material alone; and the mechanisms for seepage through geomembrane liners differ from that through clay liners. The mechanisms of seepage through a liner system constructed with a geomembrane include permeation through the intact geomembrane liner and seepage through geomembrane defects. As noted previously, geomembrane liners at the PPLM Plant Site are constructed of Hypalon, HDPE, or RPP. Geomembranes are installed on the Plant Site as part of either a composite liner or a double liner system.

A composite liner is a single liner comprised of two or more low-permeability components in contact with each other (Giroud and Bonaparte, 1989). Ponds with composite liners on the PPLM Plant Site are the Units 3&4 Auxiliary Scrubber Drain Pond, Units 3&4 North Plant Area Drain Pond, and Units 1 – 4 Sediment Retention Pond. Each of these ponds is constructed with a geomembrane component overlaying a compacted soil with low hydraulic conductivity. A double liner system includes two liners with a drainage layer to detect, collect, and remove liquids between the two liners (Giroud and Bonaparte, 1989). The Units 1&2 Flyash Pond B and Bottom Ash Pond Clearwell are constructed with double-liner systems. The double liner system at each of these two ponds consists of a 45 mil RPP primary liner, a geo-net/felt fabric drainage layer, and a 36 mil RPP secondary liner. The double liner systems also overlay clay or compacted native siltstone/shale bedrock.

Giroud et al. (1997) evaluated the optimal configuration of a double liner system to minimize seepage. In that analysis, a method of estimating seepage through a double liner system with a primary geomembrane overlaying a geonet leachate collection layer and a secondary composite liner was presented. The method (Giroud et al., 1997) includes calculating hydraulic head on the secondary liner that results from seepage through the primary liner into the leachate collection layer. Based on a comparative analysis, head on the secondary liner and seepage through the secondary liner decrease by at least four orders of magnitude compared to that of a single composite liner. Seepage estimates for double-lined ponds (e.g. Units 1&2 Flyash B Pond and Clearwell) were made using a procedure consistent with Giroud et al. (1997) that considered the inherent decrease in hydraulic head on the secondary liner produced by the geo-net drainage layer.

As demonstrated above, flow through clay liners is advective and is a function of the saturated hydraulic conductivity of the clay liner itself. Flow through a geomembrane is not purely by advection but occurs on the molecular level as either vapor transmission or liquid permeation (Giroud and Bonaparte, 1989). Vapor transmission only occurs when one side of the geomembrane is not saturated; while, liquid permeation occurs as the result of a large pressure head differential between liquids on both sides of the liner. Water vapor transmission through geomembrane liners is typically analyzed by standardized conformance testing (ASTM E-96) and results are provided by liner manufacturers. Based on available testing results, water vapor permeance of RPP and HDPE geomembrane liners ranges from 0.05 to 0.12 perms (grain/ft2*hour*in-Hg). A conservative estimate of seepage by permeation can be made for a given pond directly from the water vapor permeance results by 1.) converting the mass (grains) transfer rate to volume by assuming a density of water; and 2.) multiplying the result by both the pond area and head on the liner. This was done for Plant Site ponds constructed of either a geomembrane composite liner or geomembrane double-liner system. A conservative value of 0.12 perms was assumed in all calculations.

Conversely, permeation through geomembrane liners can be expressed using a coefficient of migration (m_g). The empirically determined m_g is head-dependent and does not imply advective flow conditions. Further, m_g increases with increasing head on the geomembrane until reaching a plateau whereby m_g is constant over the range of highest operating pressure differentials (Giroud and Bonaparte, 1989). The coefficient of migration is not commonly determined via standard geomembrane conformance testing. Also, the use of water vapor permeance values result in more conservative estimates of seepage because the estimated water transfer rate does not plateau with the addition of more head on the liner.

Note that the Units 3&4 Auxiliary Scrubber Drain Pond is constructed with a Hypalon liner; however, this pond is very small and is operated under low head. The seepage estimate for this pond is not likely to vary greatly due to the assigned water vapor permeance; and the overall seepage estimate for Plant Site Ponds is not likely to be influenced by seepage from

this small pond. In fact, at the time of preparation of this report, the Units 3&4 Auxiliary Scrubber Drain Pond has been replaced with a concrete tank.

For each geomembrane-lined pond, the cumulative estimate of seepage includes flow through the liner from geomembrane defects. Seepage through defects is calculated using the equations and methods of Giroud and Bonaparte (1992), Giroud (1997), and Giroud et al. (1997). Specifically, Giroud's equations are used to calculate the rate of seepage through a single defect in a composite liner and are parameterized by the amount of head on the liner, the hydraulic gradient, the hydraulic conductivity of the low permeability soil beneath the geomembrane, the area of the geomembrane defect, and the quality of the contact between the geomembrane and the underlying soil. For double-lined ponds, there is an intermediate step that involves calculating the reduced head on the secondary liner.

The seepage rate through an entire geomembrane liner (double-liner or composite) is calculated by multiplying the rate of seepage through a single defect by the total number of defects present on the liner. For a geomembrane liner installed under strict quality assurance protocol, one to two liner defects per 4,000 m^2 (43,055.6 ft^2) can be expected (Giroud and Bonaparte, 1989); thus, a frequency of one defect per 4,000 m^2 (43,055.6 ft^2) is often considered by Giroud et al. (1994) for liner performance evaluation. These values are typical of a lined pond with a soil cover layer (such as a landfill) and may not be appropriate for ponds filled with water. To provide a more conservative evaluation of seepage, ten defects per 4,000 m^2 (43,055.6 ft^2) were assumed for the Plant Site pond liners. A defect area of 0.1 cm^2 (0.0155 in^2) is considered for liner performance evaluation; and a defect area of 1 cm^2 (0.155 in^2) is considered for conservative design (Giroud et al. 1994). The larger defect area (0.155 in^2) was assumed for Plant Site seepage calculations.

The contact quality factor, C_q, is an empirical factor presented by Giroud and Bonaparte (1992) and Giroud (1997) to quantify the contact between the geomembrane liner and the underlying earthen liner. There are two possible values of C_q available in the calculations:

1. Good contact applies to a geomembrane that is installed with few wrinkles over a low-permeability soil that has been well compacted and is smooth. For good contact conditions, the C_q factor is equal to 0.21 (dimensionless).
2. Poor contact is assumed if a given geomembrane is installed with many wrinkles, and/or the soil has not been compacted, and/or the soil does not appear smooth. For poor contact conditions, the C_q factor is equal to 1.15 (dimensionless).

Geomembrane-lined ponds on the Plant Site were constructed on compacted low-permeability soil (silt/clay) and were subject to quality assurance procedures; however, seepage through geomembrane liner defects at the Plant Site was evaluated using the poor C_q factor. The poor C_q factor is roughly five times greater than the good C_q factor. This factor has a linear effect on seepage estimates through geomembrane defects; thus, seepage estimates through defects made using the poor C_q factor are roughly five times greater than those resulting from the good C_q factor.

Head on the geomembrane-lined Plant Site ponds is typically greater than the thickness of the underlying compacted silt/clay soil. This factor is important to note because it dictates which form of the leakage equation Giroud and Bonaparte (1992) or Giroud (1997) is necessary for the Plant Site liner evaluation. Where head on the geomembrane liner is less than the thickness of the underlying clay layer, the hydraulic gradient term i_{avg} is assumed to be one (see Tables 2-5B and 2-5C for equations and variable assignments). Where head on the geomembrane liner is greater than the thickness of the underlying clay layer, the i_{avg} term must be calculated and included in the leakage equation. Head is greatest in the double-lined Units 1&2 Flyash Pond B and Units 1&2 Bottom Ash Clearwell (24 ft (7.34 m) and 16 ft (4.88m), respectively). Seepage through double lined ponds is discussed further to follow. Head on the composite geomembrane-lined Plant Site ponds is less than 3 m (~10ft). Giroud (1997) developed an analytical expression for determination of the i_{avg} parameter for heads in this range; and it was used in seepage estimates for the Units 3&4 Auxiliary Scrubber Drain Pond, Units 3&4 North Plant Area Drain Pond, and Units 1 – 4 Sediment Retention Pond. Assumptions applied to the calculation of seepage from the Units 3&4 Auxiliary Scrubber Drain pond indicate that head is actually lower than the thickness of the underlying

compacted soil. In this case, an i_{avg} value of one would be appropriate. However, for consistency, a value of i_{avg} of 1.07 was calculated using the Giroud (1997) equation. This value of i_{avg} is more conservative but does not appreciably change the outcome of the seepage calculation.

Note that the equations for liquid migration through defects (Giroud and Bonaparte 1992, and Giroud 1997) are semi-empirical and must be evaluated using the International System of Units (SI) where length is in meters, area in m^2, volume in m^3,and time is in seconds. Final seepage results were converted to gpm at the conclusion of the seepage calculation for each pond. Seepage due to permeation and defects from ponds with double-liner systems is calculated in Table 2-5B. Seepage from ponds with composite liners is calculated in Table 2-5C.

As noted above, calculating seepage through a double-lined pond filled with water is a two-step process whereby the head on the secondary liner is evaluated; then, the seepage rate through the secondary liner is calculated given the reduced head (Giroud et al. 1997). To provide a conservative estimate of seepage from the primary liner to the between-liner leachate collection layer, singular defects are treated as orifices and free flow is calculated using Bernoulli's equation, rather than Giroud's equations. The assumption of free flow is satisfied by the relatively large hydraulic conductivity and abundance of pore space in the geonet. As the secondary liner is in contact with underlying compacted clay soils, Giroud's equations are more appropriate for estimating final seepage through the secondary liner. Adjusted head on the secondary liner is a function of the hydraulic conductivity of the geonet, the slope of the leachate collection layer, the length of the pond, and the unit rate of seepage through primary liner defects (q_i) (Giroud et al. 1997). The equation for adjusted head on the secondary liner is presented in Table 2-5B. For this evaluation, seepage due to permeation from the primary liner is added to q_i to obtain a conservative estimate of adjusted head. Note that the adjusted heads (h_2) on the Units 1&2 Flyash B Pond and Units 1&2 Bottom Ash Clearwell are 2.3×10^{-3} m and 4.7×10^{-4} m, respectively. Recall that head on the primary liner for the same two ponds was 7.32 m and 4.88 m.

The final seepage rate through the secondary liner is calculated using the form of Giroud's equation (Giroud 1997) for small head on the liner (i.e. head is less than thickness of compacted clay layer). In this form of the equation (Table 2-5B), the hydraulic gradient is equal to one. Final estimates of seepage through defects are added to that estimated by permeation to obtain the total seepage rate through each of the double-lined ponds. As shown in Table 2-5B, the total seepage rates for the Units 1&2 Flyash B Pond and Units 1&2 Bottom Ash Clearwell are estimated to be 7.9×10^{-4} gpm and 5.8×10^{-5} gpm, respectively.

Seepage estimates for ponds with composite liners are included in Table 2-5C and include seepage attributable to permeation and liner defects. As noted above, equations developed for liners with head greater than the thickness of the compacted clay layer but less than three meters (Giroud 1997) were used to estimate seepage through defects. The cumulative estimate of seepage through Plant Site ponds with composite liners is approximately 0.4 gpm. The largest of the composite lined ponds (The Units 1-4 Sediment Retention Pond) accounts for 0.3 gpm.

Discussion of Results

The total seepage estimate from clay or earthen-lined ponds on the Plant Site is approximately 80 gpm, where the total area of clay-lined ponds considered in these calculations is approximately 59 acres. Thus, the average seepage rate for clay-lined ponds is approximately 1.4 gpm/acre. The highest seepage rates are from the clay-lined Units 1&2 Flyash A Pond and Units 1&2 Cooling Tower Blowdown Ponds (north and south). Seepage estimates from these three ponds account for nearly 80% of all estimated seepage at the Plant Site. As noted, these three ponds are used to store water from precipitation runoff or other sources of water with much lower concentrations of dissolved constituents that water that is impounded in geomembrane-lined ponds.

The total seepage estimate from geomembrane-lined ponds, (composite lined ponds and double-lined ponds) on the Plant Site is less than 0.5 gpm. Geomembrane-lined ponds have a cumulative area of approximately 18 acres, resulting in an average seepage rate of less than 0.03 gpm/acre. As demonstrated previously, seepage rates vary with pond construction

specifications (i.e. double-lined ponds have much less seepage than single composite-lined ponds). Overall however, seepage from geomembrane-lined ponds is at least two orders of magnitude less than from earthen-lined ponds on the Plant Site.

Observations of water quality and quantity are made in the primary and secondary leachate collection systems at the Units 1&2 Flyash B Pond and Units 1&2 Bottom Ash Clearwell. The utility of comparison between the seepage estimates and observed leachate collection rates is limited at the Units 1&2 Flyash B Pond because of elevated groundwater levels beneath the pond. An average collection rate of 38.5 gpm was measured in the underliner system and 6.2 gpm was measured in the between-liner collection system in 2013 (Hydrometrics, April 2014). Because of the massive reduction in head that occurs between the primary and secondary liners, it is unlikely, if not impossible, for seepage through the lower liner to be greater than the upper liner. Thus, water removed from beneath the B Pond liners is attributable to a mixture of native groundwater and seepage from other nearby ponds. Note that the seepage estimate from the adjacent Units 1&2 Flyash A Pond was nearly 27 gpm. Some of the water collected between the B Pond liners could be attributable to seepage through the primary liner; however, water quality results for samples collected in the leachate collection system are not consistent with results of samples collected from within B Pond. The mean SC at the Units 1&2 Flyash B Pond is 18,250 μmhos/cm and the most recent sample collected on 7/19/2012 had an SC of 18,800 μmhos/cm. Mean SC of water collected from the between liner collection system is 13,623 μmhos/cm; and the most recent value (sampled on 5/16/2012) was 6,470 μmhos/cm. This suggests that there is another source of water collected between the primary and secondary liners. One possible source is back flow from the under-liner collection system. The between-liner and under-liner collections systems share a common pipeline and no check valve is present between them. Note that the most recent SC reported for water from the under-liner collection system 6,790 μmhos/cm (Hydrometrics, April 2014).

The primary (under-liner) and secondary (between-liner) leachate collection systems at the Units 1&2 Bottom Ash Clearwell were reported to have pumped 1.1 gpm and 0.1 gpm in 2013 (Hydrometrics, April 2014). Similar to B Pond, discussed previously, it is unlikely that

seepage through the secondary liner would be greater than that through the primary liner. Thus, water collected by the under-liner system may be from native groundwater or seepage from a neighboring pond (Units 1&2 Flyash A Pond or Units 1&2 Bottom Ash Ponds). The between-liner collection rate (0.1 gpm) is very similar to the estimate of seepage through the primary liner due to permeation that was made in the evaluation presented above (0.06 gpm, from Table 2-5B). The actual collection rate is slightly larger but the difference is within the margin of error for this evaluation. Also, the minimal amount of water collected in the between liner collection system is consistent with permeance values reported by RPP liner manufacturers and suggests little room for additional seepage by liner defects

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3.0. SUMMARY OF INVESTIGATIONS

3.1 SYNOPSIS OF PAST SPILLS, INVESTIGATIONS, MITIGATION, AND STATUS

Table 3-1 provides a list of past releases, date of the release, estimated amount of release, action taken to address the release, the fate of the released process water, and any reports prepared specifically for the release. Information provided in Table 3-1 is not inclusive of non-process water related spills such as chlorine, petroleum hydrocarbons, or other operational chemicals which have not been introduced into the process water or are not intended to be part of the process water circuit.

3.2 PAST INVESTIGATIONS

Table 3-2 contains a chronological listing of events on the Plant Site 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. The reference section of this report (Section 7) contains a complete listing of the reports outlined in Table 3-2.

TABLE 3-1
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
SUMMARY OF PAST RELEASES ON THE PLANT SITE

Date of Release	Area/Cause of Release	Estimated Amount Loss Gallons	Action	Fate of Released Material	Reports (1)
1977	Bottom Ash Storage Pond Pipeline leak	Unknown	Unknown	Soil adjacent to, and beneath, pipeline	No documentation found
1979	Possible pipeline break noted near well 13M	Unknown	Unknown	Soil adjacent to, and beneath, pipeline	No documentation found
November 1980	D3 Brine Pond - A tear in the liner occurred due to ground subsidence	1 million gallons of brine water	Liner repaired	Soil below D3, possibly shallow groundwater in area upgradient of the Units 1&2 AB Ponds	10, 13,15,16,20,22,26,36
1983	D3 Pond Line - tears observed in liner	Unknown	Repaired	Spoil & shallow groundwater underlying ponds	10, 13,15,16,20,22,26,36
1983-1984	Scrubber Drain Pond -Pipeline leak that penetrated the embankment	Unknown	Unknown	Soil underlying pipeline	No documentation found
February 1984	Scrubber Drain Pipeline	Unknown	leak repaired	Soil underlying pipeline	10 - Mentioned in brine pond report
September 1984	Scrubber Drain Pipeline	Unknown	leak repaired	Soil underlying pipeline	10 - Mentioned in brine pond report
1985	North Plant Drain Pond – Hypalon liner damaged during initial use	No indication of water losses	Liner repaired	No indication of water losses	12 – Mentioned in annual report
1988	D3 Brine Pond – tears in liner above 3280 elevation	Unknown but potential water losses	Water levels managed below tears until liner could be repaired.	Spoil & shallow groundwater underlying ponds	16
1988	Drain Collection Pond – liner breach	No estimate or verification of water losses	Liner repaired	No estimate or verification of water losses	Mentioned in numerous reports – 16, 18, 20,21, 23,27,36,42
1989	Units 1-4 Sediment Retention Pond – gas bubbles formed under liner	No losses of water confirmed	Repaired to reduce risk of hypalon liner failure	No losses of water confirmed	Mention of Units 1-4 Sed. Ret. Pond liner replacement in annual report- 21
1989-1990	Unit 4 Cooling Tower – break in canal caused by frost damage	Unknown	Repaired	Soil adjacent to canal and possibly shallow groundwater	Mentioned in annual reports - 21
May 22, 1991	Storm water ditch – water overflowed due to debris blockage	50,000	Cleaned ditch to allow better flow of water	Storm water to ground surface uphill from East Fork Armells Creek, possibly shallow groundwater	24
June 25, 1991	Storm water ditch - – water overflowed due to debris blockage	Unknown	Cleaned ditch to allow better flow of water	Storm water to ground surface uphill from East Fork Armells Creek, possibly shallow groundwater	25
1991	Units 3&4 Bottom Ash Ponds – ash noted below pond liner	Unknown	Repairs made	Soil near pond	Mentioned in annual report - 23
1992	Flyash Slurry Pipeline Spill	Unknown	Pipeline repaired	Unknown	No documentation found
1992	Storm water Ditch – overflow due to constriction	Unknown	Cleaned ditch to allow better flow of water	Storm water to ground surface uphill from East Fork Armells Creek, possibly shallow groundwater	No documentation found

TABLE 3-1
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
SUMMARY OF PAST RELEASES ON THE PLANT SITE

Date of Release	Area/Cause of Release	Estimated Amount Loss Gallons	Action	Fate of Released Material	Reports (1)
1992	D4 Sump Overflow	Unknown	Unknown	Soil adjacent to sump	Mentioned in annual report - 29
October 26, 1992	Units 3&4 Clear Water Return Pipeline – backhoe damage	10,000	Repaired pipeline	Soil adjacent to, and beneath, pipeline	28
1993	Units 3 & 4 Wash Tray Pond – backhoe damage	10,000	Repaired pipeline	Soil adjacent to, and beneath, pipeline	No documentation found
1993	D4 Sump Overflow	Unknown	Unknown	Soil adjacent to sump	Mentioned in annual report - 29
November 1994	Dredge Slurry Spill	24,000	Cleaned up	Soil	34
1997	North Plant Drain Pond Liner tear	Unknown	Repaired liner	Soil and possibly shallow groundwater below pond	Mentioned in annual report - 42
September 18, 1998	Flyash scrubber slurry pipeline failure	80,000 with estimated half entering East Fork Armells Creek	Repair pipeline, eventually replaced pipeline, remediated soil and water in the area and creek	East Fork Armells Creek	45
March 29, 2000	Clear Water Return Pipeline Failure	122,500 with estimated 9,000 gallons entering East Fork Armells Creek	Contained and repaired pipeline	East Fork Armells Creek	50
March 22, 2002	Common Effluent Tank Area – Water/slurry spill	50,000	All contained on asphalt and within drainage ditches		No documentation found
June 6, 2002	Effluent Pipeline to Units 1 & 2 B Pond - Flyash scrubber slurry spill	5,000	Pipeline repaired	Soil adjacent to and underlying pipeline	No documentation found
June 16, 2002	Units 3&4 Auxiliary Building	Unknown	Unknown		No documentation found
July 22, 2002	Road to Units 1&2 Bottom Ash Ponds	1,000	Liquid contain and 75% recovered. 8 yds of soil removed.	Contained on roadway	58
July 23, 2002	West of Units 3&4 scrubbers – flyash scrubber slurry	10,000	Contained spill, flushed into storm water ditches which flow to Units 1-4 Sediment Retention Pond	PPLM process water circuit	No documentation found
November 2005	D4 Brine Pond – liner failure due to subsidence under the pond	Unknown	Pond taken out of service, remediation system installed.	Spoil and groundwater in the spoil	74
November 15, 2005	North Plant Pond	300	Unknown	Soil below the pond	No documentation found
March 7, 2013	North Plant Salt Tank – salt added to tank when water level was too high displacing salt water mixture out of top of tank	1,500 to 8,000 estimated	Make up level and sensor repair	Water traveled down the ditch to the north plant pond.	PPL Spill Response Data Sheet 3/17/13
August 4, 2013	U3 Scrubber aux service building / U4 Lime feed line to Units 1&2 – drain valve partially open	500	Valve replaced	Lime pumped back to scrubber sump trench back to common effluent tank.	PPL Spill Response Data Sheet 8/5/13

1. See Table 3-2 for details concerning the written report including title, date of issue, and a summary of the report

TABLE 3-2
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT PLANT SITE
SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
1	April 15, 1977	MPC letter to DNRC regarding Brine Ponds D1-D3	Describes lining, materials location, and installation.	Hypalon liners installed November 1975 with two 15mil sheet laminated to form a single 30mil liner. Twenty year life but actual life of liner expected to be 40 years. Placed over 90 percent compacted base and sides. Liner secured around sides. Waste stream analysis provided. Concentrated Yellowstone River water. No long-term hazards following reclamation.
2	June 1978	Characteristics and Potential Impact of Wastewaters from a Coal-Fired Power Plant at Colstrip, Montana, Westech	Evaluation of potential impacts from process water associated with the Colstrip SES	Determined that it would be difficult to make a quantitative determination of seepage from ponds near the power plant due to the lack of pre-pond groundwater data. Ponds seepage estimates of 5 to 15 gpm were calculated. This seepage could degrade water quality in the McKay overburden. Impacts from the ponds at the time of the analysis appeared to be limited. Flow from the ponds would be towards either East Fork Armells Creek or Rosebud Creek, although impacts to Rosebud Creek were considered unlikely due to the distance, low permeability and pond linings. Four measures to mitigate or eliminate seepage were groundwater interception, reduction of seepage, new pond construction, elimination of wastewater to ponds to alter quality. Only the first two were considered viable options. Monitoring should be conducted to identify seepage from ponds.
3	April 15, 1980	Evaluation of Data From the Montana Power Company Process Pond Monitoring System at Colstrip, Montana Hydrometrics, Inc.	Report on groundwater quality data collected by Hydrometrics in 1979	Report summarizes findings of data collected in 1979. Several wells are indicated as showing increases in chemical concentrations. Some of the increase may be the result of recharge to wells following use of good quality water during well drilling and installation.
4	June 2, 1980	Report of Groundwater Studies, Colstrip, MT, Chen and Associates, Inc.	Local general groundwater study conducted to evaluate reasons for increases in soil moisture in the Colstrip area.	Identified potential sources of groundwater recharge from ponds constructed as part of the power plant facilities. Water seeping from the ponds would increase water levels east of East Fork Armells Creek but would not affect groundwater conditions west of the creek. Lawn irrigation is also a source of groundwater recharge, potentially increasing water levels locally by one to three feet.
5	1981	Evaluation of 1980 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana Hydrometrics, Inc.	Annual Water Resources Report	Water from wells 2M and 6M showed changes in sulfate or conductance of greater than 30 percent. Wells 9M, 10M, 12M, and 12R showed changes between 15 and 30 percent. Wells 2M and 10 showed increasing trends. Wells 6M, 9M, 12M, 12R showed decreasing trends.
6	July 17, 1981	Hydrologic Assessment of East Fork Armells Creek, Hydrometrics, Inc.	Evaluation of water resources north of Colstrip along East Fork Armells Creek	Conclusion of the investigation was that more water was flowing through the drainage following development of the Colstrip SES. Estimates of pond seepage from the power plant (Plant Site) were 5 to 15 gpm. Other contributions to increased water included Colstrip wastewater, local urban irrigation, surge pond, and Stage I Evaporation pond.
7	February 17, 1982	Evaluation of 1981 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana Hydrometrics, Inc.	Annual Water Resources Report	Well 4S impacted by brine ponds Well 6M possibly impacted by cooling tower blowdown pond water
8	February 2, 1983	Evaluation of 1982 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana Hydrometrics, Inc.	Annual Water Resources Report	6M appears impacted – currently capture well,
9	April 30,1984	Evaluation of 1983 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana Hydrometrics, Inc.	Annual Water Resources Report	Some impacts from A/B Ponds
10	October 1984	Investigation of Groundwater Quality Changes near the Colstrip 1 and 2 Brine Disposal Ponds Colstrip, Montana, Hydrometrics, Inc.	Investigation included a review of existing hydrogeological data, development of a potentiometric map to evaluate groundwater flow directions, aquifer testing, development of Phase II work. Work was conducted in response to a liner tear in D3 Brine Pond which released an estimated 1 million gallons of brine water.	Evaluation of existing groundwater data showed the presence of a groundwater divide near the Brine Ponds. Water quality from wells 4S, 18S, 18SP was indicative of Brine Pond water impacts. Possible impacts at 26SP but inconclusive. Well 12R (now abandoned) also showed high concentrations of chemical constituents but were thought to be from a pipeline spill related to the scrubber drain pond. Brine pond water influence both spoil and shallow bedrock units but impacts were not identified in the McKay Coal. A significant portion of the leakage may have been adsorbs by unsaturated spoil. Additional work was recommended to further investigate the area and included installation of additional monitoring wells in multiple units, hydraulic testing, additional monitoring, and groundwater modeling.

TABLE 3-2
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ADMINISTRATIVE ORDER ON CONSENT PLANT SITE
SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
11	April 24, 1985	Evaluation of 1984 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana Hydrometrics, Inc.	Annual Water Resources Report	Well 12R showed impacts - suspected seal problems, Well 20S influenced by Units 3&4 Bottom Ash Pond, and Well 25SP upward trend of parameter concentrations.
12	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	Well 1S water quality indicates A/B Pond seepage and possibly the Sediment Retention Pond. Well 6M and 6S water quality indicate seepage from Cooling Tower Blowdown Pond. Improvement in groundwater quality observed at 18 series wells as a result of B-1 through B-5 capture system. (Units 3 & 4 North Plant Area Drain Pond)) Hypalon liner tear.
13	August 15, 1986	Brine Pond Spill Mitigation Interim Report, MPC EED/Hydrometrics, Inc.	Follow up report of actions taken to mitigate leakage from the D3 Brine Pond following a liner tear. Report includes work completed toward addressing recommendations contained in the initial report.	Four pumping wells and three observation wells (B-1 through B-7) were installed spring/summer 1985 southeast of the D3 Brine Pond. Pumping from wells B-1, B-3, B-4 and B-5 started October 21, 1985 with water routed to Units 1 and 2 process ponds. Pumped until December 20, 1985, when cold weather forced shutdown.
14	May 1987	Evaluation of 1986 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana Hydrometrics, Inc.	Annual Water Resources Report	1S and 1D showing effects from Units 1&2 A/B Pond, Sediment Retention Pond modified. Dewatering of South Cooling Blowdown Pond C began in May 1986. Repairs to clay liner for Pond C planned for 1987 and 1988. Groundwater from wells 7M and 9M showing effects of seepage from 3&4 Wash Tray Pond. Water quality at wells 23S and 23M improved - related to North Plant Pond hypalon liner repairs in 1985. Wells 16M and 16D influenced by Cooling Tower Blowdown Pond and Wash Tray Pond seepage.
15	February 1988	1987 Brine Pond D-3 Groundwater Report, MPC	Provided a review of groundwater data in the vicinity of the D3 Brine Pond release.	Concluded that operation of the Brine Pond dewatering wells resulted in an overall improvement of water quality in the area affected by the 1980 spill. Water quality worsens during periods of prolonged system shutdown. Continued intermittent operation of the pumping system was expected to result in further improvement of water quality. Installation of the Units 3&4 Wash Tray Pond and Drain Collection Ponds make evaluation of sources more difficult due to the lack of water quality data before the spill occurred.
16	1988	Brine Ponds Dewatering Project System Status – 1988, Colstrip Project Division Environmental Engineering, MPC	Report describing capture system that was installed in response to 1980 liner tear.	In conjunction with seepage from the Drain Collection pond, a mound had formed under the D3 Brine Pond in response to maintaining water levels above the level of known tears in the hypalon liner. Groundwater flow was toward the Brine Pond Dewatering System. The Brine Pond Dewatering System, however, was not considered capable of totally controlling the seepage due to the fact that the D4 Brine Pond underdrain began collecting groundwater. MPC was taking steps to restore the integrity of the Drain Collection Pond clay liner and to lower the water levels in D3 Brine pond to below the critical elevation of 3280 feet. Operations had attempted liner repairs in 1987 but freezing of the pond terminated those activities. Liner repairs, and water level management, were stressed heavily to make groundwater mitigation possible by removing the source of poor quality water. The Brine Pond Dewatering System operated throughout the winter of 1988-1989 without any freezing problems. Operation of the system was recommended for year round operation until the affected area shows more stable conditions.
17	May 1988	Study of Wash Tray Pond Bank Erosion, MPC Thermal Generation Engineering	Evaluation of the Units 3&4 Wash Tray Pond to address exposed banks along the dredge access ramp where lining is absent and erosion on the east, south and west banks caused by wave action.	Evaluation provided recommendations for repairs/upgrades for the pond. Ten alternatives were considered for pond repairs. It was recommended that the ramp and pond be addresses in two phases. The recommended alternatives were to install a geotextile fabric cover covered with one-foot of scoria. A clay/soil/fabric/scoria liner was installed on the bank near the access ramp.
18	June 1988	Evaluation of 1987 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana Hydrometrics, Inc.	Annual Water Resources Report	Wells 1S & 1D apparently influenced by Sediment Retention Pond and A/B Pond. Well 31S - some impact noted. Repairs to Sediment Retention Pond and relining planned for 1989. Repairs to Cooling Tower Blowdown Pond completed in 1987, monitor 6M, 6S, and 6D for effectiveness.

TABLE 3-2
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ADMINISTRATIVE ORDER ON CONSENT PLANT SITE
SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
	June 1988 (continued)			Erosion damage noticed at Units 3&4 Wash Tray Pond with some effects on nearby wells, repairs planned for 1988. Brine pond dewatering system improving water in area. 25SP slight WQ degradation which could be related to Brine Pond or Drain Collection Pond.
19	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	Wells 33S and 34D installed next to Units 3&4 Wash Tray Pond. Tears observed in D3 Brine pond and water quality indicates some leakage. D3 water levels to be dropped to elevation of 3276 ft in spring 1989 to allow for repairs above 3280 elevation. Water quality changes at wells 4S and 26SP believed to be due to dredging and wave erosion on clay liner of Scrubber Drain Pond. Repairs made to Units 3&4 Wash Tray Ponds
20	1989	Colstrip Units 1&2 Brine Ponds Dewatering Project Systems Status – 1989, MPC EED	Status report on Brine Pond Dewatering System.	Monitoring was conducted weekly by MPC's Environmental Engineering Department personnel in 1989. The quality of the recovered groundwater remained fairly constant throughout 1989. Drain Collection Pond repairs are expected to benefit quality, as is the replacement of the pump in the Brine Pond Sump. Flows decreased throughout the year, probably from the shutdown of the pump in B-1 and line blockage in the discharge pipe from well B-4. Capture was conducted throughout the winter 1988-1989. The system was shut down in the winter of 1989-1990. SC measurements from the area wells show an improvement in shallow wells, but wells farther from the system are degrading slightly. Slight drops in water levels were observed in wells B-6 and B-7 in 1990, while B-2 water levels were relatively steady. Water quality was variable with SC increasing in some wells and decreasing in others.
21	1990	Evaluation of 1989 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana Hydrometrics, Inc.	Annual Water Resources Report	Drain collection pond and brine ponds influences observed in wells. Drain collection pond repaired. Brine pond water level kept below level of liner tears. Underdrain system built as part of D4. Sediment retention pond liner replaced using high density polyethylene (HDPE). Unit 4 Cooling Tower Canal Break – affected water quality at well 23S.
22	1990	Colstrip Units 1&2 Brine Ponds Dewatering Project Systems Status – 1990, MPC EED	Status report on Brine Pond Dewatering System for 1990 operation.	Attempts were made to start the dewatering system in 1990 but problems were encountered with pumps and piping which made operation impossible without repairs. Repairs were not made by the end of 1990 so the system did not operate. The D4 Brine Pond Underdrain Sump operated for about 32.4 hours in 1990.
23	May 1991	Evaluation of 1990 Monitoring Data From the Montana Power Company Process Pond Systems at Colstrip, Montana Hydrometrics, Inc.	Annual Water Resources Report	Water quality at well 1S was variable. Water level rises in several wells – suspect from Drain Collection Pond. Increase in pond water impacts south and east of Brine Pond and Drain Collection Pond. Brine ponds D1, D2 and D3 ponds taken out of service. D4 sole brine waste pond since 1985. Water quality at well 5M showing possible upward trend in chemical constituent concentrations. Well 9M showing possible Units 3&4 Wash Tray Pond influences. Well 16D to be plugged due to suspected bad seal. Well 34D shows no impacts although completed in same interval. Wells 16M and 17M appear to show Units 3&4 Wash Tray Pond influences. Wells 20S, 21S, 21M, 21D, 22SP,22M show water level rises possibly related to Units 3 & 4 Bottom Ash Ponds, reported to have encountered ash below pond – will repair.
24	June 20, 1991	Letter to Montana Department of Health and Environmental Sciences from MPC/LLC	Letter reporting spill and actions in May 1991	Constriction in storm water ditch caused an overflow of runoff water during/following a precipitation runoff event. Minimal environmental impacts were observed following the event.

TABLE 3-2
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT PLANT SITE
SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
25	June 25, 1991	Letter to Montana Department of Health and Environmental Sciences from MPC/LLC	Letter reporting spill and actions June , 1991	A discharge from a stormwater ditch occurred when soil built up in the canal constricting flow during a stormwater runoff event. MPC indicated they were in the process of implementing corrective measure identified in a June 20, 1991 letter. Minimal environmental impacts predicted.
26	January 1992	Colstrip Units 1&2 Brine Ponds Dewatering Project Systems Status – 1991, MPC EED	Report on Brine Pond Dewatering Systems. Summary of upgrades and performance.	The Brine Pond Dewatering System was rebuilt in the spring of 1991. Pumping resumed in June 1991. The combined flow from the pumps was 10-15 gpm. The pump in B-3 did not pump. Pumping stopped in December, 1991 and piping was purged with air. SC of discharge water dropped during the first six months of operation but then stabilized. Water levels were lowered in nearby monitoring wells B-6 and B-7. SC in area monitoring wells increased when the system was down.
27	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	Monitoring well 16D was abandoned in July 1991. Brine Pond Dewatering System rehabilitated and back in operation in June 1991. Wells 18D, 18M, 18S, 27SP, 18SP still show effects of Brine Pond water losses. Water from well 12R-2 showing Drain Collection Pond influences. Well 5M water showing slow increase in chemical constituent concentrations while 5S is variable. Water from well 9M shows an increase of boron concentration of four times. Water from well 16SP showing indications of Units 3&4 Wash Tray Pond impacts. Wells near Units 3&4 Bottom Ash Ponds Showing water level rises. Bottom Ash Pond repairs completed in 1991. Water quality at well 6M declines. Water quality at well 10M declines.
28	October 26, 1992	Letter from MPC to DNRC dated Nov 13, 1992 reporting 10,000 gallon spill of Units 3&4 Clearwell effluent on plant site just west of Units 1&2 Coal Storage.	Backhoe accidentally damaged clearwater return water pipeline resulting in 10,000 gallon spill of Units 3&4 Clearwell effluent just west of Units 1&2 Coal Storage.	The line was repaired and returned to service the next day. Current monitoring network will show any effects from this spill. No impacts are expected due to water quality of effluent.
29	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	Brine pond system not operated in winter, restarted in March 1992, 4.9 MG captured. Brine Pond D4 underdrain sump overflowed. Water quality improvement in vicinity of Brine Pond Capture System. Wells 6M, 7R, 16SP, 16M, 17M, near the Units 3&4 Wash Tray Pond showing poorer quality water. Poorer water quality at 5S, 10M, 10S possibly from Units 1&2 A/B pond seepage or spoil influences. Water quality at wells 20S, 21S, 22SP, located near the Units 3&4 Bottom Ash Ponds showed improvement.
30	December 1993	Investigation of the Quality of Groundwater and Surface Water in the Colstrip Plant Site and 1&2 Evaporation Pond Areas – Draft, Hydrometrics, Inc.	Initial phase of investigation of Plant Site that included installation of monitoring wells, evaluation of groundwater quality, and pond seepage estimates. Precursor to 1995 report	Plant site might be influencing EFAC near plant site. Changes in GW quality but mostly on-site. Sediment Retention Pond area may have off site migration. Synoptic run data show increases in SC as it passes the Sed. Ret. Pond area. Plant groundwater flow offsite estimated at 25 gpm.
31	May 26, 1994	Letter from Montana Department of Natural Resources and Conservation (A. Compton) to MPC regarding disposal of solid brine waste in the Units 3&4 EHP	Approval letter	Letter describes previous correspondence with MPC regarding disposal of solids removed from Brine Ponds D1, D2, and D3 as part of pond closure and area mitigation. Indicates nothing in the 3&4 Certificate would prohibit the disposal. Some concern about reclamation above the disposal area due to high salt content. MPC provided map, analytical results and permeability testing results, as requested.
32	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	Well 21SP abandoned and replaced with 21SP-2. Eleven new wells (35M through 41SP) installed as part of groundwater studies. Brine dewatering system restarted and 4.2 MG pumped. Poorer quality at wells 12R2, 25SP, 27SP in the Brine Pond and Drain Collection Pond, and reclaimed mine spoil area. Improved water quality in 10 wells near Cooling Tower Blowdown Pond and Units 3&4 Wash Tray Pond. Poor quality at wells 6M, 7R, 16SP, 17M, 33S.

TABLE 3-2
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT PLANT SITE
SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
	May 1994 (continued)			Poorer water quality west of A/B pond – additional study proposed. Units 3&4 Bottom Ash Pond area wells 20S, 21S, 22SP showed improved water quality. North plant drain pond area water quality generally improved. µmhos/cm Synoptic run conducted on East Fork Armells Creek showed higher flows in 1993 and lower concentrations of chemical constituents.
33	June 17, 1994	Letter from MPC to DNRC regarding disposal of Brine Pond solids in Units 3&4 EHP	Follow up letter with information previously requested by DNRC	Letter indicates modifications being made to reclamation plan. Pond dewatering underway. Disposal area prepared. Plan to have waste moved, deposited, and covered by end of July 1994. Describes re-contouring of Brine Pond area to enhance recharge by precipitation, flush soil salts, with the water being captured by Brine Pond Collection System. Maps of disposal area, cross section, location provided to DNRC. Permeability of ash and local strata provided. Brine pond D4 still in service. Wastes were removed and placed in southwest corner of ponds in 1994 – F Cell.
34	November 1994	REPORT INVESTIGATION OR CLEANUP	Report of 24,000 Dredge Slurry Spill	
35	January 9, 1995	Investigation of the Quality of Groundwater and Surface Water in the Colstrip Plant Site and 1&2 Evaporation Pond Areas, Hydrometrics, Inc.	Investigation of the Plant Site included installation of 11 groundwater monitoring wells in 1993, installation of 3 monitoring wells and one piezometer in 1994, groundwater sampling, aquifer testing, and synoptic runs along East Fork Armells Creek	A groundwater divide was present near the center of the plant in both the McKay and shallower units. Recharge likely from ponds and precipitation. There are no upgradient areas at this divide so there is little potential for dilution. Transmissivity ranges of 0.5 to 150 ft^2/day, consistent with earlier testing. Spoils may locally exhibit higher transmissivity. Groundwater flow in shallow unit toward East Fork Armells Creek estimated at 22 gpm and 3 gpm for McKay Coal. East of the divide flow from the plant site estimated at 25.5 gpm in shallow unit and 2.8 gpm for McKay. Calculated flows are consistent with earlier calculations and those originally estimated by Bechtel Corporation. Groundwater quality varies widely from and SC of 1180 umhos/cm in the McKay Coal near the Units 3&4 Bottom Ash Ponds to 9000 umhos/cm near the Brine Ponds. 28 wells were identified as having increased concentrations of indicator parameters with time. Changes in water quality appear to be mostly onsite except possibly near the Sediment Retention Pond. Small increases in boron concentrations measured along this reach of East Fork Armells Creek may be an indication of process water seepage. However, groundwater quality on the west side of the creek suggest other factors may be involved. There was no indication of off-site groundwater quality changes east of the Plant site. Synoptic runs results indicate an increase in flow downstream. Concentrations of most parameters increased between site AR-5 and AR-3.
36	March 1995	Rehabilitation, Testing, and analysis of the Brine Pond Recovery System at the Montana Power Company Electricity Generating Facility in Colstrip, Montana, Hydrometrics, Inc.	Provided information on Brine Pond capture system rehabilitation and upgrades	Investigation found that scaling problems within the wells and discharge piping were affecting the performance of groundwater capture. Air-jetting and acid treatments were conducted on the Brine Pond Capture wells. Upgrades to pumps, valves, and well housings were made. The system was restarted and adjusted to optimize capture and regulate drawdown. Modeling conducted using TwoDan analytical software to predict capture zones. Based on this analysis the capture zone from pumping the wells at maximum performance extend under the Brine Ponds, most of the Drain Collection Pond a portion of the Blowdown Pond C, and the northern portion of the Units 3&4 Wash Tray Pond.
37	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	Wells 42S, 45S, and 44S installed. Brine ponds D1, D2 and D3 removed and solids disposed of in southwest corner of Cell F at the Units 3&4 Evaporation Holding Pond. Brine pond recovery system rehabilitated with new pipe, pumps, well housing. No water was present in the D4 underdrain sump. Wells near Brine Pond Capture System wells showed improved quality. However, groundwater quality at wells 4M, 12R-2, 25SP, 27SP was poorer. Water quality at wells 7R, 17M, 39S showed poorer quality. Water quality at well 5M poorer. Water quality at well 22M poorer. Water quality at well 23S improved.

TABLE 3-2
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT PLANT SITE
SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
38	March 1996	Design and Installation of the Sediment Retention Pond Area Groundwater Capture System, Hydrometrics	Five groundwater recovery sumps (SRP-1 through SRP-5) were installed north and northeast of the Units 1&2 Flay Ash Clearwell and A pond. Each sump extended to bedrock with depths ranging from 14 to 35 feet. Groundwater capture began December 15, 1995.	SRP-1 through SRP-5 are still operational as part of the plant site groundwater mitigation efforts.
39	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	Well 32M was accidently destroyed. First five Sediment Retention Pond capture sumps installed and started. Five piezometers installed to monitor Sediment Retention Pond collection system. Brine pond collection system operated, D4 Brine Pond underdrain sump was dry. Water quality improvement near brine collection system Water quality generally better in Units 3&4 Wash Tray Pond and Cooling Tower Blowdown Pond generally better quality except for 6D, 6M 17M, 39S. Units 3&4 Wash Tray Pond to be taken out of service. MPC evaluating A/B pond liner options. Wells 20S, 21S, 21SP-2, near the Units 3&4 Bottom Ash Ponds showed poorer quality. Western Energy Co. (WECO) installed a dewatering well near their coal crusher and began pumping 50 gpm+ in 1995.
40	December 1996	Montana Power Company Colstrip Project Division Bottom Ash Systems Water Chemistry Study, Puckorius & Associates, Inc.	Study conducted to evaluate potential benefits of using fly ash the bottom ash systems to reduce scale and enhance the flow of ash sluice water in water. The water could potentially be used in place of raw water makeup to reduce pond inventories by improving the water balance.	Testing was initially conducted on the Units 1&2 Bottom Ash system. No detrimental effects were found in the testing. However, it was determined that a high potential of scaling by calcium sulfate and calcium carbonate existed due to impurities from the fly ash water which increase the level of constituents in the bottom ash water. Testing on the Units 3&4 Bottom Ash system provided only marginal reductions in scaling tendency. Based on these results it was recommended that a different long-term approach should be pursued.
41	December 1996	A/B Pond Leak Detection Investigation, Hydrometrics	Units 1&2 Flyash A/B ponds, Fly Ash Clearwell, Bottom Ash Ponds, and abandoned ponds to the east were evaluated to identify potential leakage areas. The investigation included installation, testing and monitoring of 28 piezometers (A/B-#), review of dredging practices, and water quality evaluation.	Concentrations of dissolved constituents in groundwater below the ponds are elevated. Five areas of potential clay liner damage were identified. Areas showing the highest potential for excess seepage or leakage were the south end of the Units 1&2 B Pond, Units 1&2 Fly Ash Clearwell, the northern portion of the Units 1&2 Fly ash Pond A, and the Units 1&2 Bottom Ash Pond. Liner damage may have occurred during dredging operations.
42	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	Water at well 45S improved following installation of Sediment Retention Pond Capture System. Units 3&4 Scrubber drain collection pond use discontinued. North plant drain pond liner repaired. Water quality at well 41SP much poorer. Plans to install additional wells near 5M and 10S. Units 3&4 Wash Tray Pond no longer receives scrubber slurry. Drain Collection Pond stopped receiving effluent. Water quality at Units 3&4 Bottom Ash Pond wells 20S, 21SP-2 poorer. North plant drain pond liner repaired.
43	March 1998	Extension of the Sediment Retention Pond Area Groundwater Capture System, Hydrometrics, Inc.	Investigation conducted following startup of the Sediment Retention Pond Capture System indicated groundwater with elevated constituents south of the existing system. This report summarized expansion of the existing system.	Sumps SRP-6, SRP-7, and SRP-8 were installed. A spacing of 400 feet was chosen based on distance drawdown curve which indicated a radius of influence of about 367 feet. Yield tests were conducted following development and the system was plumbed to route water to Units 1&2 A Pond Pumps were started on October 7, 1997 and all are currently operational.
44	Spring 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	Brine pond and Drain collection Pond area wells showed stable water quality. No water was present in the D4 underdrain. Sediment Retention Pond capture wells pumped 20.9 MG of water. Water quality declined at wells 9M, 17D, 17M, near the Units 3&4 Wash Tray Pond.

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SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
	Spring 1998 (continued)			Wash tray pond received overflow from Units 1&2 A/B Pond while Stage II pond was out of service for repairs.
45	November 1998	The Montana Power Company East Fork Armells Creek Slurry Spill Cleanup Report, Hydrometrics, Inc.	A Spill occurred near East Fork Armells Creek when a weld on slurry pipeline failed. Approximately 80,000 gallons of slurry spilled on the surrounding ground. An estimated 80 cubic yards of fly ash may have entered the creek.	MPC personnel contained the initial spill and initiated soil cleanup. After receiving regulatory approval, MPC rerouted a portion of the creek around the area visually impacted by fly ash slurry. Hydrometrics Remediation Services was retained to remove fly ash from the creek. Approximately 329 cubic yards of soil and fly ash were removed. Material moved from the site was staged near the area to allow drainage so spillage would be minimized during hauling. Excavated material was place in the abandoned Units 1&2 Bottom Ash Ponds. Material spilled during hauling was removed following creek remediation. Silt fence were removed and flow restored to the original channel on October 8, 2012. The diversion was backfilled.
46	April 1999	MPC Capture System Installation Report	The Wash Tray Pond, Units 3&4 Bottom Ash Pond, and the Sediment Retention Pond Areas were studied. As part of the investigation well 17M-2 was drilled so the seal on well 17M seal could be evaluated. Converted 6M for capture and started. 41SP determined to be impacted by past Brine Pond or drain collection pond and influenced by WECO well. 21S converted to capture well. Plans to reduce size of A/B ponds and line B pond	A hydrologic divide trending northeast-southwest was identified near the Wash Tray pond and Units 3&4 Bottom Ash Ponds. Water quality at well 9M improved. Water in 6M was interpreted to be affected by pond water and was converted to a capture well. Groundwater at 41SP showed increases in indicator parameters for the Brine Pond and Drain Collection ponds. These increases were interpreted to correspond with pumping at the WECO crusher dewatering well. MPC negotiated with WECO so the well could be used as both a recovery and crusher dewatering well. Well 21S was converted to a capture well. Groundwater recovery continued west of the A/B ponds. A capture zone of about 200 to 300 feet was predicted based on groundwater modeling. A mound was present in near well 33S, at the south end of the Wash Tray Pond.
47	April 15, 1999	1 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	Brine pond capture system operated. D4 underdrain collected no water. Well 4S boron concentrations increased. SRP wells operated, three more sumps installed, water quality improving. MSE/HKM began study on AB pond for long term solution. Wells 9M, 17D and 17M showed declining water quality.
	December 17, 1999	**PPL Closes on assets**		
48	March 2000	PPL Montana, LLC Fall 1999/Winter 2000 Groundwater Investigation Report Colstrip, MT, Hydrometrics, Inc.	This report included an evaluation of capture systems on the Plant Site including the Units 3&4 Bottom Ash Pond, Sediment Retention Pond, south Cooling Tower Blowdown Pond, and Brine Pond areas.	The evaluation concluded that the 21S and WECO dewatering wells were effectively capturing groundwater in the vicinity of the Units 3&4 Bottom Ash Ponds. Water flowing southward may not being completely captured, however. Additional investigation of the area south of the ponds was recommended based on the quality of water in the ponds and the presence of mining spoil to the south that may contain similar or poorer water quality. Brine pond groundwater capture system was continuing to effectively capture groundwater. A scheduled maintenance program was suggested to address scale buildup in the wells. The Sediment Retention Pond recovery system was pumping at an average of 32 gpm in 1999. Water levels were effectively being lowered in the area at this rate. PPL was in the process of altering the Units 1&2 Fly Ash A/B ponds to help mitigate local groundwater conditions.
49	April 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	Brine pond D4 underdrain collected no water. Brine pond capture system out of service 2.5 months. Improved water quality wells west of Units 1&2 A/B Flyash ponds. MSE/HKM completed design for Fly Ash Slurry pipeline so dredging not required Water at wells 6S, 6D, 9M, 16M, 16SP,17M, 37SP, located near the Units 3&4 Wash Tray Ponds, showed declining water quality.
50	May 2000	PPL Montana, LLC March 29, 2000 East Fork Armells Creek Return Water Spill and Cleanup Report, PPL Montana, LLC	A weld failed on the effluent pipeline that was used to transport flyash slurry from the Units 1&2 A/B Flyash Pond on March 29, 2000. The break	PPL shut down the dredge and mitigation efforts began a short time after the line broke. These mitigation measures included isolating the portion of East Fork Armells Creek that was impacted by the spill. Pumps were used to collect water from the creek. Water was pumped either to water

TABLE 3-2
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	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
	May 2000 (continued)		occurred as water from the clearwell was being pumped through the pipeline to purge fly ash slurry from the pipeline. The spill was the result of a broken weld on HDPE pipe. An estimated 122,500 was spilled. Most of the liquid was contained by earthen berms which directed the water to a temporary retention pond. However, an estimated 9,000 gallons of liquid entered the East Fork Armells Creek.	wagons and hauled to Plant Site ponds, or to the Waste Water Treatment Plant (WWTP) holding cell #3, from which it was pumped back to Plant Site ponds. An estimated 273,000 gallons of water (114,000 return water, 159,000 impacted water from EFAC) were recovered. An additional, 40,000 gallons of impacted water were pumped from the Wastewater Treatment Plant cell #3. Water quality samples were collected to delineate impacts portions of the East Fork Armells Creek and to evaluate creek water quality following spill cleanup efforts. Results of the sampling showed that a "slug" of water with process water impacts moved slowly downstream. Water quality following the spill was compared to data collected from previous synoptic runs. It was concluded that the creek water quality had returned to its pre-spill conditions approximately three days after the event occurred.
51	June 2, 2000	Groundwater Quality Data Assessment for Montana Power Company Regarding the Colstrip Project, URS Greiner Woodward Clyde	Groundwater quality assessment report	Description of Plant Site hydrogeology, characteristics of hydrostratigraphic units, and water quality. Potential contaminant sources were listed. Impacted wells identified in the Units 1&2 A/B Flyash Ponds, Brine ponds area, Units 3&4 Wash Tray Pond, Units 1&2 Sediment Retention Pond, Units 3&4 Bottom Ash Ponds, North Pond (North Plant Drain Pond), and various slurry spills. Summarized capture systems.
52	August 2000	Memorandum: 2000 East Fork Armells Creek, Hydrometrics, Inc.	Report summarized result of a synoptic run conducted on East Fork Armells Creek. Five existing sites and five new sites were monitored for flow and quality.	East Fork Armells Creek gaining due to groundwater inputs, contributions from the sewage treatment ponds, townsite, surge pond, golf course irrigation and domestic runoff sources. Concentrations of TDS, sulfate and boron increased between AR-5 and AR-3. Concentrations of these parameters drop downstream of AR-3 and are relatively constant to AR-6, where a slight increase in sulfate occurred. Concentrations of most chemical constituents decreased when compared to previous samples from AR-5 to AR-1.
53	January 2001	PPL Fall 2000 Groundwater Investigation Report, Hydrometrics, Inc.	Plant site studies described in this report included results of a synoptic run at five established sites on East Fork Armells Creek and an evaluation of water quality near the Units 3&4 Bottom Ash Ponds.	Water quality trends and flows were generally similar to previous synoptic runs. However, water quality at the upper sites showed a slight improvement. Mixing calculations for the 3&4 Bottom Ash Ponds using standard water quality suggest that changes in ionic composition would occur in the spoil. However, no significant changes in total dissolved solids or SC were indicated. Slight increases in boron concentrations were likely.
54	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	Water levels higher in wells near Brine Pond Collection system. D4 Pond underdrain ran for 306 hours. New fly ash slurry pipeline nearly installed from A/B ponds. Units 3&4 Wash Tray Pond area wells showing better water quality. Need to expand capture in 3&4 Bottom Ash Pond based on water quality in local wells.
55	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. PPL has implemented some of these alternatives and are currently experiencing a reduction in water storage requirements.
56	December 2001	PPL Montana Fall 2001 Groundwater Investigation and Capture System Installation Report, Hydrometrics, Inc.	Groundwater capture was evaluated in the Units 1&2 A/B pond area using computer modeling.	Results of the groundwater modeling suggested that pumping from existing wells 5M, 10M, 31M and four additional new wells were needed to better capture water west of the Units 1&2 A/B ponds. A phase approach of implementing the groundwater capture was suggested. The well seal evaluation for well 19D concluded that the seal had likely failed and the well should be replaced. Four wells (51SP, 52SP, 53SP, and 54SP) were installed around the Units 3&4 Bottom Ash Ponds to provide a system for future capture, if necessary. The wells were later converted and are currently being used to capture groundwater.

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SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
57	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	Wells 51SP through 54SP installed near Units 3&4 Bottom Ash Ponds. Plan conversion of wells for capture in 2002. These wells will supplement area capture from wells 21S and the WECO dewatering well, which pumped about 55 million gallons of water in 2001. Water quality near the Brine Pond continuing to improve. No water in Brine Pond D4 underdrain. Well 19D annular seal failed, plans include well replacement. Water quality improvement near well 19D. New slurry pipelines from plant to Units 1&2 Stage II Evaporation Pond in service. Fall 2001 began separation of A/B ponds. Deeper groundwater collection planned in Units 1&2 A/B Flyash Pond area in 2002.
58	July 22, 2002	Letter report from PPL/EED to MDEQ	Report on June 2, 2002 Slurry Spill on road to Units 1&2 B Pond	Approximately 1000 gallons of water/slurry lost due to loose flange. Fluid was contained and 75% recovered. About 8 cubic yards of soil were removed. Leak stopped with isolation valves, flange secured, pipeline put back into service. Colstrip EED contacted MDEQ.
59	January 20, 2003	PPL submits results of pond sampling for 51 parameters to MDEQ	Analytical results submitted.	Few concentrations above WQB-7 standards
60	January 2003	2002 Groundwater Investigation Report PPL Montana, L.L.C., Hydrometrics	Work recommended in the 2001 Groundwater Investigation Report was conducted including well conversions west of the Units 1&2 A/B Ponds and the Units 3&4 Bottom Ash Ponds, well installation and well abandonment.	Capture wells installed by Units 3&4 Bottom Ash Ponds (51SP, 52SP, 53SP, and 54SP) were converted to capture wells. Water from the wells was routed to the Units 3&4 Bottom Ash Clearwell. Pumping from these wells began in June 2002. These wells supplement capture by well 21S and the WECO well. Investigation of McKay and Sub-McKay units west of Units 1&2 A/B ponds indicated process pond impacts. Four wells and six piezometers were installed. Nine monitoring wells (1D, 5M, 10S, 10M, 55D, 56D, 58M, 59M, 31M) were converted to capture groundwater – only 7 fit with pumps initially. All nine are currently operational. Well 19D abandoned and replaced with 19D-2
61	January 2003	December2002/January 2003 Process Pond Sampling and Analysis Report, Hydrometrics, Inc.	Summary of process pond water quality analysis.	Samples were collected from Plant Site Units 1&2 Bottom Ash Pond Clearwell, Units 3&4 Bottom Ash Pond Clearwell, Raw water line feed, Cooling Tower Blowdown Pond C, and the Units 1 &2 AB Pond Clearwell. Parameters analyzed in the ponds were agreed upon by PPL Montana and MDEQ. Three ponds showed elevated levels of molybdenum and one showed elevated manganese.
62	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	Water quality at wells 4M and 36M declined; will continue to watch. Brine pond capture system operated and water quality in area steady or slightly improved. No water entered D4 Brine Pond underdrain. Units 1 &2 B Flyash Pond dewatered in 2002, plan to remove solids in 2003, construct new lined pond in 2004. Stable or improving water quality continues in Units 3&4 Wash Tray Pond and Cooling Tower Blowdown Pond area. Collection of groundwater began at 51SP and 54SP, 52SP and 53SP scheduled to begin pumping in 2003. Spoil recharge appears to be significant in WTP and Cooling tower blowdown pond area.
63	July 31, 2003	Memorandum: East Fork Armells Creek, Hydrometrics, Inc.	Summary of synoptic run results from May 2003 event. Included 11 surface water sites plus one treated sewage effluent pond.	Flow increased from AR-5, with the largest increase measured between AR-2 and AR-1 (directly downstream of Colstrip sewage wastewater ponds). Flow decreased between AR-1 and AR-9. Flow between AR-9 and AR-6. Water quality results were generally similar to, or slightly higher than, previous events. The main exception was chloride concentrations, which were higher at sites AR-1 through AR-5.
64	February 9, 2004	Results of additional pond analysis for Units 1&2 A/B Flyash ponds requested by MDEQ January 12, 2004.	Analytical results	Sampled for Dioxins and PAH's– results non-detect

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	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
65	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 61M, 62S, 63S installed west of Plant Site. Brine Pond wells 4M and 36M continued poorer water quality. No water in D4 Brine Pond underdrain. Well 10M began collecting groundwater (July 2003). Well 55D began collecting groundwater (July 15, 2003). Water quality improvements seen at 10S and 42S since draining Units 1&2 Flyash B Pond. Wash Tray Pond/Cooling Tower Blowdown Pond - 6M continued to collect groundwater 3&4 Bottom Ash Pond collection systems operated all year.
66	May 2004	PPL Montana, LLC, 2003 Groundwater Investigation Report Colstrip, Montana, Hydrometrics, Inc.	Further evaluation was conducted west of the Units 1&2 A/B ponds including installation of wells 61M, 62S, and 63S. Groundwater capture efforts in this area were further evaluated. Water at wells OT-12 and 63S was evaluated; groundwater in the northwest corner of the Units 1&2 A/B Ponds was evaluated. The well seal for well 4M was tested. The vicinity near well 36M was evaluated for flow and quality. A synoptic run was conducted on East Fork Armells Creek including monitoring at 10 existing sites, one new site, and one pond site.	West side of A/B pond studied to further delineate impacts. Impacts appear to be restricted to east side of creek. Areas with elevated levels of chemical constituents were identified at CA-19A, 1S, 5S, and OT-12. East Fork Armells Creek was considered a hydrologic divide since groundwater from both sides of the creek were flowing towards the creek and the creek was gaining flow through town. Magnesium chloride solution used to suppress dust on some area roads may contribute to elevated levels of these constituents. Well CA-19A was completed without protective casing and is therefore not a secure monitoring point. Groundwater quality improving northwest of A/B pond area. A sharp increase in indicator parameters suggested a possible problem with the seal at well 4M. However, based on the evaluation, it was concluded that the seal was intact. It was suggested that a small leak in the annular seal could exist which would allow water from the shallow unit to flow downward into the McKay interval. Samples collected after purging large than normal volumes prior to sample collection showed lower concentrations of chemical constituents. This could be indicative of a small amount an annular seal leakage. Additional pumping for further sample collection was suggested. 36M water quality changes believed to be from spoil recharge and additional monitoring was suggested prior to conducting further detailed evaluation in this area. Results of the Synoptic run of East Fork Armells Creek showed similar trends but water quality slightly worse as creek passes plant site. In general, however, water quality was slightly better than previous events.
67	July 2004	Preliminary Conceptual Hydrogeological Model Stage I and II Evaporation Pond and Plant Site Areas Colstrip Steam Electric Station Colstrip, Montana, Maxim Technologies	Report summarized the conceptual groundwater model for the Plant Site.	Noted that the principal water bearing zone in the Plant Site area is the alluvium, spoils, unconsolidated overburden and Rosebud Coal. Deeper systems are Mckay Coal and Sub-McKay sandstones. Groundwater in the southeastern portion of the site flows to the southeast while water in the northern portion of the site flows to the northwest towards East Fork Armells Creek. Groundwater beneath and downgradient of the Plant Site are elevated relative to the surrounding groundwater in the area. Water quality suggests seepage may still be occurring from the Units 1&2 A/B ponds. Mounding is present in the Units 3&4 Bottom Ash Pond area and moderately elevated levels of chemical constituents are present, suggesting seepage from the ponds. Water quality and potentiometric data suggest that the Units 1&2 Cooling Tower Blowdown Ponds are a continuing source of moderate to poor quality water to shallow groundwater. Poor quality water near wells OT-12, 63S and CA-18 is not likely sourced from the Plant site based on groundwater flow directions. No private wells are impacted from the Plant Site. Additional wells were suggested downgradient of the Plant Site.

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	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
68	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	Three new wells installed. Two special projects, bottom ash sales approved – amendment to Certificate and use of collection water for highway construction – water pumped to Cooling Tower Blowdown Pond and tested prior to use. 270,000 gallons used. Brine pond area exhibited increase in water levels at well 12R-2 – 8 feet. D4 underdrain damaged, no water collected. Groundwater quality in area stable to slightly improving. Sediment Retention Pond A/B pond area groundwater capture continued at collection systems. Units 1&2 B pond was rebuilt utilizing a double liner and leachate collection system. Wash Tray Pond/Cooling Tower Blowdown Pond area - WECO began pumping water to WECO Pond #10, south of area. Water levels in area rose substantially
69	September 2005	Technical Memorandum: 2005 East Fork Armells Creek Synoptic Run, Hydrometrics, Inc.	Summary of 2005 synoptic run on East Fork Armells Creek. Twelve surface water sites were monitored for flow and quality. On treated sewage effluent pond was sampled for quality. Site AR-12 was a new site during this event.	Site AR-12 was added to the synoptic run and is located directly upstream of the Highway 39 culvert. Measured flow tended to increase from the uppermost site (AR-12) to about AR-1. In 2005, flow decreased between site AR-1 and AR-6. A slight increase in flow occurred downstream of AR-6. In 2005, water quality trends along East Fork Armells Creek were similar to previous events with concentrations of total dissolved solids increasing between AR-5 and AR-3, decreasing between AR-3 and AR-1, and remained relatively steady downstream of AR-1. Slight increases in sulfate, TDS and nitrate plus nitrite were observed at AR-10 as was the case during previous events. As with previous events, chloride concentrations were highest at the uppermost site (AR-12 in 2005), decreased between AR-12 and AR-1, and were relatively stable downstream of AR-1.
70	November-December 2005	Pond D4 Capture System Progress Report, Hydrometrics, Inc.	In November 2005, PPL personnel observed rising water levels in monitoring wells northeast of the D4 Brine Pond. Subsidence features were also observed on the ground adjacent to the pond. Results of this investigation were summarized in the Plant Site 2004, 2005, 2006 Update Report, Hydrometrics, 2007	PPL immediately took action to control effects of the apparent liner failure. Water level rises were observed in wells 25SP and 26SP and elevated SC (>40,000 µmhos/cm) was measured at 26SP. Water level rises and increases in SC were observed in other area wells. Brine Pond groundwater capture system wells B-1, B-4 and B-5 were collecting water at the time of the failure. Groundwater recovery was immediately begun at wells 4S and 26SP. Wells 70SP, 71SP, and 72M were installed to further characterize the area. Expansion of area groundwater capture was implemented by converting wells 4S, 19SP, 26SP, 29SP, and 70SP to capture wells. New piping was installed for the original Brine Pond Capture system. Startup of the expanded capture system began between December 14 and December 22, 2005. Potentiometric maps constructed prior to startup of the expanded capture system showed about 12 feet of groundwater mounding near the east corner of pond D4. By January 2006, mounding affects had been removed by operation of the pumping system. PPL removed D4 from service following the failure.
71	February 2006	Plant Site Area Groundwater Model Development and Calibration Colstrip Steam Electric Station Colstrip, Montana, Geomatrix	Report describing development of a numerical groundwater flow and transport model for the Plant Site. Model was developed using MODFLOW-2000 and MODPATH was used to simulate advective transport of dissolved constituents in groundwater.	A model domain covering approximately 2365 acres of the Plant Site was developed. The model includes the process ponds at the Plant Site, East Fork Armells Creek, and the Colstrip Town Site. The model is a multiple layer simulation with grid spacing ranging from 25 feet near the center to 100 feet at the extremities. A series of boundaries, recharge sources, and well locations were incorporated into the model. Potentiometric surfaces simulated by the model were calibrated to hydrostatic heads measured between 2001 and 2003. This allowed model calibration prior to the major portion of mitigation activities at the facility. Sensitivity analysis conducted during the modeling indicates that hydraulic conductivity and recharge values reasonably simulate hydrologic conditions. The model was considered to be available for use in evaluating ongoing groundwater capture activities at the site.

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SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
72	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	Six new wells were installed; 67M, 68A, and 69R west of the Cooling Tower Blowdown Pond, and 70SP, 71SP, and 72M near the D4 Brine Pond. Bottom Ash was sampled in the second and third quarters to meet amendment requirements to the Certificate of Environmental Compatibility and Need to sell bottom ash. A breach of the D4 Brine Pond liner was discovered through monitoring at well 26SP. PPL immediately began dewatering the pond and initiated investigation and mitigation activities. These activities included installation of additional monitoring wells, conversion of five wells for capture (4S, 19SP, 26SP, 29SP, and 70SP) and upgrades to the existing Brine Pond Capture system. Water from the system was routed to the lined Units 1&2 B Flyash Pond. The D4 Brine Pond was essentially empty by late November 2005 and was being evaluated for closure. Water quality was improving in the area prior to the D4 Pond incident. Water quality at wells 1D, 5M, 5S, 10S, and 31M showed a decline when compared to the previous three years. All of these wells except 5S are collection wells. Well 5S was to be evaluated for conversion to a capture well. Wells 1S, 42S, and 45S showed improving water quality. A reduction in the volume of groundwater collected by area capture systems was observed in 2005. The lower capture volumes are possibly related to modifications made to the A/B Fly Ash ponds. Stable or improving water quality continued in the Wash Tray Pond and Cooling Tower Blowdown Pond area. Wells 16SP and 38SP, however, showed a decline in water quality when compared to previous years. Western Energy routed water to holding pond 10, located south of well 6M. Increases in the amount of groundwater pumped by well 6M are believed to be related to this activity. In the Units 3&4 Bottom Ash Pond area groundwater quality was stable with the exception of well 52SP which showed a slight decline in quality.
73	May 2007	Data Analysis and Statistical Evaluation of Un-impacted Groundwater Quality Stage I/II Evaporation Ponds and Plant Site Areas Colstrip Steam Electric Station, Colstrip, Montana, Arcadis	Data analysis and statistical evaluation were conducted on un-impacted groundwater data to establish background levels for multiple stratigraphic intervals in the Plant Site Area. This evaluation furthers a preliminary statistical analysis conducted by Maxim Technologies in 2004.	Data used in the original analysis was revised based on further evaluation of existing data and incorporation of additional data obtained since the original study. Several changes were made to the original analysis to provide a stronger analysis. One major difference was the use of an upper confidence interval for the percentile rather than for the mean. A second difference was the approach used as a weighting mechanism depending on the amount of data available for various sites. In addition, a non-parametric approach rather than a parametric approach was used to calculate the 95th percentile upper confidence limit on the mean. Outlier analyses were conducted to identify extreme values in the data set and evaluate their usefulness in the statistical studies. Baseline screen levels were calculated by parameter and hydrostratigraphic unit.
74	August 2007	PPL Montana, LLC Plant Site 2004, 2005, 2006 Update Report, Hydrometrics, Inc.	Report summarized findings of investigations and mitigation activities conducted on the Plant Site in 2004, 2005, and 2006. Work included isotope sampling of wells west of the Plant site, installation of monitoring wells north and west of the site, as well as in the D4 area, capture system expansion activities, and the 2005 synoptic run of East Fork Armells Creek.	Investigation north of the Plant Site included installation of wells 64A through 80D. Based on these studies groundwater capture was recommended for this area. D4 investigation was completed indicating a liner failure at the D4 Pond. Three new wells were installed and five additional capture wells were added to the Brine Pond Capture system. Mounding which was observed after the liner failure was removed by the pumping and a depression formed in the water table near well 70SP. This capture system continues to operate. Wells 67M, 68A, and 69R were installed west of the Plant Site. Based on the groundwater analytical results and results of Plant Site groundwater modeling, well 68A was converted to a capture well. This well continues to operate as a capture well.

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SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
	August 2007 (continued)			Results of the 2005 Synoptic run showed similar trends to previous events, with flow increasing downstream of AR-5 and concentrations of chemical constituents increasing between AR-5 and AR-3 and then decreasing below the sewage effluent ponds for Colstrip. Overall, concentrations of chemical constituents were near the higher range of historical values. Sediment samples were collected during the 2005 Synoptic run. Mercury was not detected in any of the samples, low to non-detectable levels of selenium were present. Groundwater samples were collected from several monitoring wells in the Plant Site area. Results generally plotted below the global meteoric water line for hydrogen and oxygen isotopes, suggesting some degree of evaporative effects were present in the water.
75	August 2007	Technical Memorandum: 2007 East Fork Armells Creek Synoptic Run, Sediment Sampling, and Groundwater Sampling, Hydrometrics, Inc.	Investigation involved conducting a synoptic run at existing sites along East Fork Armells Creek, sediment sampling, and groundwater sampling at several stream bank locations	East Fork Armells Creek is an intermittent creek. As in past synoptic runs, flow showed a general increase in a downstream direction between AR-12 and AR-1, decreased between AR-1 and AR-8, and increase downstream of AR-8. Overall flow patterns were similar to previous years. In general, water quality was similar to previous synoptic runs. TDS concentrations showed an overall decrease from AR-12 to AR-10 (PBR Flume). However, TDS concentrations increased between AR-4 and AR-3. Chloride concentrations higher than average and the highest concentrations were observed at upstream site AR-12 with a general overall decrease downstream. Boron and sulfate concentrations increased between AR-5 and AR-3 then decreased downstream of AR-3. However, sulfate concentrations showed a slight increase between AR-6 and AR-10. Ratios of calcium to magnesium were generally level (near 0.75) upstream of site AR-3 and then were generally higher than 0.8 downstream of AR-3 Groundwater flow was generally towards the creek from both banks in 2007. Sediment samples were mainly silty to sandy loam. Soil sample concentrations varied widely with the following observations: Sulfate concentrations were highest at AR-5 and AR-10, Chloride concentrations were highest at AR-12, as were water chloride concentrations. Boron concentrations were highest at AR-5. Selenium was generally low to non-detect and mercury concentrations were highest at AR-2.
76	July 2007	DRAFT – Conceptual Model Update Report Stage I and II Evaporation Ponds and Plant Site Areas Colstrip Steam Electric Station Colstrip, Montana, Geomatrix Consultants, Inc.	A MODFLOW based numerical groundwater flow model was updated with additional information collected since initial model development. Several wells were installed and groundwater capture systems installed. Water quality data were reviewed.	Groundwater capture information was incorporated into the model and aided in calibrations. Maps were developed showing contours of various indicator parameters. Results showed areas of elevated chemical constituents below the D4 Brine Pond, Units 3&4 Wash Tray Pond, portions of the northwest and west area of the Plant Site. Elevated chemical concentrations were indicated on the northwest part of the plant site.
77	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	Wells 73A, 74A, 75A, 76A, 77D, 78A, 79A, and 80D were installed north of, and in the northwest portion, of the Plant Site. Bottom Ash was sampled all four quarters of 2006 to meet amendment requirements to the Certificate of Environmental Compatibility and Need to sell bottom ash. D4 Brine Pond closure activities began in 2006. Solids in the pond were moved to the southwest corner where the existing liner was believed to be intact. A perimeter drain system was installed. A 35 mil RFP liner will be installed over the top in 2007 and the area will be reclaimed with a soil cover and seeding. Groundwater capture continued in the vicinity of the D4 Brine Pond in 2006 with 17.5 million gallons being pumped. Groundwater quality improved significantly in 2006.

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	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
	Oct. 2007 (continued)			Groundwater from at wells 1S, 12R-2, 49S, 56D, and 57M-P improved significantly, as did water at collection wells SRP-1 through 8, 1D, 5M, 56D, 58M, 59M, and 31M. Groundwater quality at 5S, 10S, 42S, 50S, 55D, and 60M-P showed declining water quality. Expansion of groundwater capture north of the Plant Site is planned in 2007. This is based on evaluations that were conducted in 2006. Groundwater quality improved at wells 9S, 17SP, 33S and capture well 6M in 2006. A slight change in water quality was observed at 17M, 37SP, and 62S. Groundwater quality was generally stable in the Units 3&4 Bottom Ash Pond area in 2006. Capture wells 21S and 54SP were the exceptions with a slight decline in water quality.
78	May 2008	Groundwater Modeling Update Report Plant Site Area Colstrip Steam Electric Station Colstrip, Montana, Geomatrix Consultants, Inc.	Hydrologic data obtained from the previous model update was incorporated. These data included lithologic descriptions, aquifer test data, aquifer responses to monitoring wells surrounding the D4 Brine Pond following the liner breach, groundwater elevation data from additional Plant Site wells, incorporation of additional capture wells and incorporation of capture well extraction rates. Some additional modifications were completed to incorporate potential additional recharge sources including sediment ponds on nearby mine property, ephemeral drainages, and to adjust hydraulic characteristic based on new data and/or better understanding of hydrogeological conditions. Groundwater capture analysis was conducted.	Once calibration was completed to acceptable levels under both steady-state and transient conditions evaluation of groundwater capture systems was conducted. Steady-state model simulations with particle tracking were conducted to evaluate groundwater capture system effectiveness. The particle tracking results indicate effective capture from all areas known to have affected groundwater with the exception of an area near the North Sediment Pond. Model simulations indicate particles emanating from the pond would flow into the McKay and move north past capture systems. Capture analysis further indicates that impacted water flowing north of the Plant Site will likely not migrate beyond the Colstrip Sewage Lagoons due to capture systems installed in the area. Current groundwater capture simulations indicate that water flowing from the North Sediment Pond would not be captured.
79	July 17, 2008	Technical Memorandum: 2008 East Fork Armells Creek Synoptic Run and Groundwater Sampling, Hydrometrics, Inc.	Summary of surface water and groundwater sampling and flow measurements for a synoptic run conducted on East Fork Armells Creek on April 3, 2008.	Creek Flows were lower than previous events, except for the 2004 event. Flows were lowest measured during any of the synoptic runs at sites AR-1 and AR-9. As with previous synoptic runs, a net increase in flow occurred from the upstream site to the downstream site. However, flow decreased between AR-5 and AR-3 and between AR-1 and AR-9. Lower flows may be the result of increased capture efforts by PPL at the Plant Site. Concentrations of chemical constituents followed similar trends to those observed in previous synoptic runs. Sulfate, TDS, and boron concentrations were lower than average concentrations at all of the sites. Calcium to magnesium ratios were higher than average for all sites except AR-5. Nineteen groundwater samples were collected and groundwater elevations were calculated. Groundwater was flowing towards the creek except at sites AR-6 and AR-7. TDS concentrations were higher on the east bank at AR-5, AR-6 and the golf course clubhouse. TDS concentrations at AR-3, AR-1, AR-7, AR-11, and at the ballpark. TDS concentrations were similar on both banks at AR-4. Isotope samples collected from both surface and groundwater sites plotted below the global meteoric water line suggesting at least some influence from evaporative effects which occur in surface water bodies.

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80	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	Closing of the D4 Brine Pond was completed in 2007 by installing a 35 mil RFP cap, soil cap, and seeding. Groundwater collection continued and water quality improvement was observed in the area. Several wells showing improving water quality north and west of the Units 1&2 A Pond. Wells 5S, 42S, 50S and 60M-P showed declining water quality. Wells 5S and 50S will be evaluated for capture in 2008. Groundwater capture was expanded north and northwest of the Plant Site by converting 74A, 75A, 78A, 79A, 82A, and 43S. Water quality was stable in the Units 3&4 Bottom Ash Pond area except at wells 20S, 21S, and 22SP, which showed a decline in quality but the observed concentrations were within historical ranges.
81	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	Wells 84SP, 85SP, 86SP, 87SP, 88M, 89SP, 90R, 91S were installed in 2008. Water quality has continued to improve in the Brine Pond area although well 4M showed a slight decline in 2008. Additional capture is currently being considered near well 41SP. Groundwater quality west and northwest of the Plant Site in 2008 was highly variable with several wells showing improvement and others showing declining quality. The area north of the Plant Site showed an overall improvement in quality. Well 5S was converted for additional capture and well 91S was installed to monitor quality. Water from well 40SP showed a decline in quality in 2008. Water quality was stable in the Units 3&4 Wash Tray Pond area, with the exception of well 22SP, where a decline was observed.
82	May 2009	PPL Montana, LLC 31M Area Well and Capture System Installation, Startup and Performance, Hydrometrics, Inc.	Phased installation of monitoring wells was conducted on the northwest Plant Site and the area north of the site. Wells 64A through 83A were installed to evaluate groundwater in these areas. Wells were sampled and selected wells were aquifer tested.	Based on the results of the investigations wells 43S, 74A, 75A, 78A, 79A, and 82A were converted to groundwater capture wells and pumping from these wells began in November 2007. Water levels in the capture wells and area monitoring wells are monitored to evaluate the effectiveness of the groundwater capture. Pumping rates at system startup were about 120 gpm. Potentiometric surface maps constructed using December 2008 data showed groundwater depressions near pumping well 64A and 78A. At this time groundwater flow was eastward on the east side of East Fork Armells Creek. Water quality had shown an overall improving trend.
83	May 28, 2009	Technical Memorandum: 42S Area Investigation, Hydrometrics, Inc.	Evaluation of current conditions near well 42S. Work conducted during this investigation included: expanded monitoring and sampling of the current area wells, creating a potentiometric map and total dissolved solids (TDS) iso-contour map of the area, evaluating the need for the installation of additional monitoring wells, and evaluating the need to convert existing monitoring wells to capture wells.	Potentiometric lines show depressions in the water table near wells 78A and SRP-5. Little drawdown was observed at the time near capture well 5S which was not pumping at the time water levels were measured. Mounding of the groundwater table, which was present in 1996, was no longer present. The absence of the mounding is the result of pond upgrades made by PPL which included separation of the Units 1&2 A/B ponds and lining of the B Pond, and groundwater capture initiated north and west of the ponds. Well 42S is upgradient of these capture systems. The highest concentrations of chemical constituents in wells sampled during this investigation were associated with capture systems or in piezometers located upgradient of groundwater capture within the pond system boundaries. Areas of highest TDS had moved downgradient approximately 400 feet, at a velocity of about 0.1 foot per day. Overall, water quality in the area has improved since 1996, both up and downgradient of groundwater capture systems. Further evaluation of groundwater conditions, west of the Plant Site is planned.

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84	June 2009	2009 Engineers Inspection Pond AB Dike Colstrip, Montana, Hydrometrics, Inc.	Report summarizing Engineers inspection of the Units 1&2 A/B Pond external embankment (Dike).	Report contained visual observations, appurtenant structures, and downstream areas for evidence of seepage, unstable slopes and erosion characteristics. The report included several recommendations to help maintain structure stability. These recommendations included removal of vegetation, rodent control, re-contouring, monitoring of recent disturbances to make sure vegetation becomes established, removal of abandoned piping, repair of eroded areas near crest, conduct stability analysis based on embankment geometry and composition.
85	June 2009	PPL Montana, LLC Monitoring Well Installation Plant Site Area at 41SP Colstrip Steam Electric Station, Hydrometrics, Inc.	An investigation was conducted on well 41SP. The results of which resulted in installation seven additional monitoring wells, aquifer testing, and water quality sampling. This report summarized the findings of that investigation.	Water quality in the wells was highly variable. Groundwater at well 41SP showed stratification with relatively low SC near the top of the water column and elevated SC with depth. Water at 41SP was showing pond water impacts. Groundwater from 84SP, 85SP, 86SP and 89SP had low boron concentrations, TDS concentrations between 4920 and 6980 mg/L, and sulfate between 2230 and 4100 mg/L. Values of pH ranged 5.0 to 6.8 which may be an indication of acid generation from spoils which would result in higher sulfate and TDS levels. Groundwater at 87SP, 88M and 90R did not show evidence of pond water impacts, although water at 90R exhibited a pH of 6.3. Well 91S was installed to monitor the effectiveness of groundwater capture near well 5S. A capture well near well 41SP was recommended.
86	July 2009	PPL Montana, LLC 2009 Pond Capacity Survey, Hydrometrics, Inc.	Pond survey conducted so remaining capacity and water volumes could be calculated. On the Plant Site this included the Units 1&2 Fly Ash Pond A.	The Units 1&2 Fly Ash A/B ponds were originally a horseshoe shaped pond. The ponds were separated with the A pond remaining lined with natural materials and the B pond line with reinforced polyethylene and constructed with an underdrain system. The elevation of the water surface at the time of the survey was about 3258 feet. The amount of fly ash present in the pond was calculated to be 420,000 cubic yards. The water volume was calculated at 33 million gallons. At an elevation of 3265 the pond would hold about 62 million gallons. Pond B was calculated to have 44 million gallons of water. Solids, a combination of fly ash and sediment directed to the pond from on-site storm water or water management practices was calculated to be 5 million gallons (24,000 cubic yards). Stage full capacity – elevation 3264 would hold and additional 58 million gallons.
87	July 8, 2009	Technical Memorandum: 3&4 Bottom Ash Pond Clearwell Sampling, Hydrometrics, Inc.	Memorandum summarizing sample results of the Units3&4 Bottom Ash Pond Clearwell following a malfunction of the plant turbine lube oil conditions system which resulted in an overflow of the oil-water separator sump, which resulted in oil being 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. PPL 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.
88	July 14, 2009	Technical Memorandum: 2009 East Fork Armells Creek Synoptic Run and Groundwater Sampling, Hydrometrics, Inc.	Report on 2009 synoptic run on East Fork Armells Creek. Existing sites were used for surface water and groundwater sample collection as well as flow measurement. Included sampling of thirteen surface water sites and one treated sewage effluent pond and 19 groundwater samples from stream bank sites. Stream flow measurements.	Flows were near average of previous events; flow increased overall from upstream to downstream. Flows decreased between AR-5 and AR-3 likely due to groundwater capture on the Plant Site. Flow also dropped between AR-1 and AR-9 possibly related to Town site water use or precipitation patterns. Flow decreased between AR-11 and AR-10 whereas an increase has been observed in this reach in past events. A compound weir will be installed at AR-10 in 2009 so more accurate flows may be obtained. Water quality trends (areas where concentrations typically increase or decrease) were generally similar to previous events. However, indicator parameters sulfate, TDS and boron were lower and ratios of calcium to magnesium were higher. Chloride concentrations were slightly higher than the average for previous events in the upper reaches but about average downstream of AR-2. Where groundwater samples were collected from both sides of the creek, TDS concentrations were higher at AR-5, AR-4, AR-1, Ball Park, and AR-11 and were higher on the east side at AR-3 and AR-6. The highest TDS and SC in groundwater were at the west bank at AR-4.

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89	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.	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.
90	December 22, 2009	Technical Memorandum: Plant Site Units 1&2 A Pond Sampling, Hydrometrics, Inc.	Results of pond bottom samples from the Units 1&2 Pond A. A pond bottom sample was prepared from subsamples collected from four transects across the pond. Samples were analyzed using saturated paste methods.	Analytical results showed 233 mg/L chloride, 4,700 mg/L sulfate, 13.8 mg/L boron and a specific conductance of 5,890 µmhos/cm.
91	January 2010	PPL Montana, LLC Colstrip Steam Electric Station Trailer Park Well Installation/Conversion and Pipeline Installation Report, Hydrometrics, Inc.	PPL initiated work to investigate and expand groundwater mitigation efforts west of existing capture systems that were operational east of the Units 1&2 A Pond. Work included installation of 19 wells, boring under the railroad tracks between the Plant Site and the southern portion of the townsite. Aquifer tests, either pumping or slug, were conducted, water quality samples were collected.	Based on the results of the investigation four wells (98M, 106A, 107A & 108A) were converted for groundwater capture. A pipeline was installed from the wells, under the railroad tracks and to the Units 1&2 Fly Ash Clearwell. Pumping began in September 2009 with a total pumping rate of about 43 gallons per minute. Water levels were lowered in the area and general improvement of water quality has been observed. Some scaling problems have been experienced, limiting the performance of some of the wells. Continued maintenance is conducted to optimize this capture.
92	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	PPL installed water treatment to treat relatively good quality water. The purpose of the treatment system is to allow the water to be used in different parts of the Plant so that water inventories can be reduced. The VSEP (vibratory shear enhanced process) processed up to 175 gpm after its startup in 2009. Overall, water quality has continued to improve in the vicinity of the D4 Brine Pond. A few wells have shown variable or declining water quality including 28SP and 4M. Well 111SP was installed near 41SP in 2009, and will be converted for groundwater capture. A geophysical investigation was conducted in this area in 2009. Two anomalies were identified, however, cultural interferences in the area compromised the effectiveness and no additional drilling was conducted. Concentrations of chemical constituents have increase in the Cooling Tower Blowdown Pond in 2008 and 2009. Numerous wells in the west and northwest areas of the Plant Site showed improving water quality in 2009. However, water from several of the wells showed increases in chloride. Groundwater quality at wells 5S, 42S, 50S, and 60M-P declined. An evaluation of the 60M-P area was conducted that included installation of 15 monitoring wells. Based on the results of the investigation wells 98M, 106S, 107S, and 108S were converted for groundwater capture.

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	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
	June 8, 2010 (continued)			Groundwater from well 9M showed a significant increase in chemical constituent concentrations in 2009. Other wells were stable, went dry (6S), or showed slight improvement. Water quality at well 22SP, located near the Units 3&4 Bottom Ash Ponds improved slightly. Groundwater from capture wells 53SP and 54SP showed significant increases in TDS in 2009.
93	July 2010	Technical Memorandum: 2010 East Fork Armells Creek Synoptic Run and Groundwater Sampling, Hydrometrics, Inc.	Report on 2010 synoptic run on East Fork Armells Creek. Existing sites were used for surface water and groundwater sample collection as well as flow measurement.	Flow was present at the upstream sites AR-12 and AR-5 but site AR-4 was dry. Flow resumed between AR-4 and AR-3. Overall flow was below the average of those previously measured. Lower flows are likely related in part to groundwater capture efforts at the Plant Site. Concentrations of chemical constituents tended to be at or near historical lows at most sites.
94	September 15, 2010	Technical Memorandum: Well 111SP Drilling and Conversion – DRAFT, Hydrometrics, Inc.	Describes installation of well 111SP	Well 111SP was installed near well 41SP. The well was later converted to a capture well.
95	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	Groundwater capture continued in the D4 Brine Pond area in 2010. Well 111SP was converted for groundwater capture in 2010. Groundwater quality in this area continued to improve, except at capture well 26SP were declining conditions were observed. Elevated concentrations of chemical constituents were present in water from 84SP. Groundwater in the west and northwest portion of the Plant Site was variable, although overall the quality appeared to improve. A general improvement in water quality in the Trailer Park west of the Plant Site was observed. Water quality at wellsCA-19A and OT-7 showed evidence of process water impacts. These wells will be evaluated for capture. Groundwater from well 33S located near the Units 3&4 Wash Tray Pond exhibited an increase in SC and Sulfate concentrations in 2010.
96	June 15, 2011	Letter from Hydrometrics to PPL Montana, LLC	Evaluation of Wash Tray Pond monitoring wells – PPL Montana, LLC Colstrip Steam Electric Station	The Units 3&4 Wash Tray Pond was constructed in 1983 and served as a scrubber pond until 1995. At the time of the inspection the pond contained residual fly ash and some water from precipitation runoff. Strata below the pond is primarily spoils which overlie Rosebud Coal or Interburden. The McKay Coal underlies the interburden. First groundwater is typically in the spoil or Rosebud Coal, if present. A divide was present under the pond in 1995, with groundwater flow to the east and west from the divide. More recently, the divide appears to have shifted southward resulting in the majority of the flow under the pond moving in a northwesterly direction. Current potentiometric maps showed no divide in the McKay. A single monitoring well was recommended based on the apparent flow of groundwater to the northwest.
97	August 2011	Technical Memorandum: 2011 East Fork Armells Creek Synoptic Run and Groundwater Sampling	Report on 2011 synoptic run on East Fork Armells Creek. Existing sites were used for surface water and groundwater sample collection as well as flow measurement. Thirteen surface water sites were monitored.	Flows measured in 2011 were mostly higher than the average for previous synoptic runs. As in previous years, an overall net increase in flow was observed from the uppermost site to the site AR-10, located the farthest downstream. Flow decreased, however, between sites AR-5 and AR-3, likely a result of groundwater capture at the Plant Site. 2011 was a wet year with greater than 20 inches of precipitation falling, much of it in the spring. The high precipitation may have been responsible for the highly variable flows measured in 2011.

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	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
	August 2011 (continued)			Water quality trends were generally similar to previous years. However, the concentrations of chemical constituents tended to be at or near historical lows, when compared to previous synoptic runs. One exception was chloride concentrations which were at, or near, historical highs at all sites, except AR-12 which has typically showed higher chloride levels. Generally, as streamflow increased, constituent concentrations decreased. Highest levels were observed at AR-12 and the lowest levels were present downstream of AR-1. Groundwater sampled in 2011 was primarily a magnesium-sulfate type, similar to surface water. The lowest concentration of chemical constituents was observed on the east bank near AR-1 while the highest concentrations were on the west bank near AR-4.
98	September 2011	PPL Montana, LLC Colstrip Electric Station Water Resources Monitoring Plan, PPL Montana, LLC	Water Resources Monitoring Plan	Outlines surface water and groundwater monitoring that is conducted for the operational water resources monitoring program. Monitoring sites, methods, and analytical parameters, frequency, quality control and quality assurance are all described. Contents of the annual water resources monitoring reports are based on data collected under this plan. The report supersedes previous plans.
99	December 2011	Technical Memorandum: Well 112R Installation, Hydrometrics, Inc.	Contains description of well 112R installation, testing and results – near the Units 3&4 Wash Tray Pond	Well 112R was installed about 100 feet northwest of the Wash Tray Pond. A relatively high hydraulic conductivity (51 feet per day) was calculated from short term pumping tests. The coal at well 112R is in direct contact with neighboring spoil, which likely influences the quality of water. Water from the well had an SC of around 4800 µmhos/cm, sulfate of 3,360 mg/L, chloride of 76 mg/L, boron of 1.8 mg/L and Ca:Mg of 1.17.
100	March 19, 2012	Technical Memorandum: Drain Pit#1 Sampling Results, Hydrometrics, Inc.	Results of clay liner and water quality samples in anticipation of closure of Drain Pit#1. Sediment and clay liner volumes were also estimated..	Results of analysis showed that the water present in the pond and the clay liner were non-hazardous. Between 15 and 20 cubic yards of sediment and 229 yards of clay were estimated to be in the Drain Pit.
101	June 2012	Evaluation of 2011Hydrologic Monitoring Data From Colstrip Units 1-4 Process Pond System Colstrip Steam Electric Station Colstrip, Montana, Hydrometrics, Inc.	Annual Water Resources Report	Forty-five capture wells and four under-liner secondary containment systems operated in the Plant Site in 2011. An improvement in water quality shows an improvement of 22% when compared to the worst measured SC. The VSEP wastewater treatment system operated at about 200 gpm in 2011, aiding in the reduction of pond water inventories. About 20% more groundwater was collected by the Brine Pond collection system in 2011, believed to be the result of abnormally high precipitation for the year. Water quality improved in this area, except at well 26SP where it declined. Water quality at well 28SP, located downgradient of the original Brine Pond capture system, showed an increase in sulfate and chloride concentrations and a decrease in Ca:Mg. These parameters are within historical ranges for this site but have shown an upward trend for several years. Wells 84SP, 85SP, 86SP, 87SP, 88M, 89SP, 91S, installed in 2008 between the Brine Ponds and the Units 3&4 Bottom ash ponds, have shown relatively consistent water quality or a slight improving trend. Concentrations in these wells are moderate to elevated. Potentiometric surfaces indicate groundwater from these wells would flow to existing capture wells. Water quality improved at 22 wells, declined at 13 wells, and was stable at 4 wells in the area adjacent to the Sediment Retention Pond and Units 1&2 Flyash Pond A. Overall, however, the water quality has shown an improvement over the past few years. In the trailer park area, water quality improved at eight wells, declined at four and remained relatively stable at eight wells indicating an overall improvement. Scaling problems have been experienced in capture wells in this area and are currently being addressed.

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	June 2012 (continued)			Passive groundwater capture (periodic bailing) was started at well CA-19A in March 2011. This well is a very low yield with less than one gallon being removed before it goes dry. Water quality has improved substantially at this well since these efforts began. Water quality declined at OT-7 in 2011. Passive capture was initiated at this low yield well in 2011. Well 112R was installed in 2011 in anticipation of potentially putting the wash tray pond back in service due to high water inventories caused by excessive precipitation. Water quality in the Wash Tray Pond and Units 1&2 Cooling Tower Blowdown Pond area decreased in 2011. These changes were believed to be related unusually high amounts of water in the Wash Tray Pond due to the high precipitation that was experienced in 2011. Water quality in the Units 3&4 Bottom Ash Pond area showed no significant changes in 2011.
102	November 2012	Technical Memorandum: 2012 East Fork Armells Creek Synoptic Run and Groundwater Sampling, Hydrometrics, Inc.	Report on 2012 synoptic run on East Fork Armells Creek. Existing sites were used for surface water and groundwater sample collection as well as flow measurement. Water quality samples were collected from 12 sites on the creek, one tributary, and one treated sewage effluent pond site.	Flow patterns were generally similar to previous years and were near the averages for previous synoptic runs. One difference, however, was that flow decreased between AR-5 and AR3. Average flows show an increase through this reach. Concentrations of chemical constituents were generally the lowest recorded and well below average at all sites. Exceptions are Nitrate plus nitrite concentrations which were elevated when compared to previous events. The source of the nitrogen is not known but the main increase was observed downstream of the sewage treatment plant wastewater ponds and on the golf course. Chloride concentrations were above average. Boron concentrations were near or below 1 at all sites. As in 2011 the lowest chemical concentrations in groundwater on the creek banks was at AR-1 (east bank). The highest concentrations were at the Club House –east site, AR-4 (east side) and AR-11 (west side).
103	November 2012	Plant Site Groundwater Model Redesign and Calibration Colstrip Steam Electric Station Colstrip, MT, AMEC Environmental and Infrastructure, Inc.	Update to groundwater model report	The previous version of the model was updated by adding new data for wells installed between 2005 and 2011, including lithology and aquifer test information; aquifer responses from the D4 Liner failure; routine and expanded groundwater elevation data, water quality data, and capture well information. The model was used to perform additional capture well performance analysis. The analysis indicated the majority of groundwater impacted by process pond water is being captured. Three areas with water potentially not being captured are the area south and east of the Wash Tray Pond, southeast of the Units 3&4 Bottom Ash Pond and West of the North Drain Pond.
	REPORTS/INVESTIGATIONS CONDUCTED SINCE 2012 OR REPORTS/INVESTIGATIONS IN PROGRESS			
104	March 2013	Interim Report – New Well Installation in the 43S Area. Technical Memorandum. Hydrometrics, Inc.	Install three wells in the 43S/44D Area north of the Units 1-4 Sediment Retention Pond. Evaluate water quality and groundwater capture potential at new well 119A.	Wells 119A, 123A-P, and 124A-P were installed in the area north of the Units 1-4 Sediment Retention Pond. Wells 123A-P and 124A-P were completed as one-inch diameter piezometers. Water quality at the piezometers was not indicative of process water impacts. New well 119A had groundwater quality that was indicative of a level of process water impacts consistent with nearby well 43S. A recommendation was made in the report to evaluate well 119A for groundwater capture.
105	April 2013	Evaluation Of 2012 Hydrologic Monitoring Data From Colstrip Units 1 Through 4 Process Pond System Colstrip Steam Electric Station, Colstrip, Montana	Annual Water Resources Report	Brine Pond D4 closure was completed in 2007 by installing a synthetic reinforced polypropylene (RPP) cap, adding topsoil, and establishing a vegetative cover. Collection of impacted groundwater in this area continued in 2012. Water quality in this area has generally continued to improve. Units 1-4 Sediment Retention Pond (SRP)/Units 1&2 Bottom Ash Pond Area. Mitigation activities in this area have included closing of the Brine Ponds, double lining the Units 1&2 B Pond (formerly

TABLE 3-2
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT PLANT SITE
SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
	April 2013 (continued)			Units 1&2 Flyash Pond cell B) in 2004, relining the 1-4 Sediment Retention Ponds in 1989, converting the Units 1&2 A Pond (formerly Units 1&2 Flyash Pond cell A) to a clean water pond (2005), and double lining the Units 1&2 Bottom Ash Pond Clearwell in 2006. General water quality improvement has previously been observed in this area and indicates actions taken to mitigate process pond impacts to groundwater are effective. Several piezometers were installed around the perimeter of the Units 1&2 A/B Ponds in 1996. Minimal sampling has been conducted at these piezometers; however, recent samples were collected in 2009 and 2012. Based on the limited data it appears that water quality over the three-year period has: • improved at twelve of the piezometers; o AB3-S, AB7-S, AB8-S, AB9-S/M, AB10-S, AB16-S, AB21-S, AB22-S, AB23-S, AB25-S, AB26-S, and AB29-S • declined at six piezometers; and o AB14-S, AB17-S, AB19-S/M, AB24-S, AB27-S, and AB28-S • remained relatively constant at three of the piezometers. o AB2-S, AB4-S, and AB20-S Samples collected in 2012 at Wells AB25-S, AB26-S and AB29-S had bromide concentrations of 10, 13 and 19 mg/L, respectively. These wells are located upgradient of existing capture systems. <u>Units 3&4 Wash Tray Pond/Units 1&2 Pond C</u>. Mitigation activities in this area have included removing the Units 3&4 Wash Tray Pond from service and restoring the clay lining on the banks of the Units 1&2 Pond C banks. Collection wells 6M and 68A operate in the Units 3&4 Wash Tray Pond/Units 1&2 Pond C Area.
106	June 2013	Capture System Construction, Startup, And Performance In The 5M Area -- Colstrip Steam Electric Station	Installation and sampling of nine monitoring wells. Evaluation of hydraulic properties. Conversion of seven wells for groundwater capture.	Seven wells were interpreted to have, or potentially have, impacts from process water. These wells were converted to groundwater capture wells. The remaining two wells will be monitored for quality and water levels. About 23.4 million gallons of water were pumped during the first nine weeks of operation. However, operational changes during the initial start-up, may have resulted in an overestimate of actual volumes. Actual longer term pumping rates will be lower.
107	July 2013	Former D4 Brine Pond Geoprobe Investigation PPL Montana LLC, Colstrip Steam Electric Station	The project involved extensive direct push soil sampling of soil below the former D4 Brine Pond, bench-top testing, and laboratory analysis of sediments. The purpose of the sampling was to characterize spatial variability of salinity in soil below the footprint of the former pond. Background samples were collected from areas outside of the pond footprint.	Twenty-three core samples were collected from within the footprint of the former D4 Pond. One boring was advanced near the center of each of the former D1, D2, and D3 ponds. Note that soil was previously removed from the floor of these former ponds. Four borings were completed outside of the former brine ponds. It was concluded that soil within the D4 Pond Footprint had elevated levels of salts compared to similar substrates outside of the pond footprint. Most of the soils were comprised of unconsolidated mine spoil, however, a remnant of the Rosebud Coal was also present. Based on the characterization, and estimated 88,000 cubic yards of mine spoil with elevated salts were identified. Levels in the Rosebud Coal were generally not indicative of D4 Pond impacts. Removal of the impacted soil was recommended to reduce or eliminate the potential of solutes reaching groundwater.
108	August 6, 2013	Technical Memorandum: 2013 East Fork Armells Creek Synoptic Run and Groundwater Sampling	Collection and analysis of surface water samples from 12 sites on East Fork Armells Creek, one tributary and one treatment pond. Flow measurement. Measurement of groundwater levels adjacent to the creek at 17 locations.	Flows measured during the 2013 synoptic run were near, or below average. One site (AR-1 North Flume) had higher than average flow. Precipitation during the year preceding the synoptic run was about 56% of the long-term average. For the most part, concentrations of chemical constituents were below the average for the 14 synoptic runs. Chloride concentrations, however, were slightly above average for all sites except the upstream site. The creek was gaining from AR-12 to AR-1 and variable further downstream.
109	October 2013	FINAL REPORT – Technical Memorandum - New Well Installation in the 43S Area - An Evaluation of Temporary Groundwater Capture at Well 119A	Well installation, water quality sampling, pump testing, well conversion for groundwater capture, startup, and evaluation.	Well 119A was temporarily included in the PPL Plant Site Capture System and operated for five months. Observations made during this evaluation provide a tentative indication that well 119A may have a mitigating effect on groundwater in the project area. Well 119A operates nearly continuously

TABLE 3-2
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT PLANT SITE
SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
	October 2013 (Continued)			and removes approximately 15 gpm of groundwater that has elevated levels of process water indicator parameters; Pumping well 119A has demonstrated the ability to induce drawdown in impacted well 44S to a higher degree than that induced by existing wells 43S and 78A alone; Groundwater quality appears to have improved at existing wells 43S, 44S, and 78A since pumping began at well 119A; and Concentrations of certain process water indicator parameters (e.g. boron, bromide, chloride, and Ca:Mg have become more suggestive of process water impacts.
110	April 2014	Evaluation Of 2013 Hydrologic Monitoring Data From Colstrip Units 1 Through 4 Process Pond System Colstrip Steam Electric Station, Colstrip, Montana	Annual Water Resources Report	Groundwater quality samples were collected on the Plant Site from 168 sites in the spring and 153 sites in the fall. Eight wells were converted for groundwater capture. Two shallow piezometers were installed north of the Units 1-4 Sediment Retention Pond. Sediments below the former D4 Brine pond were sampled and evaluated. Eight wells were installed to investigate the Units 3&4 Wash Tray Pond area. Five wells were installed to evaluate the area around well OT-7. Fifty-four capture wells and four under-liner secondary containment systems operated in 2013. Specific conductance measured in groundwater in these areas showed about a 22% improvement when compared to the highest SC value measured previously at the wells. Units 1&2 Brine Pond Area. Brine Pond D4 closure was completed in 2007 by installing a synthetic reinforced polypropylene (RPP) cap, adding topsoil, and establishing a vegetative cover. Collection of impacted groundwater in this area continued in 2013 from wells B-1, 4S, 19SP, 26SP, 29SP, 70SP, 111SP, and the D4 Pond under-drain system. These wells collected approximately 30% more in 2013 than in 2012, but similar to rates collected in 2011 (Table 6-1). The larger rates collected in 2011 and 2013 are likely the result of higher precipitation in those years. Collection wells B-4 and B-5 in this area were not pumped in 2012 and 2013 due to improved water quality. Groundwater captured in the brine pond area is routed to the double-lined Units 1&2 B Pond. Water quality in this area has generally continued to improve, but water collected at the Units 1&2 D4 Pond sump continued to show very high concentrations of indicator parameters. Other notable water quality trends for wells included: B-1 (capture well) – water quality improved substantially during 2013. Well 19M (monitoring well) – indicator parameter concentrations increased in the fall but remain within historical ranges. Capture well 26SP water quality declined. Well 41SP water quality improved. Monitoring wells 84SP, 85SP, 86SP, 87SP, 88M, 89SP and 90R were installed in 2008 to investigate groundwater conditions and to provide additional monitoring in the vicinity of the former brine ponds and the Units 3&4 Bottom Ash Pond. Wells in this area with observed changes in water quality trends in 2013 are as follows. Water quality improved at wells 84SP, 85SP, 88M, and 89SP. The former D4 Brine Pond was investigated in 2013 to evaluate their potential as a source of influence on local groundwater quality. The horizontal and vertical extent of sediments with elevated salinity were delineated. Units 1-4 Sediment Retention Pond (SRP)/Units 1&2 Bottom Ash Pond/ Areas. General water quality improvement has previously been observed in this area and indicates actions taken to mitigate process pond impacts to groundwater are effective. In 2013 the following trends were noted: improvements at wells 1D, 43S, 44S, 50D, 56D, 57M-P, 60M-P, 64A, 73S, 74A, 75A, 83A, 107A, 108A, SRP-3, and SRP-6. Water quality declined at wells 58M, 91S and OT-7 Units 3&4 Wash Tray Pond/Units 1&2 Pond C. Water quality declined at wells 7R, 14M, 67M, 17D, and 62S
111	May 2014	Interim Report - Monitoring Well Installation And Potential Capture Well Conversion Near Well 6M PPL Montana's Colstrip Steam Electric Station –	Installation, sampling and testing of eight monitoring wells. Data analysis and reporting.	Hydrogeological conditions of the shallow intervals are highly variable and include alluvium, fill, spoil, overburden (above the Rosebud Coal), and Rosebud-McKay interburden. These units are not laterally continuous and groundwater typically flows laterally between the shallow units.

TABLE 3-2
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT PLANT SITE
SUMMARY OF WORK CONDUCTED AND FINDINGS

	DATE	INVESTIGATION/REPORT	SCOPE	FINDINGS/RESULTS
	May 2014 (continued)	Plant Site		Groundwater is present in the alluvium, shallow overburden and interburden, spoil, Rosebud Coal, McKay Coal, and sub-McKay sandstone. Groundwater levels in the shallow units are typically higher than those in the McKay Coal. Groundwater in both the shallow and McKay units has a general flow direction to the northwest. Localized groundwater low areas are evident near groundwater capture wells. Higher concentrations of chemical constituents are present in the shallow and McKay intervals below the ponds, and oriented with the direction of groundwater flow. The majority of these chemical concentrations do not exceed baseline screening levels (BSL's). Capture wells are located down gradient of these areas. Deeper intervals do not show any process water impacts.
112	June 2014	Technical Memorandum: 2014 East Fork Armells Creek Synoptic Run and Groundwater Sampling	Surface water samples were collected and flow measured at 12 sites on East Fork Armells Creek. Sediment samples were collected from the streambed at 12 sites. In addition one tributary and one pond were sampled. Groundwater samples were collected and the elevation of the water table was measured at 17 locations along the creek.	Flow measured during the 2014 synoptic run was above the average, with the highest values recorded along the upper reach from AR-12 down to AR-1, and at sites AR-8, AR-6, and AR-11 (golf course). Precipitation during the year preceding the synoptic run was 169% of the long-term average. In general, chemical constituent concentrations were below the average values for the synoptic runs. Chloride concentrations, however, were slightly above the average in all sites downstream of AR-4. Groundwater elevations suggested flow to the creek at all but four locations. Shallow groundwater along the creek was a magnesium-sulfate type, similar to the creek. Sediment samples were typically a silty loam to sandy loam, with pH of 7.3 to 7.8 and sodium adsorption ratio of 2.03 to 3.92.
113	August 2014	Report Of Monitoring Well Installation And Groundwater Investigation In The OT-7 Area Colstrip Steam Electric Station, PPL Montana, LLC – Plant Site	Installed five monitoring wells, conducted groundwater sampling and testing of wells.	Hydrogeological conditions vary greatly from the upper alluvium to the deep alluvium. The upper alluvium consists of fine grained silts and clay and the deep alluvium consists of sub-angular to sub-rounded gravels and sands. However, the upper and deep alluviums are hydraulically connected. This is indicated from the similar groundwater elevations and response to pump tests in the upper alluvium during the deep alluvium pump test. Although hydraulically connected, flow between the two units is likely very small based on the minimal hydraulic gradients and very large different in hydraulic conductivity. Groundwater in the upper alluvium appears to have higher concentrations of chemical constituents than the groundwater found in the deep alluvium. The exception is well 137A which does not possess any chemical constituents above the Baseline Screening Levels (BSLs). Groundwater quality in the deep alluvium suggests the water is slightly impacted from process water. While groundwater sampled from the shallow alluvium appears to be influenced by a more localized sources.
114	Pending	Monitoring Well Installation Near 3 & 4 Bottom Ash Pond. PPL Montana's Colstrip Steam Electric Station – Plant Site	Installed, sampled, and tested monitoring well 138SP south of the 3&4 Bottom Ash Ponds	Well was completed in mine spoils at a depth of 120 ft-bgs. Well yield was 10 – 15 gpm at time of development. Water quality and aquifer test results pending final analysis.

3.3 CURRENT HYDROGEOLOGICAL SITE CONDITIONS

Site hydrogeologic descriptions have been presented in numerous previous site reports. A brief overview is provided here for convenience.

3.3.1 Regional and Local Hydrogeology

Colstrip is located in the northern portion of the Powder River Basin, an asymmetrical basin oriented northwest to southeast. This structural basin is responsible for the general regional orientation of bedding. "In general, Fort Union Strata dip very gently (less than a few degrees) in easterly and southerly orientations from west to east across the coalfield, respectively. Locally, however, dips are steepened by high-angle faults that are present throughout much of the Colstrip area" (Roberts, et. al, 1999).

Stratigraphy in the Colstrip area consists of, in descending order, the Fort Union Formation, Hell Creek/Lance Formation, Fox Hills Sandstone, and Bearpaw Shale. The Fort Union Formation is divided into three members; the upper Tongue River Member, the middle Lebo Shale Member, and the lower Tullock Member. The Tongue River Member is at the surface in the Colstrip area. The Lebo Shale, and then the Tullock Members are exposed to the north. At Colstrip, the total thickness of the Fort Union Formation is about 650 feet.

The Fort Union Formation consists of alternating and intercalated deposits of shale, claystone, mudstone, siltstone, sandstone, carbonaceous shale and coal. The formation was deposited in a fluvial system of meandering, braided, and anastomosed streams near the basin center and by alluvial fans at the margins. Colstrip is situated in an area that was deposited from streams. The fluvial systems were typically oriented northeast-southwest (Flores and Ethridge, 1985).

- Anastomosing streams are comprised of multiple channels within a single drainage. Individual floodplains of an anastomosing system may include braided or meandering, or straight characteristics. Deposition typically occurs under low energy conditions near a local base level (Makaske, 2000).

- Braided flow systems consist of a network of flow channels within a single floodplain or flow belt (Makaske, 2000). These channels have multiple thalwegs (deepest part of channel) that branch back and forth from single to multiple channels.
- Meandering streams consist of one or more individual channels that migrate back and forth across a single floodplain. Meandering channels consist of one thalweg.

Numerous coal seams are present in the Tongue River Member of the Fort Union Formation, the result of peat deposits which accumulated in swampy areas and channels. A tropical to sub-tropical climate resulted in thick peat deposits within the swamps and bogs (Nicols and others, 1989, Flores, R.M. and others, 1999). Because of the depositional setting, the coal beds may pinch out laterally or stop abruptly. The main coal seams of interest near Colstrip are the sub-bituminous Rosebud (~ 24 feet thick) and McKay seams (~ 8-10 feet thick) which can economically be strip mined. These two coal seams merge into a single seam on the west side of the Little Wolf Mountains near the Absaloka Mine, approximately 20 miles southwest of Colstrip. The Rosebud Coal, however, is the only seam mined in the area due to quality of the McKay Seam which makes it undesirable for use in many coal-fired boilers. Both the Rosebud and McKay coals are generally cleated. That is, they contain natural vertical fracturing generally oriented perpendicular to the bedding plane. Hydraulic conductivity of the coal seams is typically around one to three feet per day, but fluctuates locally.

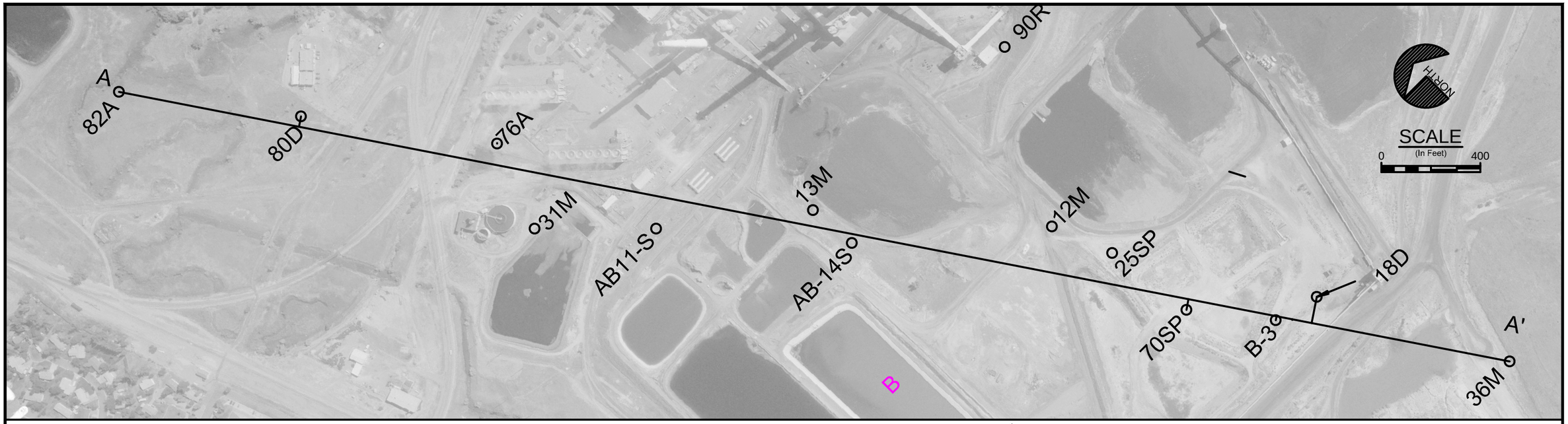
The depositional setting results in numerous lateral facies changes within the sedimentary rock deposits. Channel sandstones often grade laterally into siltstones or shale resulting in preferential pathways for groundwater flow. Cementation, or the chemical binding of individual grains to one another, is highly variable within the units, mostly consisting of weak calcium carbonate cement although thin deposits with silica cementation also occur. Localized thin limestone beds may also exist. The combination of the depositional setting of the Fort Union Formation which resulted in lateral facies changes, variations in the lithologies of vertical sequences (sandstone, siltstone, shale), mining disturbances that have interrupted the original depositional setting, formation of highly fracture clinker from insitu coal burning, secondary porosity (minor fractures in bedrock) combined with erosion and deposition from the creek result in vertical and horizontal anisotropy (the condition of having

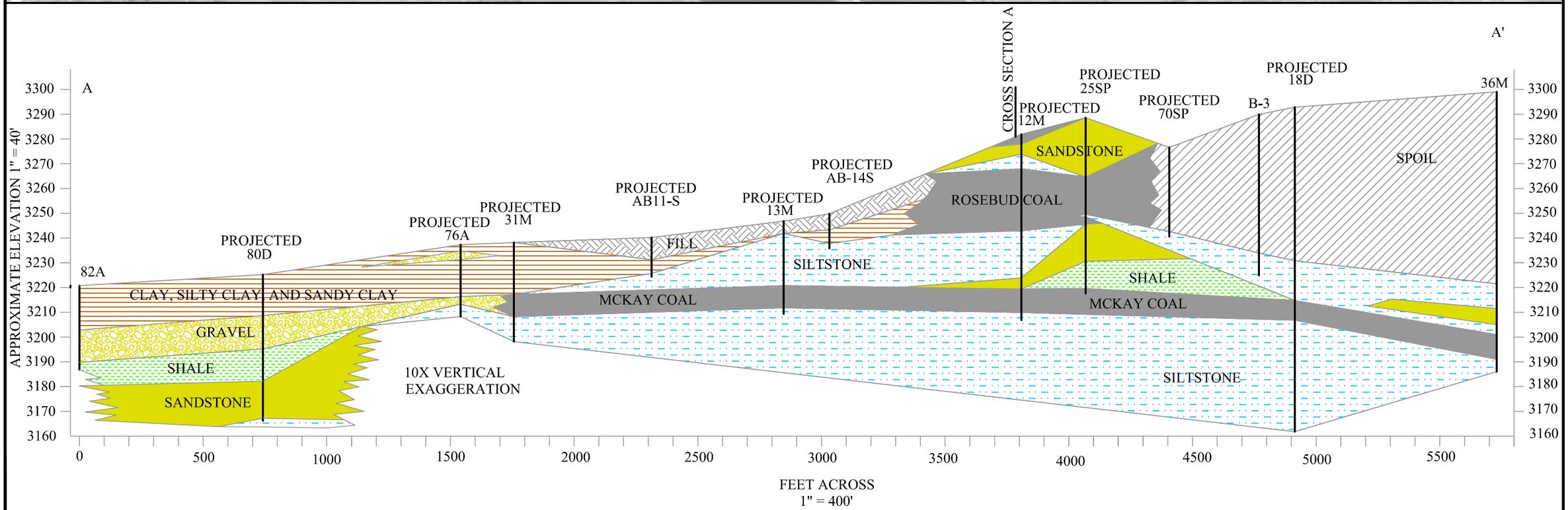
different properties in different directions) and heterogeneities (variations through space within a geologic formation). Although driven by potentiometric heads, because of the anisotropic and heterogeneious nature of the geology, groundwater flow may not always follow a direct path from high potentiometric heads to lower head areas.

Alluvium is present along many of the drainage bottoms throughout the region. The most prominent deposit in the Plant Site Area is along the creek. At the west edge of the Plant Site, alluvial deposits of clay, silt, sand and gravel reach thickness of 35 feet or more. A basal gravel, comprised of clinker, is often present in the alluvium. Clinker fragments are typically also found throughout finer-grained alluvial deposits.

As mentioned previously, the Rosebud Coal, and in some places, the McKay Coal has burned. This is most easily identified as red cap rock on hilltops around the region. Burning of the coal baked the overlying strata. As a result of the burning, the coal volume reduced either leaving a void for the overlying rock to collapse in or resulted in slow settling of the overlying rock into the space formerly held by the coal. The thermally altered rock is referred to as clinker or scoria. Collapse of the rock resulted in secondary porosity (fractures). Permeability of the clinker varies but is typically very high (exceeding 2,500 ft/day) and depends on the amount of fine grained sediments that have moved vertically into the available pore spaces and the degree and nature of fracturing. No clinker has been confirmed on the Plant Site proper but a small amount of clinker is present above the water table at the extreme northwest corner of the Plant Site Area.

Geology at the Plant Site, or in areas adjacent to the Plant Site are generally comprised of alluvium, colluvium, spoil, shallow bedrock, coal, clinker, and various strata of the Fort Union Formation. Figure 3-1 is a geological cross section that illustrates the relationship of various units in the Plant Site and adjacent area to the north. A general description of these in approximately descending order follows.





PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT PLANT SITE REPORT	**GEOLOGIC CROSS SECTION THROUGH THE PLANT SITE**	FIGURE **3-1**

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Consulting Scientists and Engineers

- Fill – Typically earthen material that is used to fill depressions, backfill excavations or build up areas to create mounds or change the grade or elevation of the ground. Fill is typically local material but may be transported to other areas. Examples of fill are spoil placed back in a mine pit, fill placed in a hole excavated to expose piping, fill placed to level roadways, parking lots, etc. Any disturbed soil that has been reworked, placed in another location, or disturbed and contoured would also be considered fill. In most cases, fill is above the groundwater table. However, in some instances, such as spoil, groundwater is present in the fill.

- Alluvium – These deposits are present in drainage bottoms on the Plant Site and near the creek. Near the creek, alluvial deposits of clay, silt, sand and gravel reach thicknesses of 35 feet or more.

  Near the Plant Site, the most significant alluvial deposits are present along the creek and are characterized by fining-upward depositional sequences. A basal gravel, comprised of clinker, is often present at the contact of the alluvium and underlying bedrock. Clinker fragments are typically also found throughout finer-grained alluvial deposits. Gravel dominant sediments often grade upward into poorly sorted sands and silts, of which a substantial amount is derived clinker. Near surface deposits are silty clay to clayey silt and are generally gradational with colluvium that lines the margins and much of the valley bottom. Deposition of the sediment occurred in a complex system under multiple energy regimes. Gravels were deposited out of high energy systems while finer grained sediments settled out of slower moving waters. Fining upward sequences often occur during episodic events where coarser grained sediments settle out at higher velocities. Finer sediments progressively drop out of the water as the energy drops. Several episodes of deposition and erosion took place to form alluvial sequences that vary both vertically and horizontally. Active channels would migrate back and forth across the floodplain forming meander channels. Deposition of sediments from the channels that were migrating laterally resulted in heterogeneities and a complex sedimentary sequence. The variations in lateral channel migration, coupled with complex depositional and erosional sequences

resulted in inter-fingering of alluvium with colluvium and the valley margins. For this reason alluvial sequences shown on Figure 3-1 are simplified. Actual sedimentary sequences vary substantially both horizontally and vertical and individual grain sizes, sequences, composition, and alluvial thickness vary over short distances from those shown on the cross section. The ancestral East Fork Armells Creek has eroded through the bedrock units down to below the McKay Coal and basal gravels are typically in contact with sub-McKay strata. This results in groundwater flow from the eroded units into the alluvium from the east and the west sides of the creek. Consequently, the creek alluvium controls flow of groundwater in the adjacent bedrock in the vicinity of the Plant.

Hydraulic conductivity of the alluvium tested near the Plant Site ranges from less than one foot per day to greater than 50 feet per day depending on the amount of matrix fines. Higher clay contents in the pore spaces are characteristic of alluvium with lower hydraulic conductivity.

- Colluvium – Colluvium is slope washed deposits which have been transported downslope by fluvial or gravitational means. In the Plant Site Area, colluvium is most often a silty clay or clayey silt composition, although coarser deposits may be present locally. Colluvium is frequently inter-fingered with the alluvial deposits along the edge of floodplains, particularly along the creek. Hydraulic conductivity of colluvium, where groundwater is present, is typically low, less than one foot per day.

- Rosebud overburden – Bedrock units of the Fort Union Formation comprised of siltstone, claystone, shales, and fine-grained sandstone typically overlay Rosebud Coal. Groundwater is often present in the overburden units in the Plant Site Area. Hydraulic conductivities of the overburden are typically on the order of one to three feet per day.

- Rosebud Coal – Cleated coal with thickness on the order of 20 to 25 feet. This coal seam has been mined throughout much of the eastern portion of the Plant Site. Cleated is defined as systematic fractures that have a common spatial orientation. Orientation and the interconnection of fractures generally dictate the hydraulic conductivity of the coal. Groundwater flow paths within the coal are also dictated by

hydraulic pressures and cleat orientation. The Rosebud Coal lies stratigraphically above the McKay Coal and is separated by interburden (see below). Hydraulic conductivity of the coal is typically low, on the order of one to three feet per day, although areas of higher and lower permeability exist locally.

- Clinker – Also referred to as scoria and baked shale – Comprised of thermally altered and collapsed overburden (sandstone, siltstone, shale, etc.) formed by the 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 highly fractured interval of metamorphosed sedimentary rock. Ash layers and/or layers of unburned coal sometimes remain at the base of the clinker.

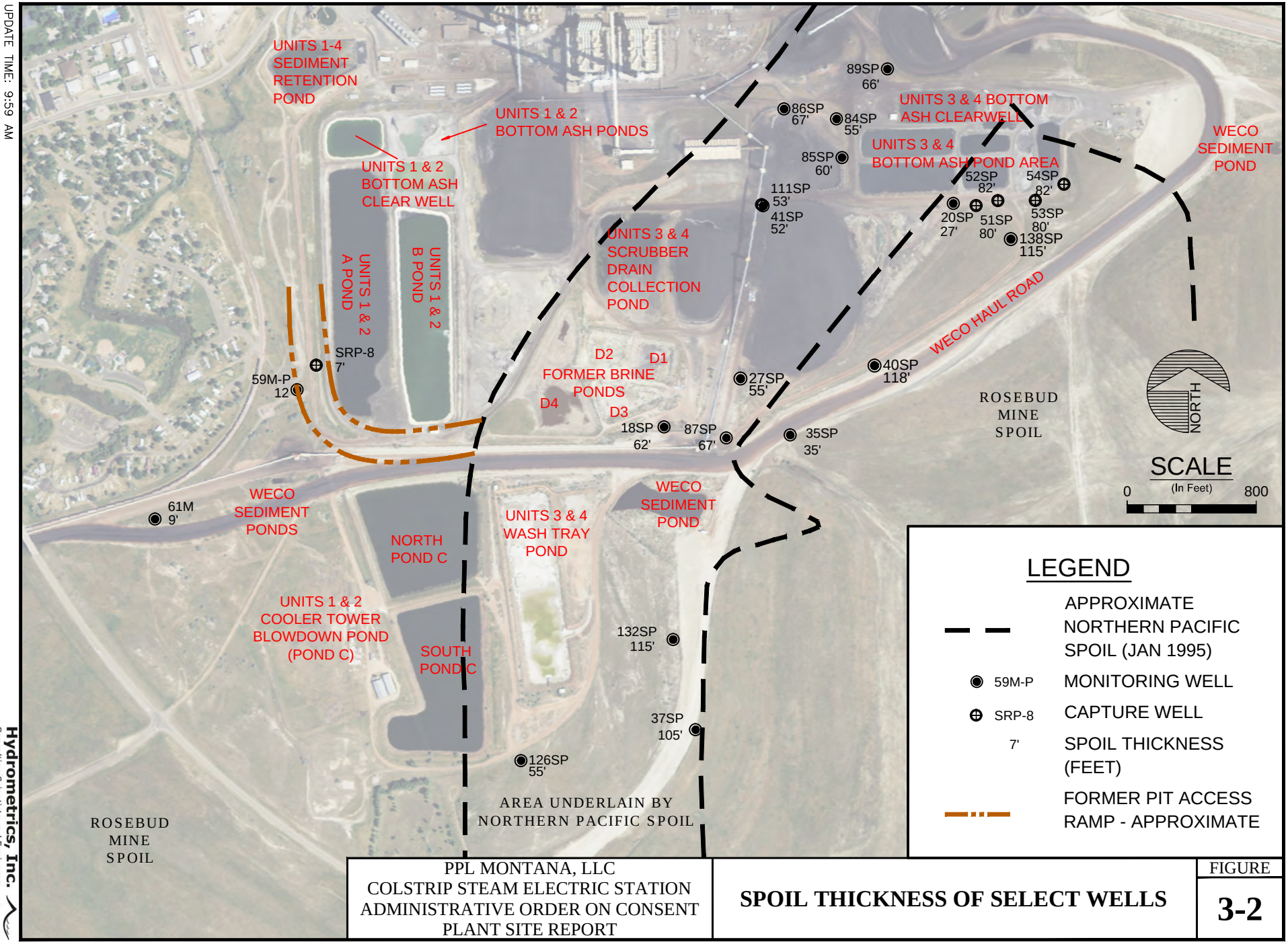
  Clinker is generally quite permeable, a function of the secondary porosity caused by fracturing. Hydraulic conductivities at the facility have been tested at over 2500 ft/day, although much higher values have been documented regionally. Groundwater flow in the clinker may be preferential in a direction parallel with the original bedding planes. Fracturing is generally widespread and interconnected making vertical and horizontal permeability nearly equal. However, most groundwater flow is parallel to the hydraulic gradient. Clinker is generally capable of transmitting large quantities of groundwater. Groundwater is rarely contained in the clinker in the Colstrip area, however, due to its presence on hilltops and ridges where it readily drains. If present, groundwater in clinker is typically "trapped" by structural low areas following periods of high recharge, either from precipitation or snowmelt. On the Plant Site, clinker is restricted to the far northwest of the site and is above the groundwater table in that area.

- Spoil – Silt, clay, sandstone, coal fragments, formerly overburden units that have been used to backfill areas where the Rosebud Coal was mined. The spoil were formed as a result of strip mining of the Rosebud Coal seam. Strip mining involves removing overburden material (sedimentary rocks that overlie the coal) and placing it

on the low wall (pit previously mined). The coal is then removed. The stockpiled overburden is then placed back in the cut as mining progresses to the next pit. The replaced overburden is referred to as spoil.

Mining on the Plant Site was conducted between 1924 and 1958 by Northern Pacific Railway. Western Energy began mining in Colstrip in 1968. Removal of the spoil disrupted the horizontal bedding planes from original deposition. The replaced spoil is typically of two types. In some cases, large rocks roll into the bottom of the pit as the spoil is placed, creating zones of high permeability (greater than 600 feet per day). Such areas are present on the north and northeast sides of the Units 3&4 Bottom Ash Ponds. In other areas, a more homogenous backfill is accomplished. Fine sedimentary rock layers may become mixed with sandstone creating areas with low permeability, typically around one foot per day. The latter setting is more common than the former and occurs in the area east of the Units 3&4 Wash Tray Pond and former Brine Ponds area and south and southeast of the Units 3&4 Bottom Ash Ponds. Spoil identified in Plant Site monitoring wells range in depth from 48 feet at well 26SP to 115 feet at well 132SP. Shallower spoil intervals are likely in isolated areas where low walls were sloped or possibly collapsed or where ramps were constructed to enter and exit the pits. The only identified ramp occurs along the south side and west sides of the Units 1&2 A Pond. (Figure 3-2)

Mining of the coal on the Plant Site has resulted in lateral heterogeneities in spoil. Strip mining of coal involves removing the overburden (sediments overlying the coal), removing the coal, then backfilling the pit with the previously removed overburden. The resulting spoil material exhibits a wide range of permeability from around 3 to more than 600 feet per day. It also results in a higher vertical permeability when compared to the pre-mining permeability. Spoil is present over much of the southeastern part of the Plant Site (directly east of Units 1&2 B Pond and Units 1&2 Cooling Tower Blowdown Ponds, and Units 3&4 Bottom Ash Ponds). A minor amount of spoil is present directly southeast of the Units 1&2 A Pond.



PPL MONTANA, LLC
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE REPORT

SPOIL THICKNESS OF SELECT WELLS

FIGURE
3-2

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Lateral variations in groundwater flow conditions may exist near mine spoil. If the hydraulic conductivity of the spoil is higher than the adjacent deposits, the spoil will act as a drain. Conversely, if the spoil hydraulic conductivity is lower, an impediment to flow will occur. Spoil are present in the eastern portion of the Plant Site. In general, permeability of the spoil is similar to the adjacent bedrock. However, spoil with a higher permeability are present north and west of the Units 3&4 Bottom Ash Ponds. This results in the high yield (~50 gpm) of the WECO well. The monitoring well log for the WECO well is included in Appendix G.

Groundwater levels in spoil start to recover once backfilling begins. Recharge may occur from precipitation, flow into the unit from the adjacent spoil or coal, and ponds constructed on or near the spoil. Recharge typically takes many years. For this reason, groundwater flow directions may change as the spoil recharges. Spoil is typically mineralized and initially exhibits higher concentrations of dissolved constituents than before mining. Spoil may serve as a groundwater source following recharge.

- Interburden – Typically siltstone, claystone, and shale which separate the Rosebud and McKay coal seams. Wells completed in the interburden are typically in areas where the Rosebud Coal has been removed by erosion.
- McKay Coal – Cleated coal with a thickness of 7 to 14 feet, but most often 8 to 9 feet in the Plant Site Area. The McKay Coal is a widespread hydrostratigraphic unit in the Colstrip area as it is often saturated with groundwater.
- Sub-McKay – Fort Union Strata consisting of interbedded claystone, siltstone, fine-sandstones, and thin coal seams. Channel sands are not uncommon. Sub-McKay sandstones are used for water supply aquifers in the Colstrip area. Yields from wells completed in sub-McKay sandstones in the Colstrip area vary from less than one gpm to more than 20 gpm.

Hydraulic conductivities observed on the Plant Site are highly variable. Alluvial deposits and localized areas of coarse fragmented spoil (typically near the base of old mine cuts) show

the highest hydraulic conductivity while shallow fine-grained alluvium, spoil and bedrock units typically exhibit lower values.

For the purposes of this report, shallow units are defined as units that may contain water under water table conditions and are typically the first water encountered. The shallow interval is comprised of alluvium, colluvium, shallow bedrock (overburden) overlying the Rosebud Coal, and spoil. These units are typically stratigraphically connected and groundwater flow can occur laterally between the units. The exception is the Rosebud overburden (shallow bedrock) and remnants of the Rosebud Coal which exist in the south central portion of the Plant Site. This area is very small and has been considered as a whole since vertical flow from the overburden to the Rosebud is expected to occur. If it does not occur, there is only a short distance of lateral flow in the overburden before erosion, mining, or other development activities have removed the overburden. In this case, water from the overburden flows downward into the Rosebud interval. The Rosebud Coal is also limited in areal extent on the Plant Site. Groundwater present in the Rosebud Coal flows laterally either into spoil, colluvium, or alluvium. Hence, the units are handled as one for this analysis. The McKay coal consists of a coal seam that is stratigraphically below the Rosebud Coal. The McKay and Rosebud intervals are separated by siltstone and shale that are typically from about a foot to 10's of feet thick. The interburden generally exhibits very low permeability and contains very little groundwater. The interburden is not considered a hydrostratigraphic unit in the Plant Site.

3.3.2 Distribution of Indicator Parameters

Several indicator parameters are used to evaluate potential process water impacts to groundwater at the Colstrip SES. These include specific conductance (SC), sulfate, dissolved boron, chloride, and the ratio of calcium to magnesium. Specific conductance - laboratory (SC), sulfate, dissolved boron, and chloride are indicators because of the high concentrations that are typically present in the pond process pond waters. An exception is the Units 3&4 Bottom Ash Pond which typically exhibits lower concentrations of the indicator parameters than process ponds associated with scrubber slurry. The calcium to magnesium ratio is also useful as an indicator of process water. This is due to the fact that magnesium is typically

enriched in process pond water when compared to calcium. Again, the exception is the Units 3&4 Bottom Ash Ponds, which are enriched in calcium when compared to magnesium. Most ambient waters in the Colstrip area have calcium to magnesium ratios that range from a little less than, to above 1. These parameters have been shown to be indicative of possible process water impacts and have been accepted as an evaluation method for water quality evaluation by PPLM and MDEQ.

Analytical parameters used for routine groundwater monitoring at PPLM Colstrip SES are in Table 2 List 1 of 4 of the Water Resources Monitoring Plan (Appendix E). Baseline screening levels (BSLs) for these parameters as presented in ARCADIS, 2007 are included on Table 3-3 and detailed in Table 5 of that report which is included as Appendix D. Note, however, that the BSL's are under review as of October 2014. Baseline screening levels are used to provide an indication of what groundwater quality for the various intervals would be expected to be without any local impacts. Water quality in the area is highly variable so the BSL's can provide clues as to potential impacts from process waters. However, the BSL's are mainly used as a basis for comparison in areas where baseline data are not available. Indicator parameters are used primarily to evaluate if groundwater is impacted by process water.

TABLE 3-3. COLSTRIP STEAM ELECTRIC STATION, GROUNDWATER QUALITY BACKGROUND SCREENING LEVELS

Physical Properties	BSL[(1)] Alluvium	BSL[(1)] Bedrock	BSL[(1)] Spoil
pH (lab), standard units (s.u.)	NA	NA	NA
Specific Conductivity (Lab)(µmhos/cm)	5,300	3,940	7,390
Total Dissolved Solids Measured at 180°C	5,470	3,750	8,010
Common Ions (inorganics)			
Alkalinity, Total as $CaCO_3$, mg/L	NA	NA	NA
Bicarbonate as HCO_3	NA	NA	NA
Carbonate as CO_3	NA	NA	NA
Sulfate (SO_4), mg/L	3,400	2,310	5,000
Chloride (Cl), mg/L	213	48	73
Bromide (Br), mg/L	0.59	--	2.4
Trace Elements (metals, dissolved)			
Boron (B), mg/L	1.5	1.2	1.3
Calcium (Ca), mg/L	432	349	649
Magnesium (mg/L)	538	353	731
Mercury (Hg), mg/L*	0.0040	0.0020	NA
Potassium (K), mg/L	17.2	16.0	20.0
Selenium (Se), mg/L	0.04	0.012	0.005
Sodium (Na), mg/L	421	961	282

BSL's are under review as of October 2014

NA – not applicable – BSL not calculated

*Wells 23S, 24S, 30S-2, 44S, 807, and U3-1 only

Concentrations of indicator parameters are identified by collecting groundwater quality samples from monitoring wells and capture wells. Samples are collected from monitoring wells using submersible pumps or bailers in accordance with standard industry methods. Samples collected from capture wells are obtained from sampling ports located near the wellhead. The sampling ports are separated from main pipelines by check valves and gate valves. This allows samples to be collected without the potential of backflow from the main pipeline. Purging of capture wells prior to sample collection is not necessary since they are operating, or at least operational, on a continual basis. Water quality samples are submitted to a commercial laboratory for analysis. SC values are measured in the field at the time of sampling. For capture wells, additional SC is measured at least monthly during system operation and maintenance checks.

Measured specific conductance values, the concentrations of sulfate, boron and chloride, and the calcium to magnesium ratio are used here to illustrate the distribution of chemical constituents on the Plant Site proper and adjacent areas within the Plant Site Area.

The distribution of indicator parameters (SC, sulfate, boron, chloride, and Ca/Mg) during spring 2012 as measured in wells completed in the shallow, McKay, and sub-McKay hydrostratigraphic units are presented on Figures 3-3 through 3-15 and described below. Also note that the figures have been revised. The figures shown in the original December 2012 submittal of this report contained data from the spring of 2012. Iso-contour figures presented in the revised report have been updated to use spring 2014 data. Wells with SC values or concentrations of specific indicator parameters greater than draft BSLs are highlighted in red on the figures.

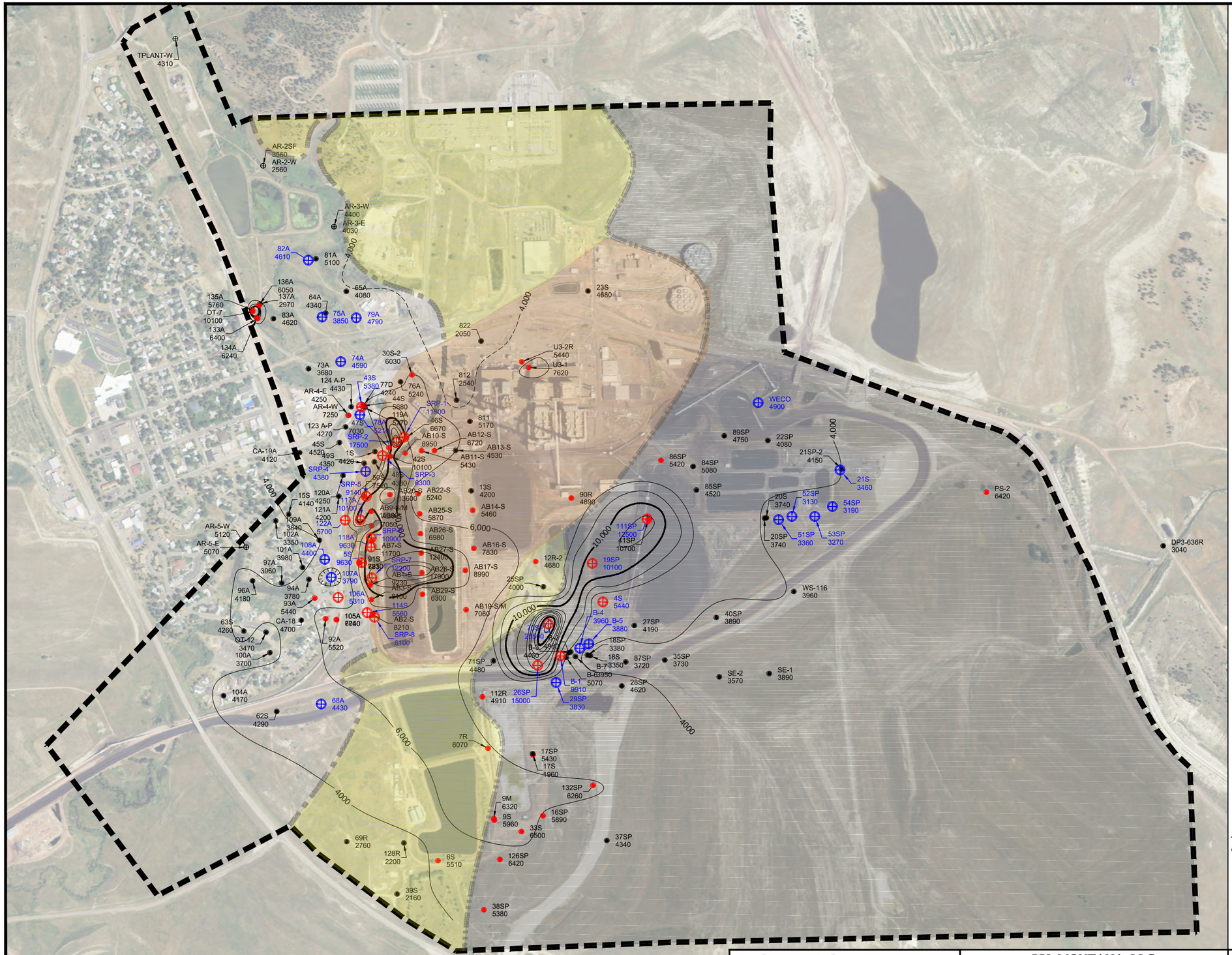
At the time of the first submittal of this report in December 2012, there was not sufficient data for sub-McKay units to adequately contour the unit. Additional information have been obtained since that time, and although there is still a relatively small dataset, contour figures showing concentrations of indicator parameters for the sub-McKay unit are included. Note also that the figures show the approximate areas that are underlain by shallow bedrock, fill, spoil. Baseline screening levels for each parameter and hydrostratigraphic unit (ARCADIS

2007) are included in the discussion below. Note, that as of October 2014, the BSL's are under review.

Baseline screening levels are intended to represent the upper end of the range in ambient background groundwater quality conditions (ARCADIS, 2007). Methods used to compile a set of wells are described in Section 1.1 (pages 2 through 9) of the 2007 ARCADIS report. A copy of the report is in Appendix D.

Evaluation of Plant Site groundwater, and potential impacts to the water, is based on many lines of evidence, site experience, and knowledge of plant operations. Water quality trends over time are examined. Mapping of chemical concentrations (iso-contour figures) allows distributions and concentrations for particular hydrostratigrphic intervals to be evaluated. Iso-contour figures are constructed in a manner consistent with topographic figures. That is, each point along a line is considered to have the approximate value for that line. Circular patterns with high concentrations in the middle suggest that a source area exists in the middle of the area that is contributing to higher concentrations in the surrounding groundwater or could be a residual high from past events which have not been completely mitigated. Concentrations typically decrease away from the source as mixing with ambient groundwater occurs. Closely spaced lines indicate very rapid mixing, very slow groundwater movement from the source, large variations in concentrations over a short distance, or a combination. Professional judgment, site knowledge, and experience are all used in a multiple lines of evidence approach to evaluate the meaning of contours.

Specific Conductance - SC exceeding the BSL of 5300 µmhos/cm for alluvium is observed in the shallow stratigraphic units in the central and western portions of the Plant Site. Highest concentrations of SC during Spring 2014 in the shallow units are found in the vicinity of the Units 1&2 A Pond and Clearwell, the Former D4 Brine Pond, directly southwest of the Units 3&4 Wash Tray Pond and in at well (OT-7) in the northwest portion of the Plant Site (Figure 3-3).



NORTH

SCALE
(In Feet)
500 0 500 1000 1500
(Approximate Only)

LEGEND

- 68A — GROUNDWATER CAPTURE WELL
- 23S — GROUNDWATER MONITORING WELL
- AR-3-E — SYNOPTIC RUN SAMPLE (SHALLOW GROUNDWATER)
- 1.2 — GROUNDWATER SC CONCENTRATION (µMHOS/CM)
- SHALLOW SC CONCENTRATION (2,000 µMHOS/CM CONTOUR INTERVALS, DASHED WHERE INFERRED)
- PLANT SITE BOUNDARY
- SHALLOW BEDROCK INCLUDES OVERBURDEN AND ROSEBUD COAL
- FILL CONSISTING OF EXCAVATED, MIXED TOPSOIL, AND BEDROCK OVERBURDEN, & THIN SPOIL
- SPOIL
- APPROXIMATE SPOIL EXTENT
- APPROXIMATE ALLUVIUM EXTENT

NOTE: SHALLOW AND COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR SC OF 5300 AND 3940 µMHOS/CM. WELLS WITH GROUNDWATER SC ABOVE BSL ARE SHOWN IN RED.

SHALLOW HYDROSTRATIGRAPHIC UNIT CONTAINS ALLUVIUM, SPOIL, ROSEBUD, AND SHALLOW BEDROCK HYDROSTRATIGRAPHIC UNITS

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PLANT SITE SC SHALLOW

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

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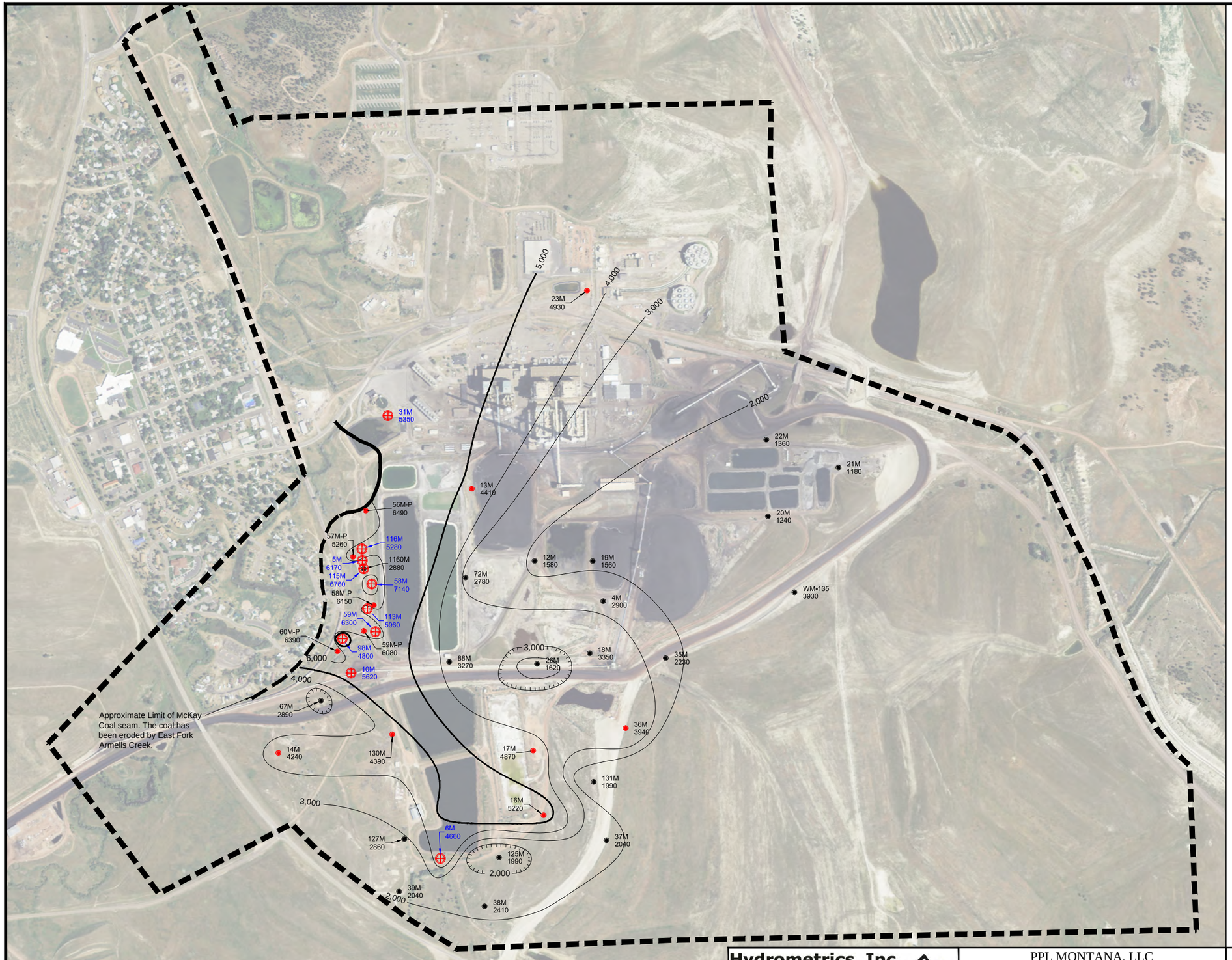
Observations of SC in the McKay Coal are the highest in the western portion of the Plant Site just to the west of the Units 1&2 A Pond. A localized area with SC above the BSL's is present directly west and south of the Units 1&2 Cooling Tower Blowdown Pond C, directly east of the Units 3&4 Bottom Ash Pond. The majority of wells around the south and east side of the Plant Site show SC below the BSL of 3,940 µmhos/cm (Figure 3-4). The BSL for bedrock was used for the McKay Coal wells shown in Figure 3-4 because BSL's were not calculated for the McKay Coal in the 2007 ARCADIS study (Arcadis, 2007). Scattered wells on the south and east side of the Plant Site Area do show SC above the BSL (wells 6M, 16M, 17M, and 36M). SC concentrations in the McKay Coal drop in an eastward direction.

Figure 3-5 illustrates SC contours developed for sub-McKay units. A band of higher concentrations is present along the western portion of the Plant Site just to the west of the Units 1&2 A Pond, in an area where active groundwater capture is occurring. Note that the sub-McKay is in contact with the alluvium in much of this area due to erosion of the strata by the ancestral East Fork Armells Creek.

Sulfate

Figures 3-6 through 3-8 show sulfate concentration contours for the shallow, McKay, and sub-McKay intervals at the Plant Site. Areas with the highest sulfate levels in the shallow units is under the Units 1&2 A Pond and B Pond, north of the Units 1&2 Bottom Ash Clearwell, and North of the Units 1-4 Sediment Retention pond. There is groundwater capture at, or downgradient of these areas. Higher concentrations of sulfate are also observed at well OT-7. Passive groundwater capture is conducted at this well due to its very low yield. Higher sulfate concentrations are also apparent in the vicinity of the former Brine Ponds. Groundwater capture is also being conducted in this area (Figure 3-6). Higher sulfate concentrations are also found in wells northwest of the former brine ponds as well as scattered wells in the southeast corner of the Plant Site Area.



NORTH

SCALE
(In Feet)

500 0 500 1000 1500

(Approximate Only)

LEGEND

59M ⊕ GROUNDWATER CAPTURE WELL

22M ● GROUNDWATER MONITORING WELL

0.7 GROUNDWATER SC CONCENTRATION (µMHOS/CM)

MCKAY COAL SC CONCENTRATION (1,000 µMHOS/CM CONTOUR INTERVALS, DASHED WHERE INFERRED)

PLANT SITE BOUNDARY

NOTE: COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR SC OF 3940 µMHOS/CM. WELLS WITH GROUNDWATER SC ABOVE BSL ARE SHOWN IN RED

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PLANT SITE SC MCKAY

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FIGURE
3-4

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NORTH

SCALE
(In Feet)

500 0 500 1000 1500

(Approximate Only)

LEGEND

55D — GROUNDWATER CAPTURE WELL

80D — GROUNDWATER MONITORING WELL

0.9 — GROUNDWATER SC CONCENTRATION (µMHOS/CM)

SUB-MCKAY SC CONCENTRATION (1,000 µMHOS/CM CONTOUR INTERVALS, DASHED WHERE INFERRED)

PLANT SITE BOUNDARY

NOTE: SUB-MCKAY DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR SC OF 3940 µMHOS/CM. WELLS WITH GROUNDWATER SC ABOVE BSL ARE SHOWN IN RED

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PLANT SITE SC SUB-MCKAY

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FIGURE
3-5

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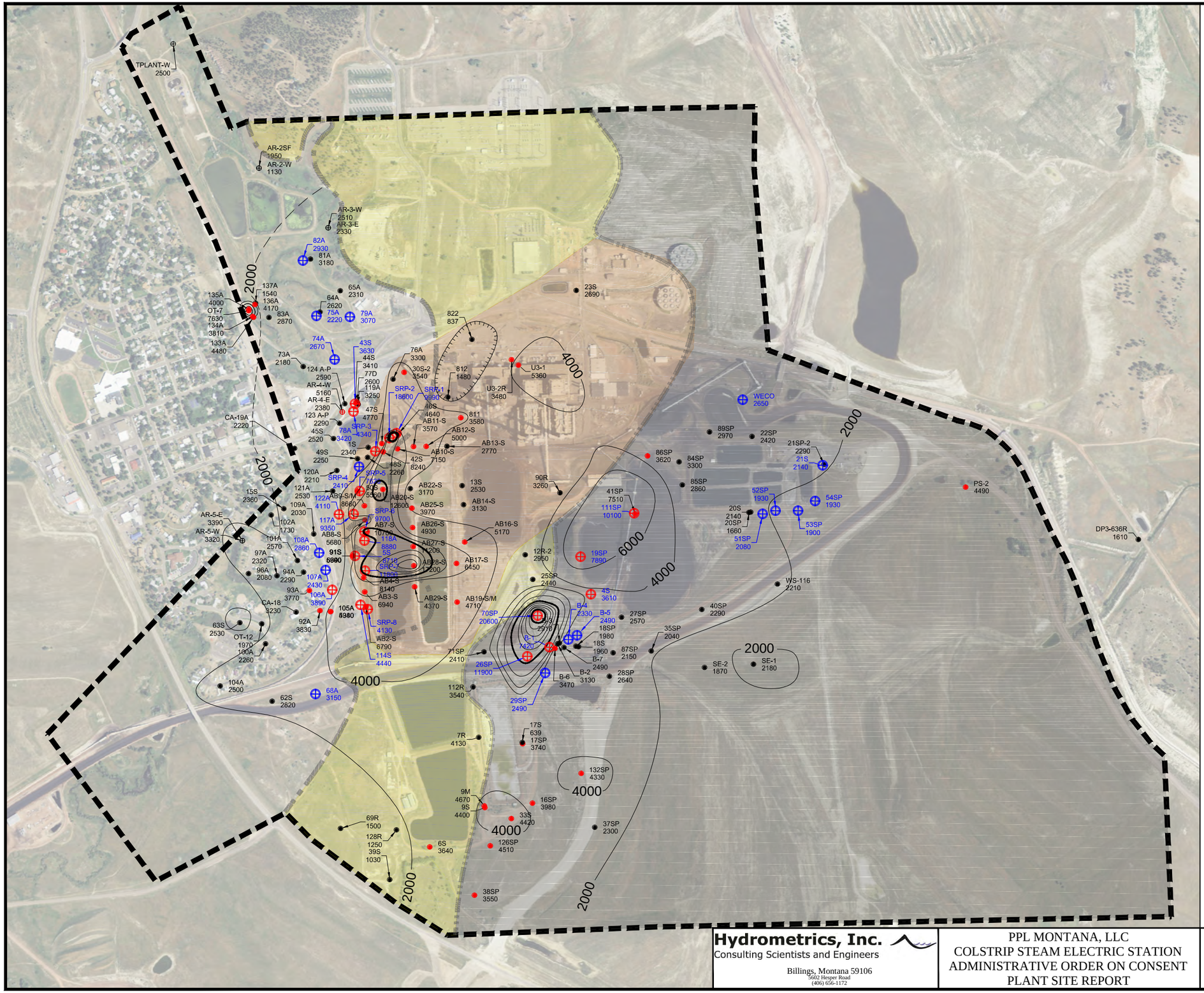

NORTH

SCALE
(In Feet)

500 0 500 1000 1500

(Approximate Only)

LEGEND

- 68A ⊕ — GROUNDWATER CAPTURE WELL
- 23S • — GROUNDWATER MONITORING WELL
- AR-3-E ⊕ — SYNOPTIC RUN SAMPLE (SHALLOW GROUNDWATER)
- 1.2 — GROUNDWATER SULFATE CONCENTRATION (MG/L)
- SHALLOW SULFATE CONCENTRATION (2000 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)
- PLANT SITE BOUNDARY
- SHALLOW BEDROCK INCLUDES OVERBURDEN AND ROSEBUD COAL
- FILL CONSISTING OF EXCAVATED, MIXED TOPSOIL, AND BEDROCK OVERBURDEN, & THIN SPOIL
- SPOIL
- APPROXIMATE SPOIL EXTENT
- APPROXIMATE ALLUVIUM EXTENT

NOTE: SHALLOW AND COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR SULFATE OF 3,400 AND 5,000 MG/L. WELLS WITH GROUNDWATER ABOVE BSL ARE SHOWN IN RED.

SHALLOW HYDROSTRATIGRAPHIC UNIT CONTAINS ALLUVIUM, SPOIL, ROSEBUD, AND SHALLOW BEDROCK HYDROSTRATIGRAPHIC UNITS

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PLANT SITE SULFATE SHALLOW

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AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-6

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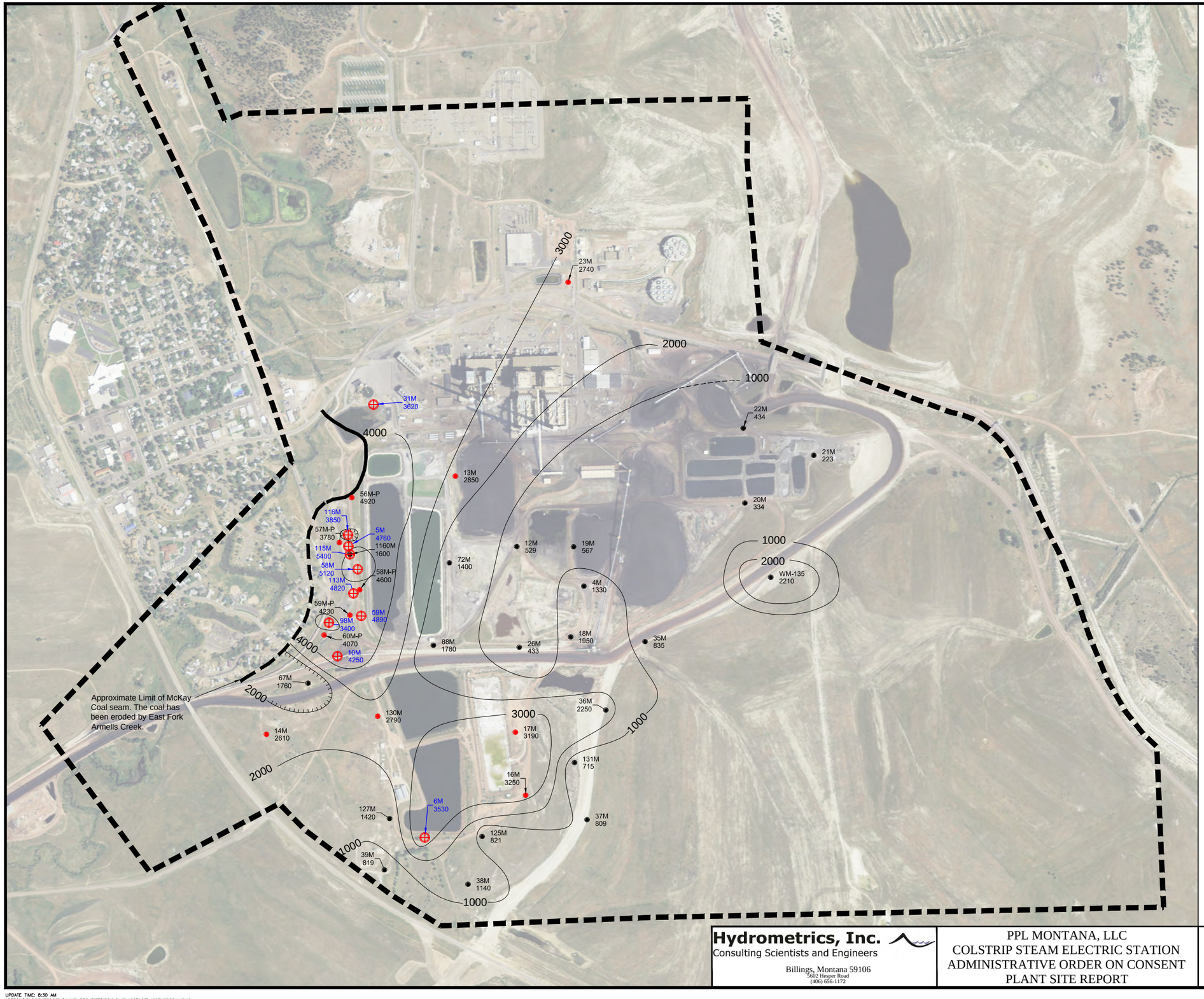
Figure 3-7 shows sulfate concentrations contours for the McKay Coal. Several wells, located directly west of the Units 1&2 A Pond have concentrations above the BSL's, which are under review as of October 2014. These wells are located within a series of capture wells. Note that the McKay Coal in this area is often in direct contact with the alluvium and/or interburden due to erosion from the ancestral East Fork Armells Creek.

Figure 3-8 shows iso-contours for the sub-McKay units. The highest concentrations occur on the west side of the Plant Site. These wells are in areas of active capture. The exception is well 24S, which is actually completed in sub-McKay strata near the Units 3&4 North Plant Area Drain Pond (North Pond), which also shows sulfate concentrations above BSL's.

Boron

The highest concentrations of boron in the shallow units are found in the area below the Units 1&2 A Pond. Other areas showing elevated boron concentrations are at and northeast of the former D4 Brine Pond and at the very southern portion of Units 1&2 Cooling Tower Blowdown Pond C (Figure 3-9). Extensive groundwater capture is conducted in this area.

Concentrations of boron which exceed the BSLs (under review as of October 2014) of 1.5 mg/l (alluvium) and 1.2 mg/l (spoils) in the shallow units are primarily contained within the main Plant Site although values slightly above this level (1.5-2.0 mg/L) are present directly west and north of the main Plant Site. An isolated area with higher boron concentrations exists outside of the main Plant Site at well OT-7 (Figure 3-9). Boron concentrations above the BSL are also observed at scattered wells in the southeast corner of the Plant Site Area and at wells in and around the Units 3&4 Bottom Ash Ponds area.



NORTH

SCALE
(In Feet)

500 0 500 1000 1500

(Approximate Only)

LEGEND

59M ⊕ GROUNDWATER CAPTURE WELL

22M ● GROUNDWATER MONITORING WELL

0.7 GROUNDWATER SULFATE CONCENTRATION (MG/L)

——— MCKAY COAL SULFATE CONCENTRATION (1000 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)

– – – PLANT SITE BOUNDARY

NOTE: COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR SULFATE OF 2,310 MG/L. WELLS WITH GROUNDWATER ABOVE BSL ARE SHOWN IN RED

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PLANT SITE SULFATE MCKAY

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AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-7

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NORTH

SCALE
(In Feet)

500 0 500 1000 1500

(Approximate Only)

LEGEND

55D — GROUNDWATER CAPTURE WELL

80D — GROUNDWATER MONITORING WELL

0.9 — GROUNDWATER SULFATE CONCENTRATION (MG/L)

SUB-MCKAY SULFATE CONCENTRATION (1000 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)

PLANT SITE BOUNDARY

NOTE: SUB-MCKAY DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR SULFATE OF 2,310 MG/L. WELLS WITH GROUNDWATER ABOVE BSL ARE SHOWN IN RED

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FIGURE
3-8

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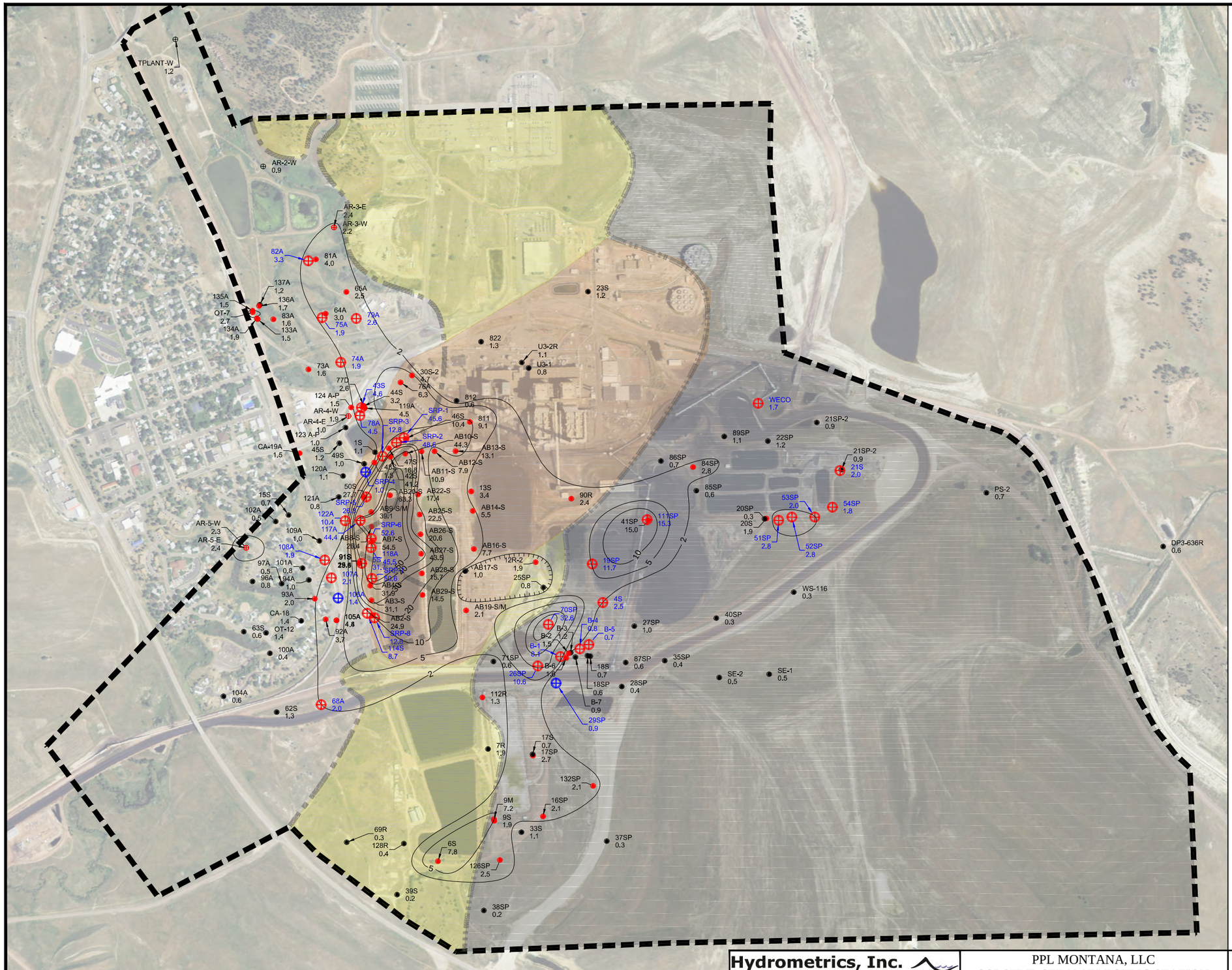

NORTH

SCALE
(In Feet)
500 0 500 1000 1500
(Approximate Only)

LEGEND

106A ⊕ GROUNDWATER CAPTURE WELL

23S ● GROUNDWATER MONITORING WELL

AR-3-E ⊕ SYNOPTIC RUN SAMPLE (SHALLOW GROUNDWATER)

1.2 GROUNDWATER BORON CONCENTRATION (MG/L)

——— SHALLOW BORON CONCENTRATION (5 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)

PLANT SITE BOUNDARY

SHALLOW BEDROCK INCLUDES OVERBURDEN AND ROSEBUD COAL

FILL CONSISTING OF EXCAVATED, MIXED TOPSOIL, AND BEDROCK OVERBURDEN, & THIN SPOIL

SPOIL

APPROXIMATE SPOIL EXTENT

APPROXIMATE ALLUVIUM EXTENT

NOTE: SHALLOW AND COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR BORON OF 1.5 MG/L AND 1.2. WELLS WITH GROUNDWATER ABOVE BSL ARE SHOWN IN RED.

SHALLOW HYDROSTRATIGRAPHIC UNIT CONTAINS ALLUVIUM, SPOIL, ROSEBUD, AND SHALLOW BEDROCK HYDROSTRATIGRAPHIC UNITS

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PLANT SITE BORON SHALLOW

DRAWING FILE NUMBER
1207100B012
AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-9

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Concentrations of boron in the McKay Coal are highest in groundwater below and just west of the Units 1&2 A Pond (Figure 3-10). The BSL of 1.3 mg/l for boron in bedrock is generally only exceeded in this same area and at wells 14M and 67M (west of Units 1&2 Cooling Tower Blowdown Pond C), wells 16M and 17M (south and east of the Units 3&4 Wash Tray Pond, and at 4M (east of former Brine Ponds). A boron BSL was not calculated for McKay Coal wells.

The highest concentrations of boron are present at well 110D and wells in the vicinity of the Units 1-4 Sediment Retention Pond. In the latter area, the sub-McKay strata (Figure 3-11) may be in direct contact with alluvium or interburden. Groundwater capture is being conducted in this area.

Chloride - Concentrations of chloride in groundwater are highest in spoils wells southeast and northeast of the Former D4 Brine ponds. Chloride is present to a lesser degree in the areas below the Units 1&2 A and B Ponds as well in an isolated area defined by well OT-7 (Figure 3-12). The BSL of 213 mg/l for chloride in shallow units is generally only exceeded at these three areas of the Plant Site; however the BSL is exceeded at scattered wells in the central, northern, and southeastern areas of the Plant Site Area.

The highest concentrations of chloride in the McKay Coal are observed in groundwater just west of the Units 1&2 A Pond (Figures 3-13 and 3-14). Calcium to magnesium ratios are also typically less than 1 west of the Units 1&2 A Pond. Groundwater capture is being conducted to mitigate this impacted groundwater in the McKay Coal as well in the shallow units. Similarly to the pattern of boron concentration, chloride concentrations above the BSL are observed for scattered wells in the southern, southeastern, eastern, and northern areas. The bedrock BSL for chloride was used in Figure 3-13 for the same reason as previously discussed. Groundwater capture in west of the Units 1&2 A Pond was expanded in 2013.

NORTH

SCALE
(In Feet)

500 0 500 1000 1500

(Approximate Only)

LEGEND

10M — GROUNDWATER CAPTURE WELL

22M — GROUNDWATER MONITORING WELL

0.7 — GROUNDWATER BORON CONCENTRATION (MG/L)

MCKAY COAL BORON CONCENTRATION (5 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)

PLANT SITE BOUNDARY

NOTE: COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR BORON OF 1.2 MG/L. WELLS WITH GROUNDWATER ABOVE BSL ARE SHOWN IN RED

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PLANT SITE BORON MCKAY

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AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-10

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NORTH

SCALE
(In Feet)
500 0 500 1000 1500
(Approximate Only)

LEGEND

55D — GROUNDWATER CAPTURE WELL

80D — GROUNDWATER MONITORING WELL

0.9 — GROUNDWATER BORON CONCENTRATION (MG/L)

SUB-MCKAY BORON CONCENTRATION (5 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)

PLANT SITE BOUNDARY

NOTE: SUB-MCKAY DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR BORON OF 1.2 MG/L. WELLS WITH GROUNDWATER ABOVE BSL ARE SHOWN IN RED

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PLANT SITE BORON SUB-MCKAY

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FIGURE
3-11

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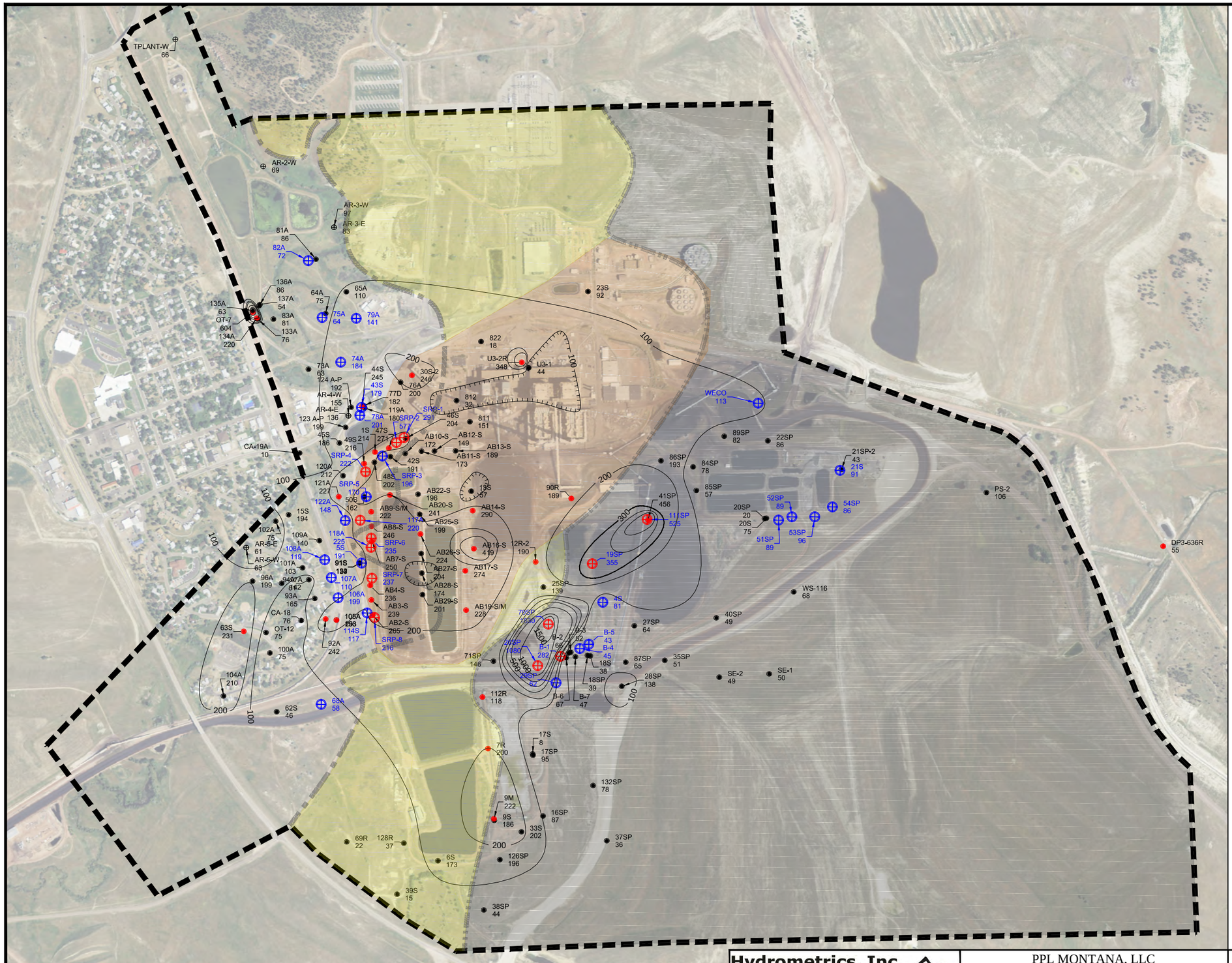

NORTH

SCALE
(In Feet)
500 0 500 1000 1500
(Approximate Only)

LEGEND

- 68A ⊕ — GROUNDWATER CAPTURE WELL
- 23S • — GROUNDWATER MONITORING WELL
- AR-3-E ⊕ — SYNOPTIC RUN SAMPLE (SHALLOW GROUNDWATER)
- 1.2 — GROUNDWATER CHLORIDE CONCENTRATION (MG/L)
- ——— — SHALLOW CHLORIDE CONCENTRATION (100 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)
- PLANT SITE BOUNDARY
- SHALLOW BEDROCK INCLUDES OVERBURDEN AND ROSEBUD COAL
- FILL CONSISTING OF EXCAVATED, MIXED TOPSOIL, AND BEDROCK OVERBURDEN, & THIN SPOIL
- SPOIL
- APPROXIMATE SPOIL EXTENT
- APPROXIMATE ALLUVIUM EXTENT

NOTE: SHALLOW AND COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR CHLORIDE OF 213 AND 48 MG/L. WELLS WITH GROUNDWATER ABOVE BSL ARE SHOWN IN RED.

SHALLOW HYDROSTRATIGRAPHIC UNIT CONTAINS ALLUVIUM, SPOIL, ROSEBUD, AND SHALLOW BEDROCK HYDROSTRATIGRAPHIC UNITS

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SPRING 2014
PLANT SITE CHLORIDE SHALLOW

DRAWING FILE NUMBER
1207100B013
AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-12

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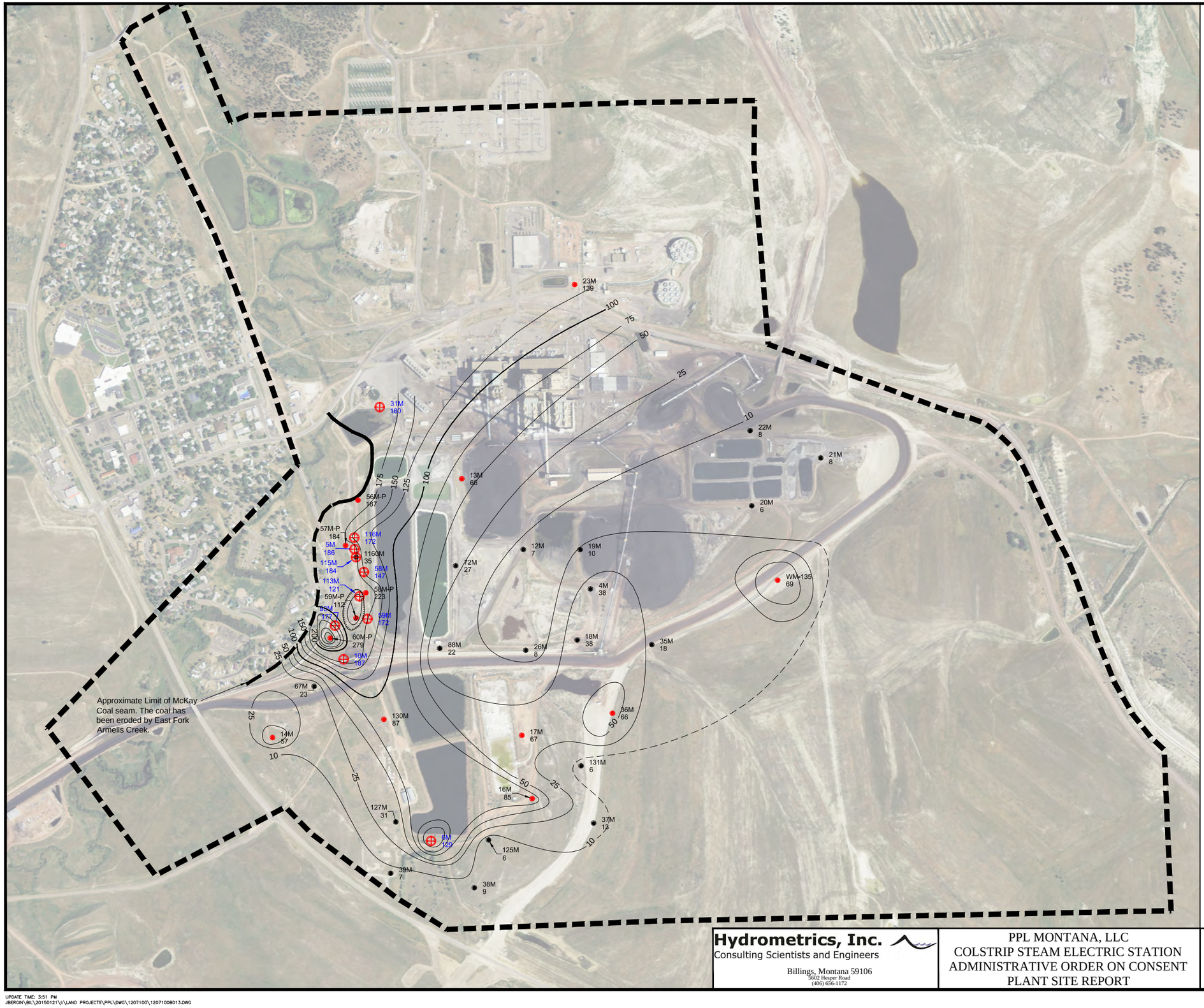

SCALE
(In Feet)

500 0 500 1000 1500

(Approximate Only)

LEGEND

59M — GROUNDWATER CAPTURE WELL

22M — GROUNDWATER MONITORING WELL

0.7 — GROUNDWATER CHLORIDE CONCENTRATION (MG/L)

MCKAY COAL CHLORIDE CONCENTRATION (25 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)

PLANT SITE BOUNDARY

NOTE: COAL DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR CHLORIDE OF 48 MG/L. WELLS WITH GROUNDWATER ABOVE BSL ARE SHOWN IN RED

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SPRING 2014
PLANT SITE CHLORIDE MCKAY

DRAWING FILE NUMBER
1207100B013
AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-13

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With respect to sub-McKay wells, values of chloride above the BSL are restricted to a few wells, mostly west and northwest of the Units 1&2 A Pond. The highest values are found at capture wells west and northwest of the Units 1&2 Bottom Ash Clearwell (Figure 3-14).

Ongoing groundwater capture in the areas where the highest concentrations of indicator parameters are observed (both in the shallow units and in the McKay Coal) limits migration of impacted groundwater from the Plant Site. Groundwater capture wells are identified on Figures 3-3 through 3-14.

Bromide, which has recently been incorporated (2010) at the Plant to remove mercury from flue gas, is also analyzed in water samples as a possible indicator parameter. Of the Plant Site ponds, the Units 1&2 B Pond contains the highest bromide concentrations (218 mg/L in 2012). The concentration of bromide is highly variable in the pond system due to differences in process water routing, amounts of raw water added, and management of the ponds. For example, ponds that receive scrubber water will typically have the highest bromide concentrations since the chemical is introduced into this circuit for mercury removal. The highest concentrations of bromide at well AB-29S, 30S-2, 20S, 51SP, 52Sp, 53SP and 54SP were between 10-20 mg/l in spring 2012. These wells are either capture wells or upgradient of capture wells.

Background screening levels were calculated for alluvial and spoil groundwater for the Plant Site based on a limited number of data points. Based on an eight-point data set, a BSL for bromide in alluvium of 0.59 was calculated. Based on 25 data points, the spoil BSL of 2.4 mg/L for bromide was calculated. The low number of data points for the BSL for the alluvium make use of this value impractical. There was insufficient data available to calculate BSL's for the other units. Note that a current detection limit of 0.5 mg/L is used during sample analysis. However, due to interferences in the samples, a detection limit of 1.0 mg/L is typically what is reported.

NORTH

SCALE
(In Feet)
500 0 500 1000 1500
(Approximate Only)

LEGEND

55D — GROUNDWATER CAPTURE WELL

80D — GROUNDWATER MONITORING WELL

0.9 — GROUNDWATER CHLORIDE CONCENTRATION (MG/L)

SUB-MCKAY CHLORIDE CONCENTRATION (25 MG/L CONTOUR INTERVALS, DASHED WHERE INFERRED)

PLANT SITE BOUNDARY

NOTE: SUB-MCKAY DRAFT BACKGROUND SCREENING LEVELS (BSL) FOR CHLORIDE OF 48 MG/L. WELLS WITH GROUNDWATER ABOVE BSL ARE SHOWN IN RED

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SPRING 2014
PLANT SITE CHLORIDE SUB-MCKAY

DRAWING FILE NUMBER
1207100B013
AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-14

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Bromide has been detected in some monitoring wells at the Plant Site. The highest concentrations have been detected in wells west of the Units 1&2 A Pond. Capture wells in this area are highly prone to scaling problems. A biocide is added to the well water in attempts to limit scaling in the wells, pumps, pipelines, and VSEP treatment system. It was recently been discovered that the biocide (Towerbrom) contains bromide. For this reason, use of Towerbrom as a biocide has been discontinued. Many of the wells that have had bromide detected along the west side of the Units 1&2 A Pond have been treated with the biocide. These include:

- Regularly treated wells (twice weekly) -704, 725, 729, 106A, 107A, 108A, 98M, 122A, 117A, 116A, 5S, 5M, 115M, 113M, 114S.
- Occasionally (every two to four weeks) treated wells - SRP-3, 19SP, 55D, 1D, 56D, 58M, 59M, 70SP, B-1, 111SP, 26SP, 29SP, 10S, 10M, 68A, 31M.

Detections of bromide in the water in this area are therefore suspect. For this reason, use of bromide as a tracer must be evaluated for each area individually and is not currently considered a reliable indicator. It should be a suitable indicator of more recent seepage in areas where well treatments are not necessary.

3.3.3 Groundwater Flow

Under normal conditions, that is when capture wells are not pumping, groundwater flow in the shallow units and McKay Coal generally mirror the topography with flow through the Plant towards the northwest, except for the southeastern part of the Plant Site that flows toward the east/southeast. Prior to pumping, a distinct hydrologic divide was also present through the south central portion of the Plant Site. On a more regional scale, groundwater flow in the Tongue River Member of the Fort Union Formation is generally eastward (Van Voast, W.A., and Reiten, J.C. 1988).

Water levels are periodically measured at the facility in monitoring wells and capture wells using commercial water level meters equipped with calibrated tapes. Groundwater elevations are calculated by subtracting the depth to water (pumping or static) from the measuring point

elevation. Water levels measured in monitoring wells represent static conditions. Water levels measured in capture wells represent pumping water levels, or levels measured during some portion of "recovery" when pumps have turned off. Water levels inside a pumping well are often lower than those in the surrounding formation due to frictional losses caused by drilling and well completion processes. Multiple types of head losses occur in and around a pumping well. These are formation losses, disturbed zone losses, and well losses. Formation head losses are a function of the rate at which water is removed from a well and the hydraulic conductivity. Head losses also occur at the interface between the formation and the portion of the formation that is disturbed during the drilling process. This "disturbed zone" may have lower permeability than the surrounding formation from an accumulation of drilling fluids, fines pushed into the formation during drilling, or other effects of the drilling process. A head loss will occur where the hydraulic conductivity at the interface between the two media is lower than that of the adjacent water bearing formation. Well losses are a result of the well installation itself and are a function of restrictions of groundwater flow to a well. These may be caused by the presence of a filter pack, size and amount of perforations, type of flow into the well (turbulent versus laminar), and post-construction factors such as scaling of perforations causing blockage. Any or all of these factors may restrict flow to a well, causing water levels inside a well to be lower than those in the adjacent formation. Water levels measured inside a pumping well are typically an overestimate of actual drawdown affects outside of the pumping well because of the head losses not associated with the formation. Therefore water levels from capture wells that are used for potentiometric map construction represent an estimate of actual conditions.

Water levels are measured in select monitoring wells during the first 10 days of each month. A broader set of water levels are measured twice a year, typically in late spring and fall. Water levels measured in shallow units are typically higher in the spring than in the fall. However, the effect on groundwater flow direction is negligible.

Water levels measured are used to construct figures that illustrate the configuration of the water table (unconfined) or potentiometric surface (confined). These figures are typically referred to as either water table or potentiometric figures. For the purposes of this report, all

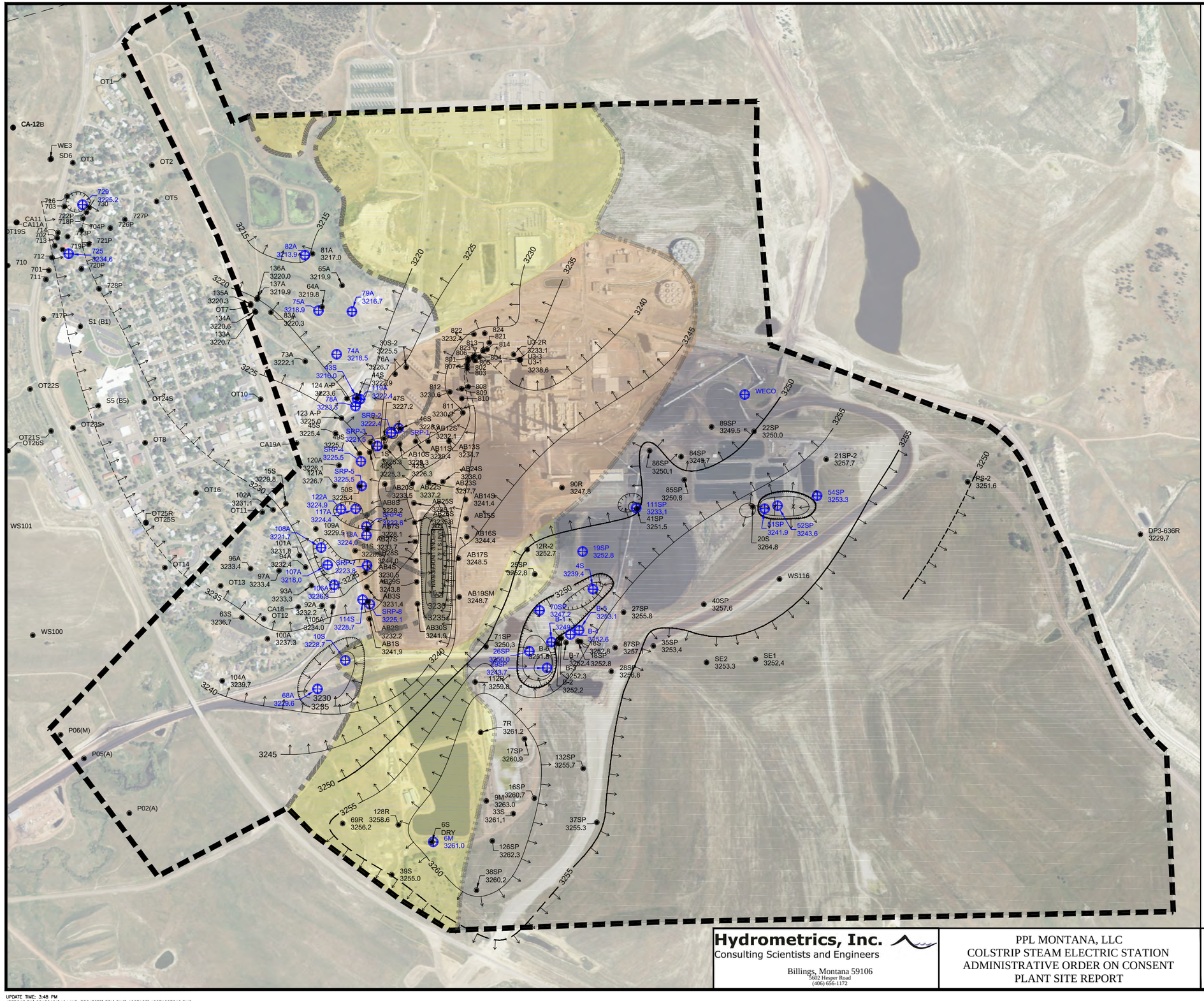
figures depicting groundwater surfaces are referred to as potentiometric figures. Potentiometric figures are constructed by plotting elevations for various units on a map and then adding contours lines (lines representing equal elevations). Available data for wells is used during map construction. Some areas have a smaller density of wells than others and the frequency of water level measurements also vary. The number of wells used to construct a map is dependent on the density of wells in an area which are completed in similar hydrostratigraphic units and the time that water levels were measured (used measurements from a similar time period if possible). Calculated water table elevations are used for all available wells except when data appear erroneous or there are multiple wells in close proximity to one another with similar water level elevations. Only one well may be used in an area with a high density of wells are present and exhibit similar water level elevations in order to make the figures more legible. In these cases, the location of contour lines is not affected.

Potentiometric figures are presented in Figures 3-15, 3-16 and 3-17 for the shallow units, McKay Coal, and sub-McKay. Shallow units include alluvium, shallow overburden bedrock, Rosebud Coal, and spoil. Each of the "shallow" units flow laterally into the adjacent material making mapping as a single unit appropriate. Shallow bedrock only exists in a small area in the southern portion of the Plant Site. The shallow bedrock is bound on all sides by unconsolidated deposits so groundwater, if present, flows into these units forming a single surface. Approximate boundaries of the different deposits are delineated on the shallow concentration figures. Note that the extent of spoil on the spoil thickness figure (Figure 3-2) varies slightly from the shallow groundwater concentration figures (Figures 3-3, 3-9, 3-12). This is a function of well location and completion in relation to the adjacent spoil (the upper portion of the well may have penetrated dry spoil before entering deeper bedrock units. McKay Coal figures represent water level elevations calculated from water levels measured in that unit. Sub-McKay potentiometric figures are based on calculated water levels from measurements in wells completed in strata that are stratigraphically below the McKay Coal.

East Fork Armells Creek generally has a lower hydraulic head than the surrounding bedrock (Rosebud interval, if present, Rosebud-McKay Interburden, McKay Coal, shallow sub-

McKay) and alluvium near the Plant Site and throughout much of the reach that passes through town. Where the head in the creek is lower, groundwater flows from the bedrock to the east and west to the alluvium. Groundwater does not flow under the creek in areas where the hydraulic head is lower than in the adjacent alluvium and bedrock. As can be seen on Figures 3-15 through 3-17 (potentiometric figures for the shallow units, McKay Coal, and sub-McKay Coal based on May 2014 measurements) groundwater capture efforts on the Plant Site have created a series of depressions (areas of lower hydraulic head) near capture wells. The depressions are formed in areas where groundwater pumping has lowered the groundwater level (head potential) relative to the normal flow direction. "Tick" lines drawn on potentiometric lines identify depressions on the map, pointing in the direction of local groundwater flow. The pumping has moved the area of lowest hydraulic head from the creek eastward towards the Plant.

Groundwater flow in the Plant Site is changed by the current capture system operation. In the mid 1980's a distinct hydrologic divide was present that extended from the south end of the Units 1 & 2 Cooling Tower Blowdown Pond C towards the Units 3&4 Bottom Ash Ponds. In the shallow system, overall groundwater flow is generally still to the northwest (Figure 3-15). However, several depressions in the water table are present near groundwater capture systems. On the northeastern side of the site, flow is generally to the northwest, but on the southeastern side of the site flow may be towards the southeast. A relatively distinct depression in the water table, as indicated by inward facing tick marks on contour lines, is present around the Brine Pond capture wells and the south side of the Units 3&4 Bottom Ash ponds. Note that the previously mentioned groundwater divide in the shallow units near this area has shifted eastward. This is shown by flow arrows pointing in opposite directions on adjacent 3255 contours on the southeast side of Figure 3-15. The shift in the hydrologic divide is believed to be a function of increases in water levels in spoil to the east and southeast, and from dewatering on the Plant Site. The combination of increasing water levels in the spoil on the southeast portion of the Plant, and dewatering, result in a shift of the divide slightly to the east.



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PLANT SITE SHALLOW HYDROSTRATIGRAPHIC UNITS POTENTIOMETRIC SURFACE MAY 2014

DRAWING FILE NUMBER
1207100B010
AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-15

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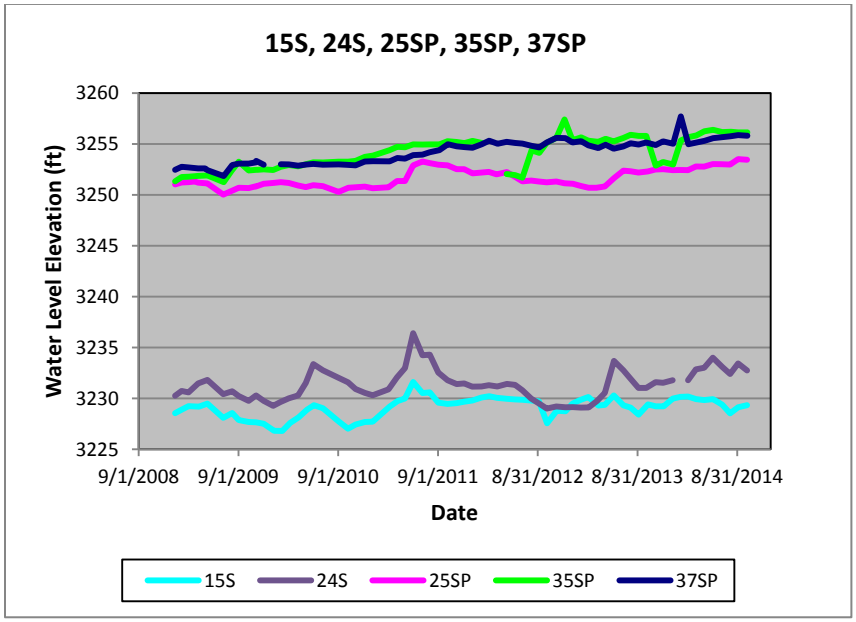
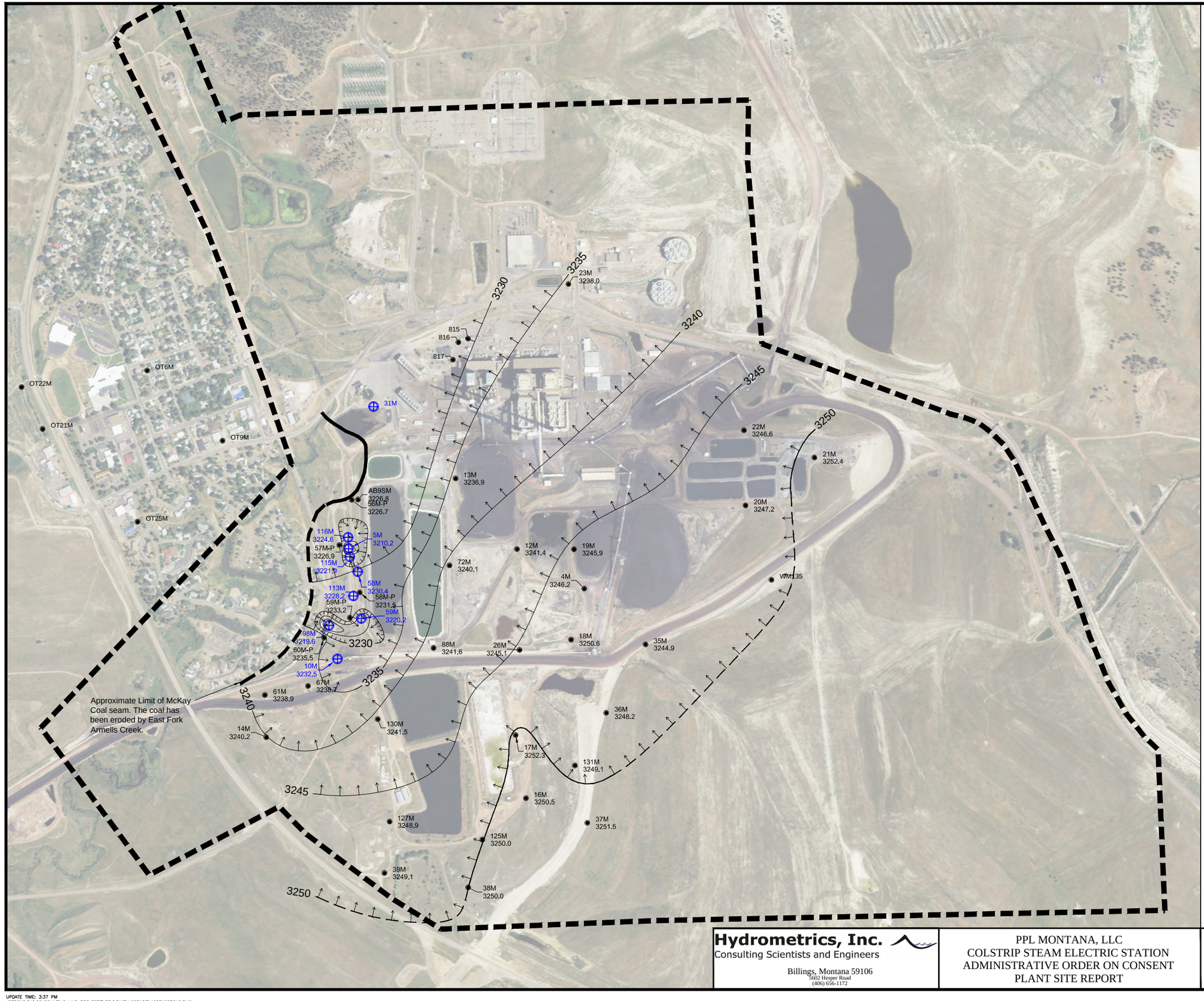
Water levels in the alluvial wells and shallow wells near the creek show some seasonal fluctuation. However, the overall configuration of the potentiometric figures is relatively similar throughout the year. Very little seasonal variation in water levels and groundwater flow directions is typically observed in the McKay Coal and deeper units. Long term variations in water levels have been observed in the spoil in the southeastern part of the Plant. For example, as shown below, water levels in wells 35SP and 37SP, located at the far southeast corner of the Plant Site have shown a gradual increase in water levels of about five feet since 2008. At the same time, well 15S, located near the creek has shown no definitive changes in water levels.



Groundwater flow in the McKay Coal is also towards the northwest (Figure 3-16). Note that the coal has been eroded by the ancestral East Fork Armells Creek. Groundwater from the McKay flows into the alluvium along this sub-crop. Note also, that significant groundwater depressions are present in the potentiometric surface along the west side of Units 1&2 A Pond.



NORTH

SCALE
(In Feet)

500 0 500 1000 1500

(Approximate Only)

LEGEND

- 5M — GROUNDWATER CAPTURE WELL
- 21M — GROUNDWATER MONITORING WELL
- 3252.4 — GROUNDWATER ELEVATION (FEET)
- MCKAY POTENTIOMETRIC DEPRESSION
- MCKAY POTENTIOMETRIC LINE WITH FLOW DIRECTION ARROW (5 FOOT CONTOUR INTERVALS)
- INFERRED MCKAY POTENTIOMETRIC LINE WITH FLOW DIRECTION ARROW (5 FOOT CONTOUR INTERVALS)
- PLANT SITE AREA BOUNDARY

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PLANT SITE MCKAY
HYDROSTRATIGRAPHIC UNIT
POTENTIOMETRIC SURFACE
MAY 2014

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

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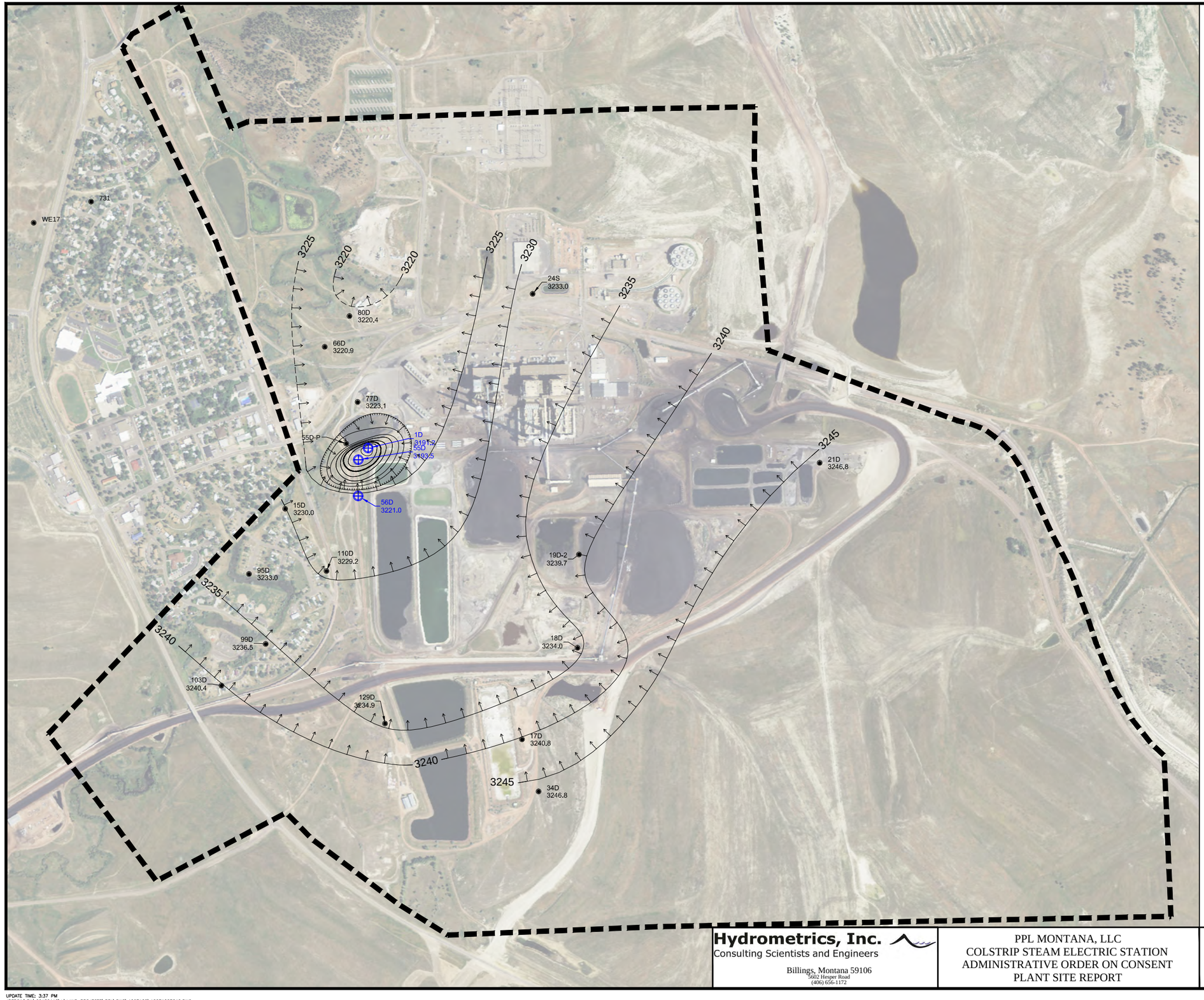
Figure 3-17 is a potentiometric map for the sub-McKay. The contours indicate that groundwater in the sub-McKay is flowing towards the northwest under most of the Plant. However a more northern component exists along the west boundary of the ponds. Northeasterly flow occurs on the west side of the site close to the creek. A depression exists near capture wells 1D, 55D, and 56D.

3.3.3.1 Vertical Gradients

Figure 3-18 contains hydrographs for various paired or nested wells, or for wells in very close proximity to one another. The hydrographs illustrate the potentiometric head in each well. Groundwater flows from areas of higher potentiometric head to those with lower potentiometric head. It is critical, however, to understand that significant groundwater flow may not occur between units even though there may be a relatively large differential in potentiometric head at various locations. Actual flow between the units is controlled by the hydraulic conductivity of the individual units and any units separating them, and the potential head difference. Units with very low hydraulic conductivity, such as claystone, shale, clayey siltstone for example, will have very little porous groundwater flow through them, regardless of the head differential. Note that head differentials in individual wells may be affected by completion intervals, and method of completion. This can occur if a well is completed with perforations positioned over multiple water bearing intervals. An interval containing a very small volume of water may over time raise water levels in a well giving the appearance of increasing water levels. This is not uncommon when a low yield interval is not identified during drilling due to its extremely low yield. Completion methods may also affect the heads in wells. Accepted completion methods have changed substantially throughout the life of the Colstrip SES. Initially, wells were completed by either placing neoprene packers above the perforated interval or by covering the perforations with a filter material, commonly pea gravel. The annular space above the packer or gravel pack was then typically covered with about two feet of bentonite and then the remainder of the annulus filled with cuttings. Placement of cuttings into the annulus could result in bridging resulting in a poor seal.



NORTH

SCALE
(In Feet)

500 0 500 1000 1500

(Approximate Only)

LEGEND

- 55D ⊕ — GROUNDWATER CAPTURE WELL
- 21D • — GROUNDWATER MONITORING WELL
- 3246.8 — GROUNDWATER ELEVATION (FEET)
- MCKAY POTENTIOMETRIC DEPRESSION
- MCKAY POTENTIOMETRIC LINE WITH FLOW DIRECTION ARROW (5 FOOT CONTOUR INTERVALS)
- INFERRED MCKAY POTENTIOMETRIC LINE WITH FLOW DIRECTION ARROW (5 FOOT CONTOUR INTERVALS)
- PLANT SITE AREA BOUNDARY

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PLANT SITE SUB-MCKAY HYDROSTRATIGRAPHIC UNIT POTENTIOMETRIC SURFACE MAY 2014

DRAWING FILE NUMBER
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AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-17

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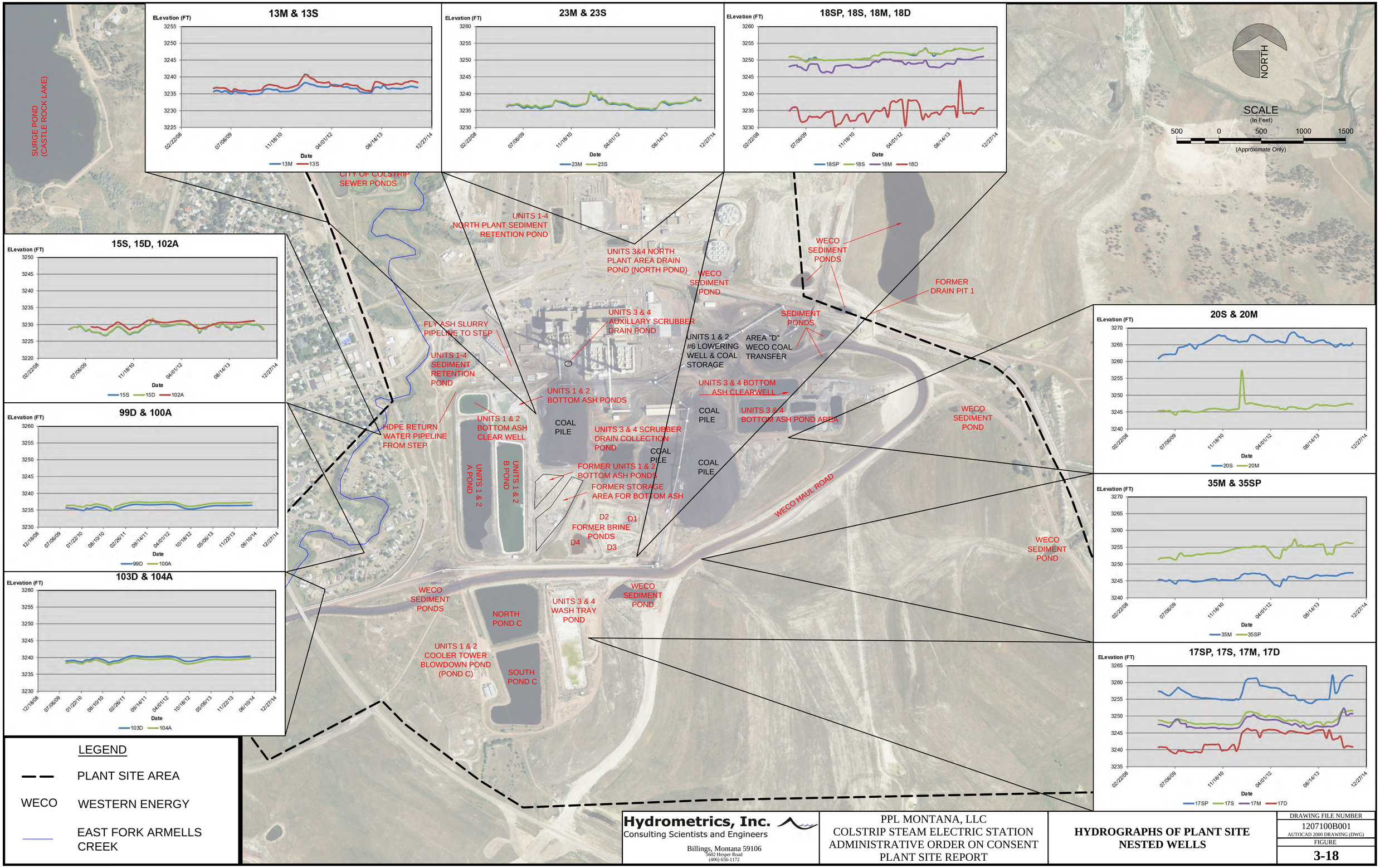

13M & 13S

23M & 23S

18SP, 18S, 18M, 18D

15S, 15D, 102A

99D & 100A

103D & 104A

20S & 20M

35M & 35SP

17SP, 17S, 17M, 17D

LEGEND

PLANT SITE AREA

WECO WESTERN ENERGY

EAST FORK ARMELLS CREEK

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HYDROGRAPHS OF PLANT SITE NESTED WELLS

DRAWING FILE NUMBER
1207100B001
AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-18

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A poor seal would also occur if the cuttings were primarily coarser grained. Later wells were completed using neoprene packers with bentonite seals placed above them to the surface. Packer failure could also potentially result causing the annular seal to become unstable resulting in possible groundwater flow downward through the annulus. Currently, wells are completed by placing a filter pack, generally silica sand, over the perforations, and then backfilling to the surface. A solid seal commonly is completed once the bentonite has hydrated with formation water. Note too, however, that high sodium content water may affect the bonding strength of bentonite, potentially weakening a seal.

Observations for the hydrographs (Figure 3-17) are included under the following bullets. Wells were chosen that would demonstrate gradients in areas that have minimal effects from pumping of groundwater capture wells.

- 13S and 13M – These wells are located near the northeast edge of Units 1&2 B Pond. Well 13S is completed in shallow bedrock into the first water encountered. Stratigraphically, the shallow interval at this location is equivalent to the Rosebud-McKay interburden but it exists under unconfined conditions. The Rosebud Coal is missing at this location. A slight downward gradient of about 0.6 to 1.3 feet exists at this location.
- 15S, 15D, and 102A – These wells are located adjacent to the creek, west of the facility. Well 15S is completed in the shallow sub-McKay sandstone. At this location, this unit is hydrologically connected to the alluvium. This is demonstrated by the correlation of groundwater elevations at well 15S to those in adjacent alluvial well 102A. Well 15D is completed in deeper sub-McKay siltstone. A downward gradient of about 1.1 to 1.6 feet typically exists between the shallow and deeper intervals. Very little overall change in groundwater elevations has been observed at these wells.
- 17SP, 17S, 17M and 17D – This set of wells is located east of the Units 3&4 Wash Tray Pond. Well 17SP is completed in mine spoil resulting from past mining of the Rosebud Coal. The base of the spoil is equivalent to the base of the Rosebud Coal. Groundwater levels in the spoil and the adjacent Rosebud Coal are similar. Well 17S is completed in the Rosebud-McKay interburden sandstone. The completion interval

is separated from the base of the Rosebud interval by clayey siltstone. Well 17M and 17D are completed in the McKay Coal and sub-McKay strata, respectively. A downward gradient exists between each well in this area.

- 18SP, 18S, 18M, and 18D – These wells are located southeast of the former Brine Ponds and northwest of the Units 3&4 Wash Tray Pond. Well 18SP is completed in mine spoil. Well 18S is completed interburden siltstone that is in direct contact with mine spoil. Well 18M is completed in the McKay Coal, which is overlain by siltstone (interburden). Well 18B is completed in sub-McKay sandy siltstone directly below the McKay Coal. Groundwater levels in the spoil and interburden are nearly identical through time indicating a good hydraulic connection between the two intervals. A downward gradient exists between the shallow units (spoil and interburden) and McKay Coal and between the McKay Coal and sub-McKay.
- 20S and 20M – These wells are located directly south of the Units 3&4 Bottom Ash Ponds. Well 20S is completed in the McKay overburden but is equivalent stratigraphically to the Rosebud-McKay interburden. The Rosebud Coal was not present at this location. Well 20M is completed in the McKay Coal. A strong downward gradient of about 15 to 21 feet exists at this location.
- Wells 23S and 23M – These wells are located directly east of the Units 3&4 North Plant Area Drain Pond (North Pond). Well 23S is completed in colluvium just below the contact with overlying spoil. Well 23M is completed in the McKay Coal. A very slight downward gradient of zero to 0.5 feet exists at this well pair.
- Wells 35SP and 35M – These wells are completed in a mined and reclaimed area east of the Brine Ponds along a mining haul road. Well 35SP is completed across the contact with spoil and underlying interburden. This well yields very little water. Well 35M is completed in the McKay Coal. A relatively strong downward gradient of about 6 to 11 feet exists between the spoil and McKay Coal at this location.
- Wells 103D and 104A – These wells are west of the facility a few hundred feet downstream from the Highway 39 creek crossing. Well 104A is completed in the creek alluvium. Well 103D is completed in sub-McKay sandstone. The McKay Coal

has been removed by erosion at this location. A slight upward gradient of about 0.5 to 0.8 feet exists at this set of paired wells.

- Wells 99D and 104A – These wells are near the creek west of the facility. Well 99D is completed in sub-McKay sandstone. The McKay Coal has been removed by erosion at this by the creek. A slight downward gradient of about 0.7 to 1 foot has been observed at this location.

3.3.4 Hydraulic Parameters

Hydraulic parameters for Plant Site hydrostratigraphic units are listed below. The parameters were used in development of the groundwater flow model included as Appendix A. The geometric mean was used in the calculation of transmissivity, hydraulic conductivity, and storativity. Geometric mean was calculated by multiplying the values in a data set together and then taking the nth (number of values in data set) root of the product. A geometric mean indicates the central tendency or typical value of a set of numbers by using the product of their values (as opposed to the arithmetic mean which uses their sum). For aquifer parameters that vary by more than two orders of magnitude, (e.g. hydraulic conductivity) the geometric mean is often thought to be more representative of average values than the arithmetic mean (Fetter, 1988).

Hydro Stratigraphic Unit	Geometric Mean Transmissivity ($feet^2$/day)	Geometric Mean Hydraulic Conductivity (feet/day)	Minimum Hydraulic Conductivity (feet/day)	Maximum Hydraulic Conductivity (feet/day)	Arithmetic Mean Saturated Thickness (feet)	Geometric Mean Storativity
Alluvium	225	18.3	0.15	355	14	0.0003
Spoils/Fill	111	7.5	0.01	622	19	N/A
Rosebud	149	12.5	0.9	65	13	N/A
Interburden	13	1.1	0.02	39	15	N/A
McKay	26	2.3	0.06	9.3	10	N/A
Sub-McKay	41.5	2.5	0.03	242	18	0.0008

N/A – not applicable
"--" – no data available
1 – Rehm and others (1980), Van Voast and Reiten (1988), and Van Voast and others (1977)
2 - Assumes same values as McKay Hydrostratigraphic Unit

Aquifer Properties from Studies[1] of the Fort Union Formation			
Hydro Stratigraphic Unit	Transmissivity (feet^2/day)	Hydraulic Conductivity Range (feet/day)	Storage Coefficient
Alluvium	1,900	0.00007 – 492	--
Spoils	0.1 – 64	0.02 – 5.7	0.00001 to 0.00003
Rosebud	1.3 – 1,700	0.1 – 68	--
Interburden	28	0.9	--
McKay	0.7 – 31	0.01 – 3.1	--
Sub-McKay[2]	0.7 – 31	0.01 – 3.1	--

N/A – not applicable
"--" – no data available
1 – Rehm and others (1980), Van Voast and Reiten (1988), and Van Voast and others (1977)
2 - Assumes same values as McKay Hydrostratigraphic Unit

3.3.5 Surface Water – East Fork Armells Creek

PPLM has conducted 15 synoptic runs on the creek in 1993, 1994, 1996, 2000, 2003, 2004, 2005, 2007, 2008, 2009, 2010, 2011, 2012, 2013, and 2014. In 2014, the synoptic run was completed on April 8, 2014. A synoptic run, also referred to as a seepage run, consists of surface water monitoring along a reach (portion of a creek between two points) of a creek or river to characterize flow and quality conditions. Synoptic run monitoring sites are currently as follows:

- AR-12 – Upstream of Plant Site and directly upstream of Highway 39 culvert;
- AR-5 – Directly upstream of the culvert located on Currant Drive. This location is west of the Units 1&2 A and B Ponds and northwest of Units 1&2 Blowdown Pond C North and South Ponds;
- AR-4 – Directly upstream of the culvert on Willow Ave. This site is a very short distance west of the Units 1-4 Sediment Retention Pond;
- AR-3 – Upstream and upgradient from the City of Colstrip Wastewater Treatment Plant settling ponds;
- AR-2 – Also known as the South Flume, this site is located downgradient and downstream of the two easternmost City of Colstrip Wastewater Treatment Plant settling ponds and adjacent to the westernmost pond (North Sewage Effluent Pond);
- AR-1 – Also known as the North Flume, this site is located downstream from the City of Colstrip Wastewater Treatment Plant settling ponds, downstream of a tributary that

drains the town site, downgradient from the Surge Pond, and downstream from Power Road. This site is also downgradient from the boundary between the Plant Site and Units 1&2 Stage I and II areas;

- AR-9 – Located about midway between AR-1 and the Ponderosa Butte Golf Course;
- AR-8 – Located on Ponderosa Butte Golf Course upstream from the irrigation holding pond. This pond receives water from the City of Colstrip Wastewater Treatment Plant;
- AR-7 – Located on Ponderosa Butte Golf Course downstream from the irrigation holding pond and upstream from the confluence of the tributary that holds the SOEP and STEP;
- AR-6 – Located downstream from the City of Colstrip sports fields (baseball, softball, soccer, etc.) and downstream from the confluence of the tributary that holds the SOEP and STEP;
- AR-11 – Located on the Ponderosa Butte Golf Course between sites AR-6 and AR-10
- AR-10 – Also known as the Pine Butte Road Flume this site is located at the northern edge of the golf course and upstream of Pine Butte Road.

Note that the synoptic run sites AR-12, AR-5, AR-4, AR-3 and AR-2 are within the area defined as Plant Site for the purposes of this and subsequent AOC reports for this defined area. Site AR-1 is the first site downstream of the Plant Site boundary.

Synoptic runs have been conducted in the springtime before golf course irrigation or fertilization has occurred for the coming year, and before vegetation growth is sufficient to cause significant evapotranspiration effects on flow and water quality. This timing is intended to monitor the stream during "baseflow" conditions. Baseflow conditions exist when creek flow is the result of groundwater contributions and are not affected by precipitation or artificially caused runoff events. Synoptic runs are conducted over a short period of time to minimize diurnal flow variations. Higher flows, typically attributable to snowmelt typically occur between February and March when snowmelt occurs when the ground is still frozen. Lowest flows typically occur in late summer and early fall due to

evapotranspiration affects. Short term high flows also occur in response to intense rainfall and runoff events.

Stream reaches may be defined as gaining (increasing in flow) or losing (decreasing in flow) based on flow measurements. Gaining reaches are supplied by groundwater inflow while surface water is recharging groundwater in losing reaches. Occasionally, groundwater levels and quality are also monitored in association with the synoptic run. Groundwater levels higher than the creek are indicative of areas that are likely flowing into the creek (gaining), and conversely, lower groundwater levels are suggestive of places where surface water is recharging groundwater (losing). In some reaches, groundwater levels are higher than the level of the creek while on the other side the groundwater levels are lower. This indicates that groundwater is flowing into the creek where the groundwater is higher and out of the creek toward the side with lower groundwater elevations.

During the spring 2014 synoptic run event, fourteen surface water sites were sampled including twelve sites on the creek, one tributary, and one pond. Water quality samples were collected from each site, and flows were measured in the creek. Groundwater samples were collected immediately adjacent to the creek at 17 sites. In addition to water quality monitoring, sediment samples were collected from the streambed at thirteen sites along the creek in 2014 at the request of MDEQ. All of the samples were analyzed for an extensive list of parameters. A copy of the spring 2014 synoptic run technical memorandum is included in this report as Appendix C. Also included in Appendix C are figures showing losing and gaining reaches based on flow measurements between 2005 and 2014, and concentration trends SC, sulfate, boron, chloride, and the calcium to magnesium ratio for all synoptic runs and for the spring 2014 event.

3.3.5.1 Synoptic Run Results - Current Conditions

Figure 3-19 shows the synoptic run monitoring sites used during the April 2014 synoptic run. Flows measured during the 2014 synoptic run were above average. Along the upper reach of the creek from site AR-12 through AR-1 (Plant Site) and also at sites AR-8, AR-6, and AR-11, measured flows were the highest recorded during synoptic runs. Note that

precipitation during the year preceding the synoptic run was much higher than normal at 169% of the long-term average. Flow is typically the lowest at upstream site AR-12 and increases in a downstream direction. During recent years, however, flow has increased between AR-12 and AR-5, decreased between AR-5 and AR-3, and increased downstream of AR-2. Decreases in flow between AR-5 and AR-3 are likely the result of groundwater capture conducted on the east side of the creek on the Plant Site.

Indicator parameters concentrations have generally increased between sites AR-5 and AR-3. In recent years, however, the magnitude of this increase has been smaller, and in some years concentrations of indicator parameters have decreased through this reach. Graphs for the various indicator parameters illustrating chemical constituent concentrations along the creek are in Appendix C. Improvement in water quality through this reach is likely the result of ongoing groundwater capture efforts, best management practices by PPLM and better water management within the town of Colstrip, and improved water quality from upstream.

In general, 2014 concentrations of chemical constituents in the creek were below the average for previous events and below BSL's for alluvial groundwater. Chloride concentrations, however, were slightly above average in all sites downstream of AR-4. Calcium to magnesium ratios were above average except at AR-7 indicating improvement (note that low calcium to magnesium ratios are more typical of process water).

UPDATE TIME: 4:30 PM
JBERGIN\HEL\20150121\i:\LAND PROJECTS\PPL\DWG\1207100\1207100B015.DWG

ARM-CRK1
PBR FLUME (AR-10)
AR-11
AR-11-E
AR-11-W
AR-6
AR-6-E
AR-6-W
CHE (CLUB HOUSE EAST)
AR-7-1W
AR-7
AR-7-2W
TREATED SEWAGE WATER/ IRRIGATION STORAGE POND (NOT SAMPLED)
AR-8
AR-9
AR-1NF-E
ARM-CRK2
NORTH FLUME (AR-1)
AR-1NF-W
EAST FORK ARMELLS CREEK
POWER ROAD TRIBUTARY
TPLANT-W
AR-2P-W
NORTH SEWAGE TREATMENT POND (NSTP)
ARM-CRK3
SOUTH FLUME (AR-2)
AR-3P-E
AR-3P-W
AR-3
AR-4P-W
AR-4
AR-4P-E
AR-5-W
AR-5-E
AR-5
AR-12

NORTH

SCALE
(In Feet)
0 1200

LEGEND

- BANK GROUNDWATER SAMPLE LOCATION
- AR-12 SYNOPTIC RUN SITE
- NSTP SEWAGE LAGOON SAMPLE SITE
- PLANT SITE AREA

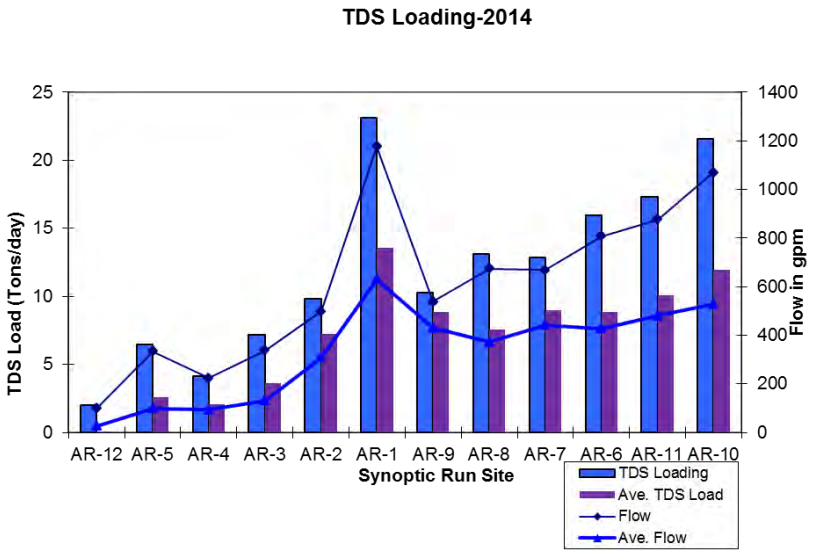
Hydrometrics, Inc.
Consulting Scientists and Engineers

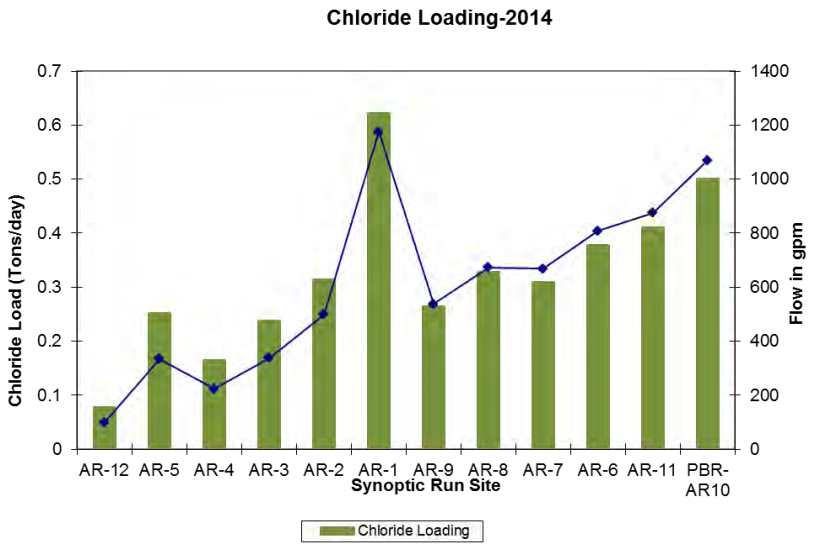
PPL MONTANA, LLC
2014 EAST FORK ARMELLS CREEK
SYNOPTIC RUN

2014 SYNOPTIC RUN SITES

FIGURE
3-19

Loads in surface water are a function of flow and concentrations of chemical constituents in the water. Loading is dictated by the flow when there are only slight variations in the concentration as is the case in East Fork Armells Creek. The following two charts illustrate loading versus flow in the stream for TDS and chloride. TDS is used for this comparison since it is a concentration value available for simple load calculations. SC and TDS values typically show parallel trends so use of TDS as an indicator for comparison of loading is reasonable. Note that both patterns are very similar even through the trend of concentrations vary. TDS concentrations were the highest (3,530 mg/L) at site AR-3; however, loads were the highest at AR-1 (TDS – 3,270 mg/L) because the flow rate is greater at AR-1 as influenced by the wastewater lagoons and the Surge Pond. Chloride concentrations progressively decreased in a downstream direction in April 2014. However, chloride loads showed a general increasing trend downstream as a function of variations in flow. Other indicator parameters sulfate, boron, calcium and magnesium showed very similar trends as illustrated.





Groundwater elevations were measured at 19 sites and compared to adjacent surface water levels in the creek. Results for spring 2014 indicate that overall the creek shows a net increase in flow (gain) through Colstrip. Measured flows from the spring 2014 synoptic run show that the reaches between AR-5 and AR-4, and between AR-1 and AR-9 were losing reaches, while all others were gaining. Since 2005, the reaches between AR-4 to AR-3, AR-1 to AR-8, and AR-11 to AR-10 are losing flow based on simple harmonic mean flow calculations. All other reaches were gaining.

Shallow groundwater along the creek is primarily a magnesium-sulfate type, similar to the surface water type, suggesting the local connection between the surface water and groundwater. Constituent concentrations in shallow groundwater varied in relation to adjacent surface water sites. In general, groundwater samples near the upper creek sites recorded higher constituent concentrations than the adjacent creek samples and groundwater samples along the lower creek sites recorded constituent concentrations generally similar to or lower than the adjacent creek site samples.

Thirteen sediment samples were collected from upstream of the surface water sample locations along the creek. Soil from all sites ranged from silty loam to sandy loam with pH ranging from 7.3 to 7.8 and sodium adsorption ratios (SAR) ranging from 2.03 to 3.92.

3.3.6 Simplified Conceptual Groundwater Model

A detailed conceptual model for the Plant Site is included in the groundwater model report in Appendix A. The conceptual model in the groundwater model report contains graphics that allow the reader to better visualize the hydrogeological system at the Plant Site. A simple conceptual model is presented below.

Colstrip is located in Rosebud County in the northern portion of the Powder River Basin. Surficial geology is dominated by the Fort Union Formation, which dips at less than two degrees to the east, and unconsolidated sediments which occur in valley bottoms as unconsolidated alluvium and along hillslopes as colluvium. The unconsolidated sediments, spoil, and bedrock of the Fort Union Formation comprise the major hydrogeologic units of the area.

The Fort Union Formation is comprised of an upper Tongue River Member, middle Lebo Shale, and lower Tullock Member. The Plant Site is underlain by the Tongue River Member. The Tongue River Member of the Fort Union contains numerous coal seams. The Rosebud and McKay are the coal seams of interest at the Plant Site. The Rosebud Coal has been mined along much of the eastern part of the Plant Site. Clinker, resulting from insitu burning of the coal is present in the northwestern extent of the Plant Site. However, this unit is above the water table and has no bearing on the Plant Site hydrogeology. More detailed descriptions of the geology are included in the hydrogeology section. The cross section in Figure 3-1 shows typical Plant Site geology.

Groundwater at the site is contained in alluvium, shallow bedrock (may include overburden, Rosebud Coal, and Rosebud-McKay Interburden), Rosebud Coal, spoil which is laterally equivalent to the Rosebud Coal, Interburden, McKay Coal, and sub-McKay strata. Shallow units are typically unconfined, although some semi-confined conditions exist along the creek where fine grained sediments overlie coarser grained sediments. The McKay Coal and sub-McKay units exist under both confined and unconfined conditions. Unconfined conditions

typically exist near the creek where erosion has removed these units. Confined conditions often exist in these units in other parts of the Plant Site.

Hydraulic conductivity is variable in all units. The alluvium typically exhibits the highest hydraulic conductivity (avg. ~ 18 ft/day or less); the shallow units, coal seams, and sub-McKay typically exhibit relatively low hydraulic conductivity (1.1 to 12.5 ft/day); and spoil (avg. ~ 8 ft/day). Both the spoil and alluvium exhibit wide ranges of hydraulic conductivity. Groundwater in the alluvium flows to the north under the creek, which is the most prominent natural surface water feature in the area.

The majority of groundwater flow in Plant Site bedrock units is toward the Northwest. Some of this water flows to the creek. East Fork Armells Creek controls flow in the shallow unconfined units as groundwater issues to the creek. Groundwater flow is also controlled by a hydrologic divide that is present along the east side of the site in the shallow units, at the edge of the spoil. Groundwater in the spoil east of this divide flows eastward. Vertical gradients between units are downward except at a few localized areas.

Groundwater quality is variable and is discussed in detail in Section 3.3.2. Mitigation measures have been implemented in areas showing groundwater impacts. A portion of this includes groundwater removal using pumping wells. The pumping creates areas of local depressions (cones of depression). Other mitigation actions include pond reconstruction, lining, and improved water management practices.

Groundwater recharge in the area comes from precipitation, which averages about 15 inches per year, infiltration of domestically used water (lawn water), infiltration from the creek in losing reaches, seepage from the surge pond, seepage from plant site ponds, closed Plant Site ponds that receive stormwater runoff, and stormwater runoff ponds, either Colstrip SES or WECO. Groundwater discharges include flow to the creek, evapotranspiration, and extraction from groundwater supply wells and capture wells.

Surface water (other than ponds) is limited to the creek. East Fork Armells Creek flows through town and adjacent to the main Plant Site. East Fork Armells Creek is a gaining reach from the upstream end of town at the Highway 39 road crossing to the northern end of Ponderosa Butte Golf Course, located at the north end of Colstrip. Increases in flow to the creek are from groundwater on both sides of the creek, and from surface water additions from minor tributaries that flow through town. Flows vary seasonally in response to precipitation, urban uses, and upstream activities.

Surface water is also present in ponds in the area including the Plant Site process ponds, WECO stormwater ponds, City of Colstrip Sewage Lagoons, and Castle Rock Lake (Surge Pond), drain pits, and low areas that pond following precipitation or snowmelt. The Surge Pond supplies the majority of the water used at the facility, town and the Rosebud Mine.

3.4 DESCRIPTION OF COMPLETED AND ONGOING REMEDIAL ACTIONS

PPLM conducts several activities associated with the Plant Site as part of their groundwater monitoring activities, and in response to changes detected through operational water quality monitoring indicating process pond seepage, and/or in response to past spills or releases. These activities include operational monitoring, groundwater mitigation, groundwater or surface water investigation, operational changes and best management practices. These items 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 are/will be conducted to further improve groundwater conditions in the vicinity of the Plant Site process ponds.

3.4.1 Operational Monitoring

PPLM conducts groundwater monitoring (routine ongoing measurement and sampling for water quality) on the Plant Site at a network of wells. Monitoring includes collection of water level measurement and collection and analysis of water quality samples. The monitoring program is outlined in the site monitoring plan (PPLM, September 2011, Water Resources Monitoring Plan – Appendix E). The monitoring plan includes lists of monitoring wells, monitoring frequency for ponds and wells, analytical parameters, and evaluation and

reporting criteria. As per the 2011 plan in the Plant Site Area, 139 wells twice a year, 23 wells are sampled annually, six wells every two years and nine wells every three years. New wells are sampled and evaluated for addition to the monitoring program when the monitoring plan is updated. During 2013 water quality samples were collected from 168 sites in the spring and 153 sites in the fall. In spring of 2014, 212 samples were collected. Sampling frequency has been determined in coordination with the MDEQ and is designed so changes in water quality are identified. Biannual sampling is conducted at most of the wells to allow seasonal variations to be documented. Less frequent monitoring is conducted at wells that are located in less critical locations or in areas where sampling intervals are less critical to the evaluation of groundwater conditions. Wells that are considered critical for detection monitoring or to evaluate current water quality conditions are generally monitored twice a year. Less frequent monitoring is conducted on wells that have been installed for specific investigational purposes but are not critical for the overall evaluation of an area, typically because of the high density of wells. An example is wells identified as AB-# that were installed around the former Units 1&2 A and B Ponds, an area that currently may still seep a reduced amount of lower concentration process water. The majority of these wells still exist around and between the Units 1&2 A Pond and B Pond. These wells are monitored for water quality on a three year basis which allows changes in water quality below and very near these ponds to be evaluated. An extensive network of monitoring wells and capture wells are present downgradient of the ponds to detect, mitigate, and characterize conditions.

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. With the exception of selenium, these parameters are present in the water at relatively high concentrations. Hence, many of these parameters are used as indicators of the presence of process waters. Broader spectrum analyses were conducted from the mid 1970's to the mid 1980's. The analytical parameter list has been modified to the current list based on discussions with MDEQ and results of prior analysis. Mercury is analyzed at a few select sites. These sites are at locations that are considered as "sentinel" type wells, that is, they are

in locations that would likely be most susceptible to impacts from efforts to remove mercury from the flue gas.

PPLM routinely samples the Units 1&2 B Pond, Units 1&2 Bottom Ash Clearwell Underliner, Units 1&2 Brine Pond sump, Units 1&2 B Pond below liner, and Units 1&2 B Pond between liner on an annual basis and Units 1&2 Bottom Ash Pond, 1&2 Bottom Ash Pond Clearwell, Units 1&2 Pond C South, Units 1&2 Pond C North, the Units 1&2 A Pond, the Units 3&4 Bottom Ash Pond and Clearwell every three years. Water quality sampling at this frequency is considered sufficient to characterize water within the ponds. Water quality samples are collected just below the surface of the water, typically at, or near the same location. Sampling location may change based on site conditions which make it necessary to collect samples from a different location. Pond samples are also collected and analyzed periodically for a more extensive list of parameters than indicated in the monitoring plan. For example, in 2012, pond water quality samples were collected from Plant Site ponds including: Units 1&2 Bottom Ash Clearwell, Cooling Tower Blowdown Pond C South, Units 1&2 A Pond, Units 1&2 B Pond, Units 3&4 Bottom Ash Clearwell, North Plant Area Drain Pond, Units 1-4 Sediment Retention Pond, and a sample of the raw water from the supply pipeline (untreated water being pumped to the Plant from the Surge Pond). These samples were analyzed for SC, TDS, pH, hardness as $CaCO_3$, Alkalinity as $CaCO_3$, nutrients (N+N, nitrate, orthophosphate, phosphorus), anions (sulfate, chloride, bicarbonate as $CaCO_3$, carbonate as CO_3) an extended suite of metals (Al, Sb, As, Ba, Be, B, Cd, Cr^{+6}, Cr, Co, Cu, Fe, Mn, Hg, Mo, Ni, Se, Ag, Ar, Tl, V, Zn) as total and dissolved, volatile organic compounds (VOC's), semi-volatiles, diesel range organics, and cyanide. Collection of a sample from the raw water pipeline allows characterization of water prior to entering the process water circuit.

There are no natural surface water bodies on the Plant Site proper. However, three sites (South Flume – AR-4, North Flume – AR-5, and the PBR Flume – AR-10) are included in operational monitoring. Samples are collected twice a year and flow is monitored continuously using pressure transducers (instruments are removed during cold months). In addition to this sampling, samples are collected independent of the operational program from

the creek during periodic synoptic runs. In 2014, samples were collected from 12 sites along the creek, five of which are within the AOC Plant Site boundary. These sites are monitored for flow and water quality samples were collected if water was present. Surface water samples from the creek are typically analyzed for dissolved oxygen, pH, SC, TDS, Alkalinity as $CaCO_3$, nitrate plus nitrite, bicarbonate as $CaCO_3$, carbonate as CO_3, selenium, sodium and potassium as well as indicator parameters sulfate, chloride, boron, calcium and magnesium. These parameters are similar to those monitored during operational monitoring. Groundwater samples collected as part of the synoptic runs have been run for similar parameters except metals are analyzed as dissolved. Two synoptic runs were conducted in 2014 during which an expanded list of parameters were analyzed. The expanded analysis will be used, along with existing stream quality water, for human health and ecological risk assessment purposes. Appendix C contains a memorandum summarizing the synoptic run conducted in the spring. The fall 2014 synoptic run data are currently being evaluated.

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 7.0). 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 a path forward to mitigate a condition if it is interpreted to be related to Plant 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 potential result in environmental impacts. Such events could include surface observations such as stressed 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 Plant Site and process pond activities. Changes which are attributed to Plant Site activities are further evaluated through continued monitoring, site investigation, implementation of mitigation activities, and/or changing of normal processes or a combination of the previous.

3.4.1.1 Water Level Measurements

PPLM measures water levels at most non-capture system monitoring wells on a monthly basis. At a minimum, the wells listed in Appendix B of the site monitoring plan (PPLM, 2011) are measured. Newly installed wells may also be monitored on a monthly basis until official inclusion in the updated monitoring plans.

Monitoring wells are typically measured on either a monthly, quarterly, semi-annually, or every three years. Monitoring frequency depends on the density of wells in an area, previous observations in the area indicating wide variations in water levels, and relation to area capture wells. Water levels will be measured more frequently in connection with particular site activities. For example, water levels in wells may be measured more frequently if investigations are being conducted that require additional information for construction of potentiometric figures.

Water levels in the wells are measured using electronic probes with calibrated tapes. The probes are lowered into the well until electrical contacts encounter water at which time the meter provides an audible signal and a light comes on. The probe is moved up and down until the surface of the water is accurately located. The tape is then placed against a measuring point and the depth to water below the measuring point is recorded in a field book. The elevation of the groundwater for the well is then calculated by subtracting the measured depth to water from the surveyed measuring point elevation.

3.4.1.2 Capture System Monitoring

Capture wells are routinely monitored at least once per month for operation, water levels, and pumping rate. Water levels in capture wells are measured to evaluate groundwater capture system performance. Field specific conductance is measured monthly. In addition, water quality samples are collected and submitted for laboratory analysis twice a year. Samples submitted for laboratory analysis are analyzed for PPLM's standard list of analytes (Table 2 of the Water Resources Monitoring Plan – Appendix E). These data (field and laboratory) will be reviewed prior to shutting down any capture well. Capture wells may be shut down if water quality improves to conditions that were observed prior to conversion for capture, or if water quality improves to below calculated BSL's, or if water levels drop in the area so capture from a specific well becomes impossible or impractical. Any capture wells that are shut down will continue to be monitored for SC on a monthly basis and sampled for laboratory analysis twice a year. Pumping will be resumed if data indicate worsening water quality.

3.4.2 Groundwater Mitigation Activities

Groundwater mitigation at the Plant Site is conducted in areas where groundwater has been interpreted to be impacted by process water. Monitoring wells are typically converted to groundwater capture wells when impacts from process waters are identified. Wells that are upgradient of active capture wells or trenches that show impacts of process water may not be converted to capture wells depending on capture systems that are in place downgradient.

Mitigation includes groundwater collection at 52 wells and four underdrain collection systems. A total of 54 wells are converted for capture but wells B-2 and B-3, located near the former D1-D3 ponds, have been taken out of service due to low yield and evaluation of the capture system which indicated good groundwater capture without use of these wells. In addition to the PPLM capture wells, the Rosebud Mine operates a well (WECO well) to lower water levels at a coal crusher that is located north of the Units 3&4 Bottom Ash Ponds. A summary of the wells, the date the wells began collecting water, the location the water is

piped or potentially piped, well completion depth, and unit are shown on Table 3-4. Further information regarding pumping intervals can be examined on the well logs.

Capture wells are monitored one to three times per month. During these visits, the flow rate, water levels, SC, are measured and hour meters read. Flow rates are typically measured near the wellhead using volumetric methods. That is, a valve is opened near the well and water is directed to a calibrated bucket. The time to fill the bucket is measured and a flow rate calculated. The SC of the water is measured in the pumped water. This flow rate is considered constant until the next monitoring event. Hour meters are installed at each capture well. Hour meter readings are recorded during each visit. The pumping time between visits is calculated and multiplied times the flow rate to calculate gallons pumped between visits. Approximate average pumping rates for each capture well is shown in Table 3-4. Note that this method of measurement and calculation likely overestimates the actual amount of water pumped. This is caused by head differentials at the discharge point during normal pumping and those that occur at the well head during flow measurement. Back pressure in some of the pipelines and wells may occur if a substantial amount of scale buildup occurs, if the discharge point is at a higher elevation than the well, if multiple wells use the same pipeline filling it to capacity, if air-locking occurs, or if flow regulating valves or check valves create restrictions to flow. Under these conditions, flows measured at the wellhead will be higher than the actual amount coming out of the end of the pipe.

This is because the pressure that the submersible pump has to overcome is greater in the actual pipeline than the pressure at the end of the hose used in volumetric flow measurement. Calculated flow rates are highly variable because of the constantly varying pipeline back pressures noted above. The pumping rates shown in Tables 3-4 and 3-6 are current best estimates. The rates in Table 3-4 have been adjusted to 75% of the measured values to compensate for backpressure effects.

TABLE 3-4
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATION ORDER ON CONSENT
PLANT SITE CAPTURE WELLS

Site ID	Area	Screened Interval Depth Bgs feet	Screened Unit	Start Date	Approx. 2014 Pumping Rate[1] gpm	Approx. 2013 Pumping Rate[1] gpm	Approx. 2012 Pumping Rate[1] gpm	Approx. 2011 Pumping Rate[1] gpm	Approx. 2010 Pumping Rate[1] gpm	Approx. 2009 Pumping Rate[1] gpm	Comments[10]
SRP-1[2]	North A pond	7-15	Alluvium	12/15/95	0.5	0.2	0.1	0.3	0.0	0.0	Periodically shuts down due to lack of sufficient water or water column
SRP-2[2]	North A pond	8–18.5	Alluvium	12/15/95	0.7	0.5	0.3	0.3	0.3	0.3	Periodically shuts down due to lack of sufficient water or water column
SRP-3[2]	North A pond	7-32	Alluvium	12/15/95	6.5	9.8	7.4	7.2	6.9	6.3	
SRP-4[2]	West of A Pond	9-34	Alluvium	12/15/95	4.8	6.2	9.0	10.0	11.2	12.7	
SRP-5[2]	West of A Pond	9.5-35.5	Alluvium	12/15/95	11.4	10.3	5.7	8.1	9.3	12.2	
SRP-6[3]	West of A Pond	12-27	Alluvium/ Rosebud-McKay Shallow BR Interburden	10/7/97	0.5	0.5	0.7	1.1	0.8	0.8	
SRP-7[3]	West of A Pond	11-26	Alluvium/ Rosebud-McKay Shallow BR Interburden	10/7/97	0.5	0.5	0.7	0.6	0.2	0.9	
SRP-8[3]	West of A Pond	10-28	Alluvium	10/7/97	3.3	3.5	2.1	2.6	1.5	2.5	
B-1[3]	Brine Ponds	38-58	Spoil	1985	0.4	0.5	1.2	2.1	4.0	5.1	
B-2[4]	Brine Ponds	45-60	Spoil	1985	0	0	0	0	0.0	0.0	Pump turned off June 1996 due to mechanical problems and lack of need for area capture
B-3[4]	Brine Ponds	35-65	Spoil	1985	0	0	0	0	0.0	0.0	Pump turned off July 1995 due to lack of need for area capture
B-4[3]	Brine Ponds	45-65	Spoil/interburden	1985	0	0	0.1	0	0.0	0.0	Pump turned off July 31, 2008 due to improved water quality
B-5[3]	Brine Ponds	45-65	Spoil/interburden	1985	0	0	0	0	0.0	0.0	Pump turned off July 31, 2008 due to improved water quality
4S[5]	Brine Ponds	41-51	Spoil	12/14/05	2.6	1	2.3	3.8	4.6	6.5	
19SP[3]	Brine Ponds	22-42	Spoil	12/14/05	0.1	0.5	0.1	0.1	<0.1	<0.1	
26SP[3]	Brine Ponds	30-50	Spoil	12/22/05	5.4	2.6	1.2	0.4	0.2	0.3	
29SP[3]	Brine Ponds	26-46	Spoil	12/22/05	5.9	5.3	5.7	4.3	3.9	4.8	
70SP[3]	Brine Ponds	26-36	Spoil	12/22/05	1.4	3	0.5	0.5	0.4	0.6	
111SP[3]	Brine Ponds	42-57	Spoil	4/15/10	3.8	5.1	1.8	6.6	2.4	NA	
1D[2]	West of A Pond	48.5-58.5	Sub-McKay bedrock	11/6/02	5	2	1.0	0.6	0.8	0.7	
5M[2]	West of A Pond	36-46	McKay Coal	11/6/02	1.7	0.5	4.3	2.1	3.6	2.7	
5S[2]	West of A Pond	19-29	Shallow bedrock - interburden	1/5/09	3.3	0.3	3.9	3.5	2.8	3.0	
10M[2]	West of A Pond	38.5-48	McKay Coal	11/6/02	6.8	6.2	10.3	10.6	10.9	7.79	
10S[2]	West of A Pond	26-36	Alluvium/ Rosebud-McKay Shallow BR Interburden	7/22/03	5	2.3	5.0	2.6	2.0	0.6	
55D[2]	West of A Pond	40-60	Sub-McKay bedrock	7/15/03	0.7	0.3	0.8	0.4	1.0	0.9	
56D[2]	West of A Pond	40-60	Sub-McKay bedrock	11/6/02	15	12.9	17.7	14.7	16.0	13.9	
58M[2]	West of A Pond	30-38	McKay Coal	11/6/02	7.4	2.3	2.2	2.7	3.5	0.2	

TABLE 3-4
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATION ORDER ON CONSENT
PLANT SITE CAPTURE WELLS

Site ID	Area	Screened Interval Depth Bgs feet	Screened Unit	Start Date	Approx. 2014 Pumping Rate[1] gpm	Approx. 2013 Pumping Rate[1] gpm	Approx. 2012 Pumping Rate[1] gpm	Approx. 2011 Pumping Rate[1] gpm	Approx. 2010 Pumping Rate[1] gpm	Approx. 2009 Pumping Rate[1] gpm	Comments[10]
59M[2]	West of A Pond	36-44	McKay Coal	11/6/02	1.6	0.2	0.1	0.1	0.4	<0.1	
113M[2]	West of A Pond	27-38	McKay Coal	3/21/2013	0.9	0.5	NA	NA	NA	NA	
114S[2]	West of A Pond	16-25	Alluvium	3/21/2013	0.7	0.9	NA	NA	NA	NA	
115M[2]	West of A Pond	29-39	McKay Coal	3/21/2013	2.2	1.3	NA	NA	NA	NA	
116M[2]	West of A Pond	27-37	McKay Coal	3/21/2013	3.7	2.9	NA	NA	NA	NA	
117A[2]	West of A Pond	15-25	Alluvium	3/21/2013	2.6	2.6	NA	NA	NA	NA	
118A[2]	West of A Pond	15-25	Alluvium	3/21/2013	0.6	0.4	NA	NA	NA	NA	
119A[2]	North A pond	25-35	Alluvium	3/21/2013	6.3	3.7	NA	NA	NA	NA	
122A[2]	West of A Pond	19-39	Alluvium	3/21/2013	7.2	8.1	NA	NA	NA	NA	
6M[6]	South CTBP	33.5-43.5	McKay Coal	12/17/98	3.8	0.5	4.4	4.8	3.2	5.6	
21S[7]	Units 3&4 BAP	57-102	McKay Overburden	12/10/98	3.5	2.7	3.9	5.8	5.0	6.6	
31M[8]	North SRP	20-30	McKay Coal	11/6/02	1.1	1.1	1.1	1.4	1.6	1.7	
43S	North Plant	9.5-24.5	Alluvium	9/13/07	4.6	0.6	2.4	3.5	3.1	3.2	
78A	North Plant	17-31	Alluvium	9/13/07	9.3	7.7	12.5	9.1	12.7	11.9	
51SP[7]	Units 3&4 BAP	60-90	Spoil	6/14/02	4.8	4.1	3.6	2.8	5.4	7.0	
52SP[7]	Units 3&4 BAP	57-87	Spoil	6/30/02	0.2	0.2	0.4	1.0	1.2	1.4	
53SP[7]	Units 3&4 BAP	55-85	Spoil/Rosebud Coal Remnant	5/26/03	5.1	7.4	5.4	5.3	6.0	7.0	
54SP[7]	Units 3&4 BAP	67-97	Spoil/Rosebud Coal Remnant	6/14/02	0.9	0.7	0.6	1.8	2.6	3.8	
68A[2]	West CTBP	21-32	Alluvium	12/15/06	5.1	2.1	4.4	5.5	3.8	4.8	
74A[8]	North Plant	17-32	Alluvium	9/6/07	11.3	11.7	14.6	14.0	14.9	15.8	
75A[8]	North Plant	17-37	Alluvium	9/6/07	10.6	11.1	11.4	11.9	12.2	12.8	
79A[8]	North Plant	18-31	Alluvium	9/6/07	44	42	50	46	43.5	47.1	
82A[8]	North Plant	19-34	Alluvium	11/27/07	6.8	8.3	7.8	7.4	8.4	9.7	
98M[2]	West of Plant	33-43	McKay Coal	9/6/09	9.2	6.1	9.3	7.3	7.3	1.1	Pumps off late fall 2013 for pipeline replacement
106A[2]	West of Plant	16-31	Alluvium/weathered McKay Coal	9/17/09	4.8	8.3	1.8	6.9	13.3	3.7	Pumps off late fall 2013 for pipeline replacement
107A[2]	West of Plant	17-32	Alluvium	9/17/09	6.4	5.4	6.5	7.7	4.6	0.2	Pumps off late fall 2013 for pipeline replacement
108A[2]	West of Plant	17-37	Alluvium	9/17/09	11.2	6.5	10.7	12.3	8.8	3.0	Pumps off late fall 2013 for pipeline replacement
WECO Well[2]	North of Units 3&4 BAP	65-75	Spoil	1995	54.5	41	38	41	45.7	41.5	

TABLE 3-4
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATION ORDER ON CONSENT
PLANT SITE CAPTURE WELLS

Site ID	Area	Screened Interval Depth Bgs feet	Screened Unit	Start Date	Approx. 2014 Pumping Rate[(1)] gpm	Approx. 2013 Pumping Rate[(1)] gpm	Approx. 2012 Pumping Rate[(1)] gpm	Approx. 2011 Pumping Rate[(1)] gpm	Approx. 2010 Pumping Rate[(1)] gpm	Approx. 2009 Pumping Rate[(1)] gpm	Comments[(10)]
Underdrain Units 1&2 Bottom Ash Clearwell Sumps	Primary		Below Liner	2006		1.1	1.3	1.8	1.7	1.6	
	Secondary		Between Liners	2006		0.1	0.002	0.05	0.01	.03	
Underdrain Units 1&2 B Pond North End Sumps	Primary		Below Liner	2004		38.5	5.7	16.1	NR	29.1	Discharge routed to 1&2 VSEP in late 2009, no flows estimated during 2010.
	Secondary		Between Liners	2004		6.2	32.9	18.1	NR	0.1	Discharge routed to 1&2 VSEP in late 2009, no flows were estimated during 2010.

(1) Approximate - includes down time, not adjusted for pressure.
Calculated flow rates adjusted by a factor of 0.75 to compensate for pipeline back pressure effects during flow measurement. This calculation does not apply to underdrain systems.

(2) Piped to either the Units 1&2 Cooling Tower Blowdown Pond or Units 1&2 Bottom Ash Clearwell.

(3) Piped to the Units 1&2 B Pond – not currently pumping.

(4) Not currently pumping.

(5) Piped to VSEP (Vibratory Shear Enhanced Process) or Units 1&2 B Pond.

(6) Piped to south end Cooling Tower Blowdown Pond C.

(7) Piped to Bottom Ash Ponds or 3/4 coal system dust suppression system.

(8) Piped to either VSEP or Units 1&2 Bottom Ash Clearwell.

(9) WECO Well – owned and operated by Westmoreland Rosebud Mine. Water directed to PPLM.

(10) Note that all pumps are sometimes shut down for maintenance, the majority of pumps cycle due to low water, the pumps are operated by pump controllers that turn pumps on and off in response to power surges or drops, pumps are turned off at times for pipeline maintenance or other plant operation associated activities.

(11) Wells 113M through 122A installed and started after original December 2012 AOC Plant Site Report submittal.

(12) Well 78A converted for groundwater capture after original December 2012 AOC Plant Site Report submittal.

BAP – Bottom Ash Pond

CTBP – Cooling Tower Blowdown Pond

SRP – Sediment Retention Pond

bgs – below ground surface

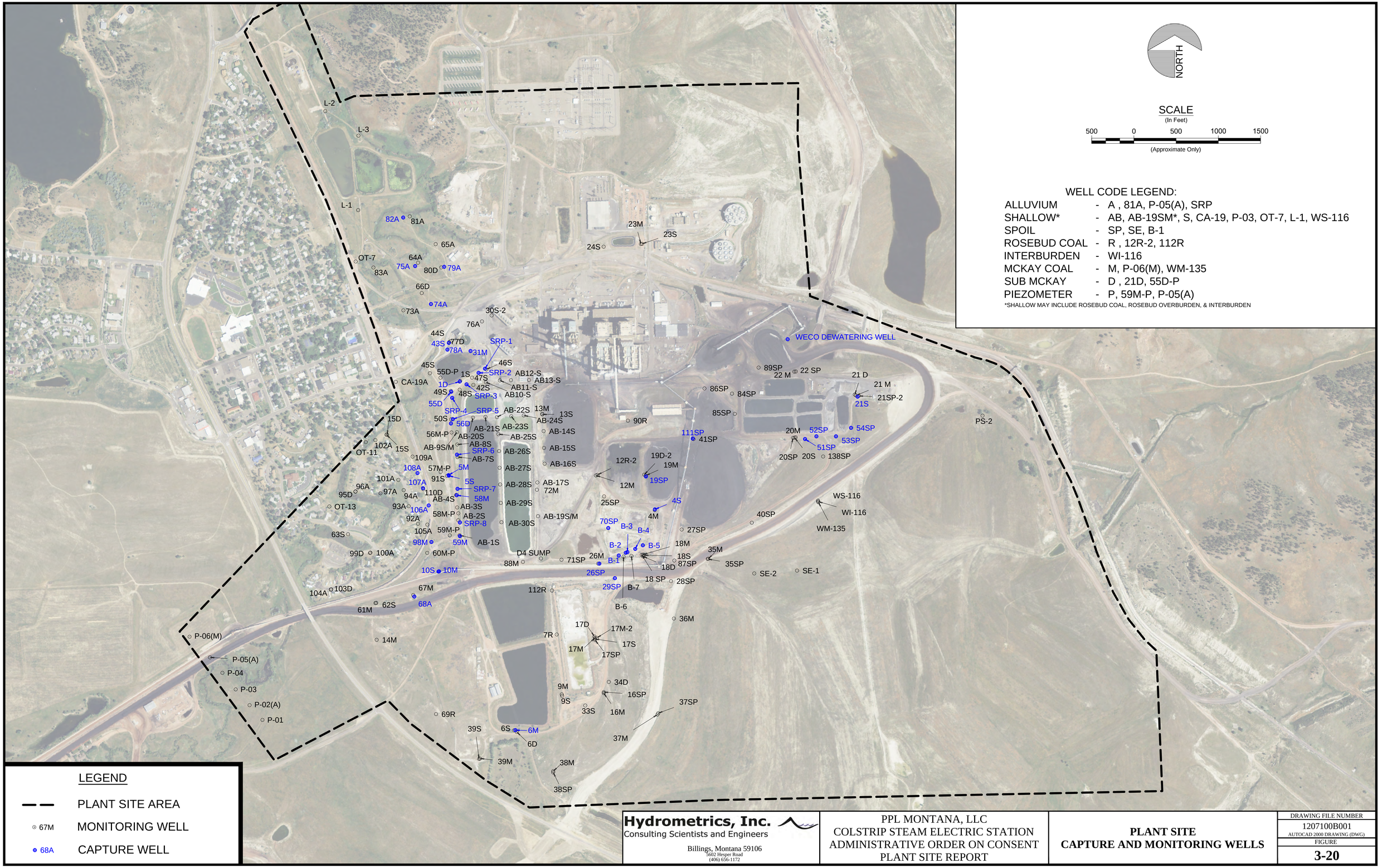
BR - Bedrock

NA = Not applicable, system not yet installed

NR – Not recorded

The majority of groundwater capture wells are located along the western edge and northwest of the Plant. However, additional extraction wells are located adjacent to the brine pond in the central part of the pond area, and the Unit 3&4 Bottom Ash Ponds toward the eastern portion of the site. Locations of groundwater capture wells are shown on Figure 3-20. Figure 3-20A shows capture wells only. Groundwater capture wells are routinely monitored for flow, hours operated, water level, and specific conductance. Monitoring of the capture systems is conducted to document depth to water in pumping wells, approximate pumping rates, make adjustments to increase drawdown in the wells, and to identify problems. Maintenance requests are made when problems arise and repairs are made. Data collected from the capture systems are documented in a project field book and then maintained in an electronic file.

During the years 2011, 2012, and 2013 adjusted capture rates (estimated at 75% the calculated value) for the Plant Site were 287, 253 gpm, and 264 gpm, respectively. The amount of water captured varies depending on several factors. One factor is the actual amount of wells that are being pumped. For example, in 2004 there were 25 capture wells pumping at an average rate of about 118 gallons per minute. The WECO crusher dewatering well was estimated to be pumping about 30 gpm during that time. In 2009, 38 capture wells were pumping about 229 gpm and the WECO crusher dewatering well was pumping about 42 gpm. Wells 74A, 75A, 79A and 82A, located north of the main Plant area, were added during this period and accounted for about 85 gpm.



Hydrometrics, Inc.
Consulting Scientists and Engineers
Billings, Montana 59106
5602 Hesper Road
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PPL MONTANA, LLC
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE REPORT

PLANT SITE
CAPTURE AND MONITORING WELLS

DRAWING FILE NUMBER
1207100B001
AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-20

UPDATE TIME: 10:08 AM
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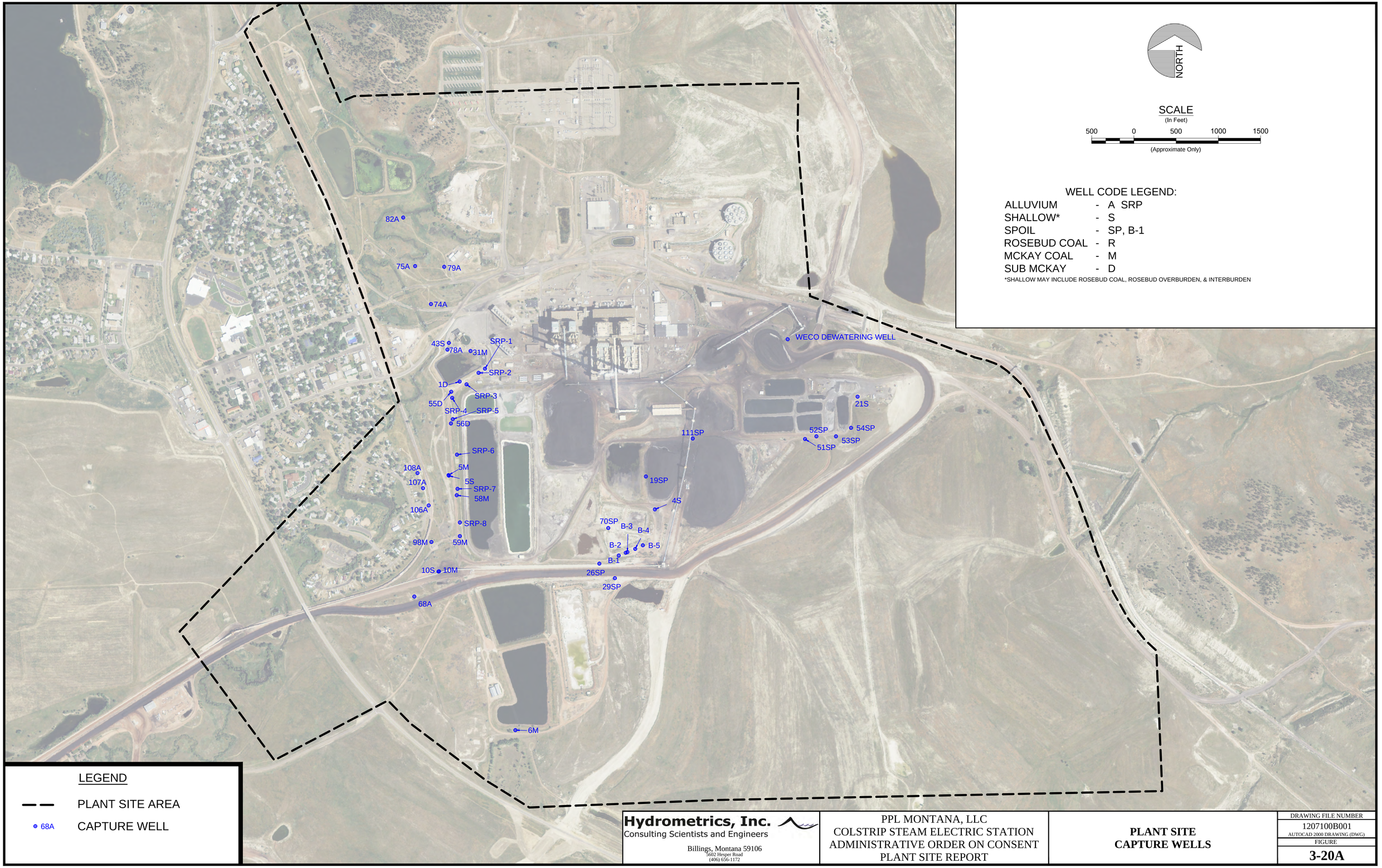

WELL CODE LEGEND:

ALLUVIUM	-	A SRP
SHALLOW*	-	S
SPOIL	-	SP, B-1
ROSEBUD COAL	-	R
MCKAY COAL	-	M
SUB MCKAY	-	D

*SHALLOW MAY INCLUDE ROSEBUD COAL, ROSEBUD OVERBURDEN, & INTERBURDEN

LEGEND

PLANT SITE AREA

68A CAPTURE WELL

Hydrometrics, Inc.
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PPL MONTANA, LLC
COLSTRIP STEAM ELECTRIC STATION
ADMINISTRATIVE ORDER ON CONSENT
PLANT SITE REPORT

PLANT SITE CAPTURE WELLS

DRAWING FILE NUMBER
1207100B001
AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-20A

UPDATE TIME: 10:08 AM
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Other factors that affect the amount of water captured include changes in recharge to groundwater from precipitation, capture system operational factors (scaling, pump performance, the number of wells pumping, change in discharge point which changes back pressure and pump performance, etc.), and the number of wells that are operating. Other factors such as a general lowering of local water table or a reduction in potentiometric heads will cause variations in the amount of water pumped from the well. The amount of water available at each well will reduce as zones of influence intercept those created from adjacent well. This is most pronounced during early startup periods.

Capture well pumping rates for 2013, requested by MDEQ, for all Plant Site capture wells including 10S, 68A, 75A, 78A, SRP-5, SRP-8, 91S, 106A, and 108A are provided in Table 3-6 found in Section 3.6.

Water is also withdrawn from underliner collection systems at the Units 1&2 B Pond and the Units 1&2 Bottom Ash Clearwell. For the Units 1&2 B Pond approximate pumping rates were about 60 gpm in 2013, 52 gpm in 2012, and 34 gpm in 2011. For the Units 1&2 Bottom Ash Clearwell underliner collection system, approximate pumping rates were 1.6 gpm in 2013, 1.3 gpm in 2012 and 1.1 gpm in 2011. The water table is encountered by both of the underdrain system so the vast majority of pumped at these locations is comprised of groundwater from below the liners.

Note that capture systems are overestimated to some degree. Scaling problems have made it necessary to operate the majority of systems without flow meters (also refer to Section 2.1.3 for more discussion on scaling issues). Flow is measured at the well head through a sampling port. This flow is measured without back pressure that is present on the system under normal operating conditions. Less water is pumped when the system is back pressured. The result is the measured flow and calculated capture volumes are overestimated. Higher pipeline back pressures result in a higher margin of error.

3.4.3 Completed Plant Site Mitigation Measures

Mitigation measures are actions, plans, or procedures that are intended or designed to eliminate, prevent, or reduce adverse effects of a process or situation. A mitigation measure may be implemented prior to an action, such as designing a lined impoundment to reduce potential seepage. Mitigation measures may also be implemented after an adverse situation has been discovered, such as pumping and treating affected groundwater.

Several activities have been conducted on the Plant Site to assist with groundwater remediation. Each of these activities and their potential influence on the groundwater system, and associated remedial activities are described hereafter. The list is not all encompassing of mitigation measures that have or will be conducted at the Plant Site. The operators of the facility have conducted mitigation measures from the construction period through current operations to minimize potential impacts to water resources as the Plant operated. These mitigation measures, which are beyond the scope of this report, include initial pond designs and upgrades, pond construction methods, materials used in pond construction, piping design, upgrade, and maintenance, education of employees, refining the process water circuits which enabled certain ponds or processes to be closed, and numerous other actions. Additional mitigation measures will be developed during remedial evaluations and as closure and further operational plans are developed.

- Relining the Units 1-4 Sediment Retention Pond – This pond was relined using HDPE in 1989. Gas bubbles which had formed under the original Hypalon liner had the potential to result in possible liner failure. The HDPE lining resulted in a more robust bond with less chance of leaking. The pond is used to collected stormwater from the Plant Site. However, flyash slurry can potentially enter the pond during upset conditions. Relining of the pond reduces the potential that water with elevated levels of dissolved constituents can enter the groundwater. Relining of the pond is mentioned in the 1989 Annual Report (Hydrometrics, 1990).
- Removal of Brine Ponds D1 through D3 from service. These ponds were removed from service following failures of the liner in the D3 Brine Pond and subsequent leaks. The ponds were removed and material impacted by previous spills were removed and placed in the southwest corner of the Units 3&4 EHP F Cell. The basin

footprints of the original ponds were left in place to capture precipitation to provide recharge to the area. Water recharging the spoil under this area is expected to flush mobile salts. Groundwater is then captured by the Brine Pond Capture system. Improving water quality was noted after the removal of these ponds. Groundwater capture wells, referred to as the Brine Pond Capture System, were installed to mitigate impacts to the local groundwater. Please refer to Table 3-2 for reports that pertain to or have mention of the brine pond remediation or removal (1, 10, 13, 15, 16, 18, 19, 20, 21, 22, 23, 26, 27, 31, 33, 36).

- Removal of Brine Pond D4 from service. Brine Pond D4 experienced a liner failure in the fall of 2005. In response, PPLM immediately dewatered the pond and removed it from service. Material in the pond was moved over competent underliner material within the pond, capped with synthetic liner material, and reclaimed. The D4 Brine Pond underdrain system was left in place to remove any residual draining through the area. Removal of the pond from service and reclamation of the pond contents eliminates a source area for future impacts to groundwater. Removal of soil below the pond has been completed as of this writing. Please refer to reports listed in Table 3-2 (70, 72, 74).
- Change in flyash management resulting in the ability to alter management of the Units 1&2 A/B Flyash Ponds. This involved installation of twin pipelines, one to convey flyash slurry and a second to return water from the STEP Clearwell. Installation of these pipelines made it possible to split the Units 1&2 A/B Flyash Ponds into two separate ponds (A Pond and B Pond). A pond was left in place. Stormwater is directed to the A Pond from the Units 1-4 Sediment Retention Pond. The stormwater directed to this pond is a higher quality than the water previously contained in the Units 1&2 A/B Flyash Ponds. B Pond was double lined with collection under the primary and secondary liners. Use of a double lined pond and underliner capture reduces source area and provides capture below the primary and secondary liners. Groundwater also intersects the underdrains and is captured reducing downgradient flow. Furthermore, use of high density polyethylene (HDPE) pipe replaced older fiberglass pipeline reducing the potential for line failure. Refer to Table 3-2 reports numbered 49, 54, 57, 67).

- PPLM installed a double liner system under the 1&2 Bottom Ash Clearwell in 2006. Collection was installed between the liners and below both liners. The lower sump allows collection of groundwater. Double lining this pond removes a source area and the lower collection sump allows collection of water from below the ponds. Monitoring well 42S, located directly downgradient of the pond has shown steady improvement since installation of the liner.
- Units 3&4 Auxiliary Scrubber Drain Collection Pond was a small Hypalon lined pond near the Unit 3 scrubbers. The liner was in need of repair. This structure was rebuilt in 2014. The new pond is larger and constructed of sulfate resistant concrete.
- Stormwater on the main plant site uses a collection ditch to capture and direct flow to the Units 1-4 Sediment Retention Pond. This ditch contained numerous joints with potential to leak. PPLM installed a new exterior concrete stormwater collection ditch with continuous joints to replace the old system. Best Management Practices will be put in place to ensure the ditch is free of obstructions which have caused overflows in the past.

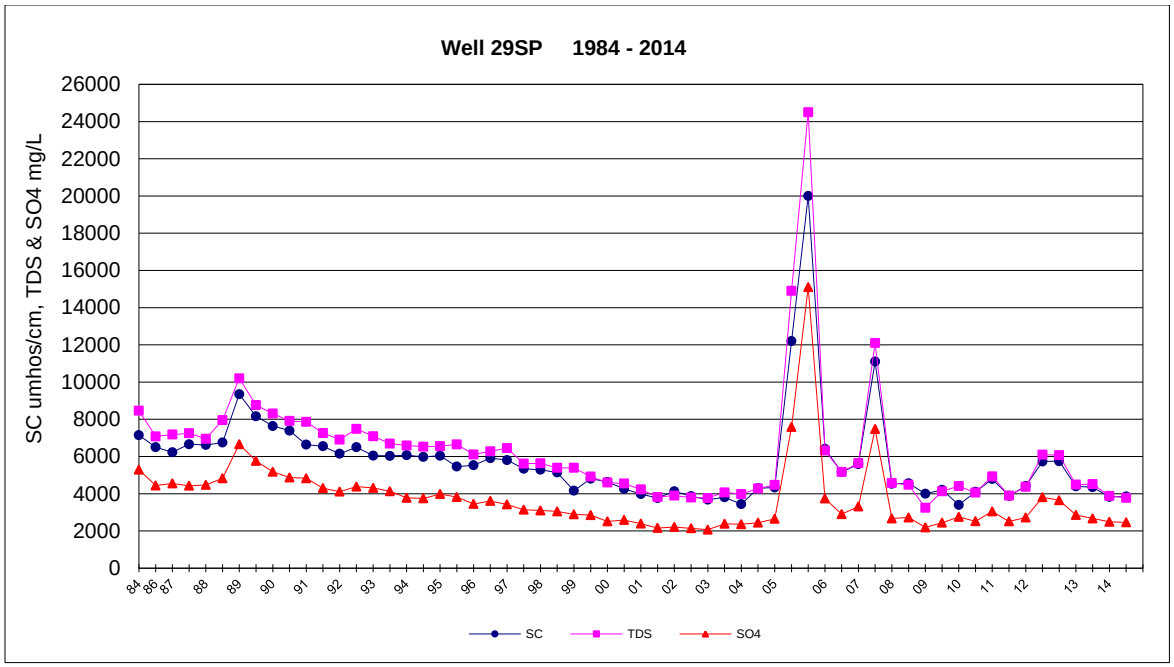
3.4.4 Planned Plant Site Activities

PPLM continues to improve best management practices, training, and facility upgrades to improve environmental conditions near the Plant Site to aid in groundwater mitigation efforts, and to reduce the potential of compounding existing or creating new problems in the future. Some of the activities that are planned or being considered in the future are as follows.

- Solids from past operations are still in place in parts or all of the Units 3&4 Wash Tray Pond. Samples were collected of pore water following a period of high precipitation which resulted in the bottom of the pond being covered with runoff water. Samples were collected at multiple locations by advancing a small diameter probe into the sediment at the edge of the pond. The probe was advanced at a 45 degree angle and extended approximately two to three feet under the water. Water samples were collected and submitted for laboratory analysis. A sample from the surface of the pond was also collected and analyzed. Results of the analysis showed higher concentrations of dissolved materials in the pore water samples than in the

pond sample indicating the likelihood of soluble materials on the pond bottom. Well 112R was installed to provide additional monitoring at the northwest (downgradient) corner of the pond. PPLM is planning removal of these materials. Removal of these materials will eliminate a potential source for elevated dissolved constituents. Plans for use of this area following removal of soils have has not been completed at this point. However, options include leaving a depression to collect clean water to provide a recharge source near the center of the former pond location. Lining of the pond to provide additional storage for process water and reclaiming the site to natural grade and using the area for other purposes; return the area to natural grade and use it as a storage area; and/or regrade and reclaim the area.

- Abrupt increases in levels of conductivity were observed following the D4 liner breach in late 2005. Water quality in nearby monitoring and capture wells was improving at the time of the breach. A water quality chart for well 29SP showing SC, TDS, and SO4 over time is shown on the following page as an example. Well 29SP is south of the former brine pond area and is currently a capture well. Water at well 29SP showed possible impacts in the late 1980's when influences from the D3 Pond liner tear became apparent. Groundwater capture wells B-1 through B-5 were installed and gradual water quality improvement was observed. Water quality leveled out at near background levels about 2001 and remained relatively constant until November 200, following the D4 liner tear. Additional groundwater capture (including conversion of well 29SP) was installed in the area and water quality rapidly improved. Precipitation in 2011 and 2012 resulted in ponded water in the depression left following the removal of D4 Pond. Increases in SC observed at 29SP are in response to salts being mobilized by the precipitation. The low levels of SC observed between the peaks are evidence that the groundwater near 29SP is not currently influenced by other sources.



- Some solids were removed from below the former D4 Pond following the liner failure in 2005. Additional investigation and possible mitigation were planned for the D4 Pond area in December 2012. A limited amount of soil waste removed in 2006 as part of the liner removal. However, based on observations following removal of the liner, it was evident that soil containing elevated levels of salt remained in this area. PPLM conducted additional investigation in the area to delineate the extent of soil having elevated salts. The project involved extensive direct push soil sampling of soil below the former D4 Pond, bench-top testing, and laboratory analysis of sediments. Background samples were also collected from areas outside of the pond footprint. Based on the characterization, an estimated 88,000 cubic yards of mine spoil with elevated salts were identified. The Rosebud Coal was encountered below a portion of the pond. However, salt levels in the Rosebud Coal were generally not indicative of D4 Pond impacts. Removal of the impacted soil was recommended to reduce or eliminate the potential of solutes reaching groundwater (Hydrometrics, July 2013). PPLM removed effected soil in the fall of 2014. Grading of this area is in progress.
- Units 1&2 A Pond contains residual flyash from past operations. The pond is no longer used to store process water but has better quality stormwater routed to it. However, study of the flyash on the floor of the pond suggests the material is still a potential source for chemical constituent transport to groundwater (see Table 3-2,

Hydrometrics December 22, 2009). Several samples were collected during the 2009 investigation and composited into a single sample. This composite sample was submitted to an analytical laboratory for analysis using saturated paste methods. Analytical results showed 233 mg/L chloride, 4,700 mg/L sulfate, 13.8 mg/L boron and a specific conductance of 5,890 µmhos/cm suggesting mobile salts were present in the material collected from the pond bottom. PPLM plans to remove the residual flyash. Water management practices thereafter will continue to involve directing better quality water to this pond, including stormwater. Stormwater typically exhibits low concentrations of dissolved solids. This higher quality water will provide a recharge source for the underlying and lateral hydrostratigraphic units to further improve groundwater quality in the area. Note that PPLM currently directs stormwater to this pond.

- Unit 1&2 B Pond is a double-lined pond. This pond receives return water from the STEP Clearwell for reuse in the Plant scrubbers. The composite liner incorporates two layers of synthetic liners separated by a porous layer (geonet drainage layer) designed to intercept water leaking through the upper liner; and a collection sump is situated between the liners to collect water that possibly leaves the pond through liner breaches. It may also collect groundwater if water levels in the area increase and trigger the pumps. A sump, that intercepts groundwater, is present under the liners and is a collection point for two drain pipes which extend about two-third of the way southward under the pond. One pipe is near the center and the second collection pipe is near the east side of the pond. The system serves to provide additional groundwater collection in this area. Plans are to operate the pumps in the sumps under the current operating scenario and monitor flow and quality at both sumps.
- Units 3&4 Scrubber Drain collection pond - This pond is currently not in service. It is in place and catches runoff from coal piles. Bottom ash, dredged from the secondary Units 1&2 Bottom Ash Ponds was placed in the pond in 2010. Plans are to remove material from the pond bottom.
- Units 1&2 Cooling Tower Blowdown Pond (Pond C) – Now comprised of the North Pond C and South Pond C, these ponds are also referred to as the Units 1&2 Cooling Tower Blowdown ponds. The original pond was divided into a North Pond C and

South Pond C in 1987. Stormwater collected in the Plant Site ditches flows to the Units 1-4 Sediment Retention Pond and is then pumped to North Pond C and South Pond C. Raw water (water that has not been used in plant processes) is also sometimes directed to these ponds. This provides an area of potential recharge to groundwater of better quality water since the ponds are downgradient of areas of known impacts. Water levels in the pond are above the level of the local groundwater so a downward vertical gradient exists. Slight mounding, as indicated by wider spacing of shallow water table contours lines (Figure 3-8), is apparent in the potentiometric map associated with the ponds.

- Units 3&4 North Plant Area Drain Pond– This pond is lined with HDPE. There are currently no indications of seepage or leakage from this pond. Water quality in the Units 3&4 North Plant Area Drain Pond has been highly variable. The following ranges of concentrations for indicator parameters have been reported in water collected in the pond between 1996 and 2012: SC 1740 to 4730 µmhos/cm; sulfate 477 to 2560 mg/L, boron 0.4 to 1.9 mg/L, calcium:magnesium typically greater than 2, and chloride of 71 to 439 mg/L. Well 24S is completed in the first water encountered and is located downgradient of the pond. Since 1996, SC has been consistently above 4000 µmhos/cm while only one sample from the pond has exceeded this value. Sulfate levels in groundwater from well 24S have averaged 2450 mg/L since 1996 while the Units 3&4 North Plant Area Drain Pond water has averaged less than 1500 mg/L with only one sample exceeding the average observed at 24S. Dissolved boron concentrations in groundwater from well 24S have been consistent throughout the monitoring period ranging from 1.0 to 1.5 mg/L. Chloride concentrations in water from well 24S have shown a slight increasing trend throughout the monitoring period. However, without the presence of consistent increases of SC and sulfate, it is unlikely that the increases are due to the Units 3&4 North Plant Area Drain Pond. Note that this pond is very small and holds minimal amounts of water. Water that does enter this pond (raw water filter backwash, north plant area drainage, and overflow from the 3&4 Cooling Towers) is pumped into the bottom ash system or the circulating water system. Hydraulic head on top of the HDPE liner is reduced by limiting the amount of water in the pond further

minimizing any potential for seepage. No future activities are currently planned for this pond.

- Units 1-4 North Plant Sediment Pond captures stormwater runoff from the northern portion of the Plant Site. The pond is lined with clay. Water quality in this pond is good. Currently there is no evidence of leakage that would result in negative environmental impacts. There are not any groundwater monitoring wells directly downgradient of the Units 3&4 North Plant Sediment Pond. However, there is not visual evidence of leakage such as plant die off or monoculture formation. The water quality in the pond is generally better than background shallow groundwater quality. For example, water quality samples have been collected from the pond once every three years since 1993. Samples analyzed during that time have had reported ranges of concentrations as follows; SC 619 to 1320 µmhos/cm; sulfate 119 to 479 mg/L; boron 0.2 to 0.6 mg/L and chloride 38 to 98 mg/L. Based on these data, any leakage from the pond would likely improve the receiving groundwater. No plans currently exist for alterations to this pond or revisions in its operation.
- The Units 1-4 Sediment Retention pond is lined with HDPE. There is currently very little water in the pond. However, the amount of water changes frequently in response to precipitation events. Excess water from stormwater events is pumped to other ponds to maintain capacity in the Sediment Retention Pond. At present, there are no plans for altering the operation or structure of this pond.

Note that PPLM also responds to changes in water quality, spills, or other identified problems associated with the ponds or pond operations. Responses typically include an internal evaluation, reporting to regulatory agencies, if required. Additional study and investigation is conducted if potential problems are identified and/or if regulatory agencies request more extensive evaluation. Future investigation will be covered under guidelines of interim actions outlined in the AOC which include preparation of a work plan, regulatory review, conducting the investigation, evaluation, and reporting.

3.4.5 Best Management Practices

Best Management Practices (BMPs) is a term used to describe activities conducted to minimize or eliminate impacts to surface and groundwater. PPLM implements multiple types of BMP's to reach this end. Many of the measures described in the previous sections are further examples of BMP's that are, or will be, implemented or used at the facility. Several other BMP's are described in the following paragraphs.

- Training and Education – employees are educated as to the importance of water management and control at the facility. The goal of the training is to limit unnecessary losses of water, reduce the amount of water in the process circuit, and quickly respond when incidents occur to minimize potential migration and to remove affected materials.
- Removal of flyash residual material from former process ponds. Removal of the materials will eliminate a potential source area.
- Water management – PPLM has made significant progress in reducing the amount of water at the facility. Reduction of the amount of water reduces hydraulic head and the amount of seepage that can occur. Methods used include forced evaporation and water reuse methods.
- Stormwater management – site drainage control systems have been upgraded to better contain stormwater runoff and direct it to sediment retention ponds. A lined canal was recently upgraded to eliminate cracks to further contain stormwater in the system.
- Pond liner upgrades – as discussed previously, PPLM is, has, or will be installing synthetically lined ponds with underdrain capture. Use of the liner/underdrain system reduces potential releases due to seepage through the liners if it occurs.

3.5 EFFECTIVENESS ASSESSMENT OF REMEDIAL ACTION

The effectiveness of the existing remedial measures should be evaluated in two ways. First, the effectiveness of existing source control measures such as pond liner upgrades can be evaluated based on trends in water quality for extraction wells and monitoring wells located nearby (but downgradient from) the pond source area. Second, the effectiveness of migration management measures such as hydraulic barriers produced by groundwater extraction wells

can be evaluated using multiple lines of evidence. These lines of evidence include evaluation of the induced hydraulic gradients toward the extraction well using potentiometric figures and trends in water quality for monitoring and capture wells. Often, a capture well near a pond serves to evaluate the combined effectiveness of both source control and migration management at that source area.

The induced hydraulic gradients and associated capture zones are discussed in Sections 3.3.3 and Appendix A. Results of capture analysis from the 2014 steady-state model (Newfields, 2015, see Appendix A), indicate impacted groundwater from most source areas in the Plant Site area is intercepted by the current capture systems. Areas where current capture systems may not be completely capturing groundwater include:

- the alluvial groundwater around OT-7 and the Sewage Lagoons; however, reverse particle tracking indicates groundwater in this area is not sourced from the Plant Site ponds;
- a small area in the interburden and McKay around the North Plant Area Drain Pond;
- spoil in the area around the Units 3&4 Bottom Ash Ponds; and
- an area of spoils, Rosebud, interburden and McKay near the southern end of the Units 3&4 Cooling Tower Blowdown Pond.

The remainder of this section discusses trends in groundwater quality. Trends for the majority of wells discussed in this section are in Appendix H. Overall, water quality has shown improvement for the Plant Site as a whole. This improvement could result from the source control measures, migration management measures, or both. SC is used in this analysis as an overall indicator of water quality degradation by releases from the process wastewater system. SC is proportional to the concentration of dissolved major constituent ions in a water sample (i.e. total dissolved solids). For the process wastewater ponds at Colstrip, the major ions are sulfate and magnesium. These ions are highly mobile in groundwater and contribute substantially to the measured SC values. Therefore, in evaluating overall trends in groundwater quality in response to remedial measures, SC is a very useful overall indicator of the concentration of process wastewater constituents of interest (COIs).

PPLM evaluates capture system effectiveness by analyzing water quality trends in monitoring and capture wells downgradient from and near the capture systems. Evaluation of indicator parameter trends provides an additional line of evidence of capture system effectiveness if source area control measures are working well.

A comparison is made of the highest SC measurements in capture wells to current groundwater quality data collected during routine capture system monitoring. This comparison provides an additional line of evidence of overall capture system effectiveness. This approach yields calculated improvement of SC from 0 to 82% (reduction in SC). The least amount of improvement is present at well 98M, located west of the Units 1&2 A Pond and between the liner for the Units 1&2 B Pond. The greatest amount of improvement (82%) has occurred at well 26SP, located south of the former Brine ponds, and represents a reduction in SC from 43,100 µmhos/cm to 7,610 µmhos/cm. None of the capture wells have shown an increase in SC over the maximum SC measurement.

Effectiveness of remedial actions in each of five areas is discussed in the following sections. Figures 3-21A, 21B, and 21C show the general locations of these areas. Boundaries of the areas identified on these figures are very loosely defined based on the general area that groundwater capture is occurring. As such, a well is shown within a particular area does not in itself indicate that the well is impacted by process water. Since the boundaries are loosely defined, there is overlap with adjacent areas.

3.5.1 Units 3&4 Wash Tray Pond, Units 1&2 Cooling Blowdown Pond

Actions have been taken in the Units 3&4 Wash Tray Pond and Cooling Tower Blowdown Pond (North and South Pond C) areas to address source area control. These actions include the initial construction that included lining the pond bottoms with clay, groundwater extraction (6M, 29SP), taking the Units 3&4 Wash Tray Pond out of service in 1995, and changing the water management practices of the North and South Ponds C to hold stormwater runoff water rather than cooling tower blowdown water.

NORTH

SCALE
(In Feet)
500 0 500 1000 1500
(Approximate Only)

L-2
L-3
L-1
FLY ASH SLURRY & RETURN WATER FROM STEP
82A 81A 65A 64A 75A 80D 79A 83A 66D 74A 73A 30S-2 76A 44S 43S 77D 78A 31M SRP-1 45S 46S 55D-P 1S SRP-2 AB12-S 47S AB13-S CA-19A 1D 42S AR11-S 49S 48S SRP-3 AB10-S 55D SRP-4 SRP-5 AB-22S 13M 13S AB-24S 15D 50S 56D AB-21S AB-23S 56M-P AB-20S AB-25S AB-14S 102A 15S AB-9S/M AB-8S SRP-6 AB-26S OT-11 109A AB-7S AB-15S 108A 57M-P 5M AB-27S AB-16S 101A 91S 5S AB-28S AB-17S 107A SRP-7 72M 96A 95D 97A 94A 110D AB-1S 58M AB-29S OT-13 93A 106 AB-3S AB-19S/M 58M-P 92A AB-2S SRP-8 AB-30S 63S 105A 59M-P 98M 59M AB-1S 99D 100A 60M-P D4 SUMP 88M 10S 10M 104A 103D 67M 61M 62S 68 69R 14M P-06(M) P-05(A) P-04 P-03 P-02(A) P-01
23M 23S 24S
WECO DEWATERING WELL
89SP 22 SP 21 D 22 M FLY ASH 16" SLURRY LINE TO 3 & 4 EHP
22" HDPE RETURN LINE FROM 3 & 4 EHP CLEARWELL
86SP 84SP 21 M 21SP-2 21S 85SP
20M 52SP 54SP 53SP 51SP 20SP 20S 138SP
PS-2
90R 111SP 41SP 19D-2 19M 12R-2 19SP 12M 25SP 4S 4M
WS-116 WI-116 WM-135 40SP
70SP B-3 B-4 27SP B-2 B-5 18M 35M 26M B-1 18S 87SP 18D 35SP 71SP 26SP 18 SP 28SP 29SP B-7 B-6 SE-2 SE-1
112R 36M 17D 17M-2 7R 17S 17M 17SP 34D 9M 16SP 9S 33S 16M 37SP 37M 39S 6S 6M 6D 39M 38M 38SP

LEGEND
- PLANT SITE AREA
- WECO WESTERN ENERGY
- NORTHWEST AREA
- AREA OF UNITS 1&2 AB PONDS
- FORMER BRINE POND AREA
- AREA OF UNITS 3&4 BOTTOM ASH POND
- UNITS 3&4 WASH TRAY POND, UNITS 1&2 COOLING TOWER BLOWDOWN POND
- SHALLOW GROUNDWATER FLOW DIRECTION

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PLANT SITE REPORT

APPROXIMATE CAPTURE SYSTEM BOUNDARIES AND SHALLOW GROUNDWATER FLOW DIRECTION

DRAWING FILE NUMBER
1207100B001
AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-21A

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NORTH

SCALE
(In Feet)
500 0 500 1000 1500
(Approximate Only)

L-2
L-3
L-1
FLY ASH SLURRY & RETURN WATER FROM STEP
82A 81A 65A 64A 75A 80D 79A 83A OT-7 66D 74A 73A 30S-2 76A 44S 43S 77D 78A SRP-1 31M 45S 46S 55D-P 1S SRP-2 AB12-S 47S AB13-S CA-19A 1D 42S AB11-S 49S 48S SRP-3 AB10-S 55D SRP-4 SRP-5 AB-22S 13M 15D 50S 56D AB-24S 13S AB-21S AB-23S 56M-P AB-20S AB-25S AB-8S AB-9S/M SRP-6 AB-26S OT-11 102A 15S 109A AB-7S AB-14S 108A 57M-P 5M AB-27S 101A 91S 6S SRP-7 AB-16S 107A AB-28S AB-17S 96A 95D 97A 94A 110D AB-4S 58M 72M AB-29S OT-13 93A AB-3S 106A 58M-P AB-19S/M 92A AB-2S SRP-8 AB-30S 63S 105A 59M-P 99M AB-1S 99D 100A 60M-P D4 SUMP 88M 10S 10M 104A 103D 67M 62S 68A 61M 14M P-06(M) P-05(A) P-04 P-03 P-02(A) P-01
23M 23S 24S 90R 12R-2 19D-2 19M 19SP 12M 25SP 4S 4M 70SP B-3 B-4 27SP B-2 B-5 18M 71SP 26M B-1 18S 87SP 18D 26SP 18 SP 28SP 29SP B-7 B-6 112R 17D 17M-2 7R 17S 17M 17SP 9M 34D 16SP 9S 33S 16M 37SP 37M 69R 39S 6S 6M 6D 39M 38M 38SP
WECO DEWATERING WELL
89SP 22 SP FLY ASH 16" SLURRY LINE TO 3 & 4 EHP
22-M 21 D 22" HDPE RETURN LINE FROM 3 & 4 EHP CLEARWELL
21 M 21SP-2 21S 86SP 84SP 85SP 20M 52SP 54SP 53SP 51SP 20SP 20S 138SP 111SP 41SP 40SP 35M 35SP 87SP SE-2 SE-1 36M
PS-2
WS-116 WI-116 WM-135

LEGEND
- PLANT SITE AREA
- WECO WESTERN ENERGY
- NORTHWEST AREA
- AREA OF UNITS 1&2 AB PONDS
- FORMER BRINE POND AREA
- AREA OF UNITS 3&4 BOTTOM ASH POND
- UNITS 3&4 WASH TRAY POND, UNITS 1&2 COOLING TOWER BLOWDOWN POND
- MCKAY COAL GROUNDWATER FLOW DIRECTION

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PLANT SITE REPORT

APPROXIMATE CAPTURE SYSTEM BOUNDARIES AND MCKAY GROUNDWATER FLOW DIRECTION

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AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-21B

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NORTH

SCALE
(In Feet)
500 0 500 1000 1500
(Approximate Only)

L-2
L-3
FLY ASH SLURRY & RETURN WATER FROM STEP
FLY ASH 16" SLURRY LINE TO 3 & 4 EHP
22" HDPE RETURN LINE FROM 3 & 4 EHP CLEARWELL
WECO DEWATERING WELL
SRP-1
SRP-2
SRP-3
SRP-4
SRP-5
SRP-6
SRP-7
SRP-8
D4 SUMP
PS-2
SE-2
SE-1
WS-116
WI-116
WM-135

LEGEND

- PLANT SITE AREA
- WECO WESTERN ENERGY
- NORTHWEST AREA
- AREA OF UNITS 1&2 AB PONDS
- FORMER BRINE POND AREA
- AREA OF UNITS 3&4 BOTTOM ASH POND
- UNITS 3&4 WASH TRAY POND, UNITS 1&2 COOLING TOWER BLOWDOWN POND
- SUB-MCKAY COAL GROUNDWATER FLOW DIRECTION

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PLANT SITE REPORT

APPROXIMATE CAPTURE SYSTEM BOUNDARIES AND SUB-MCKAY GROUNDWATER FLOW DIRECTION

DRAWING FILE NUMBER
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AUTOCAD 2000 DRAWING (DWG)
FIGURE
3-21C

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A limited amount of groundwater capture is currently conducted in this area. However, there is extensive groundwater capture downgradient of this area in the area west of Units 1&2 A Pond. Water management practices have changed the source of water stored in the Units 1&2 Cooling Water Blowdown Ponds from blowdown water to stormwater runoff water with the goal to maintain a groundwater quality with an SC less than 5,000 µmhos/cm. This goal can generally be achieved unless the pond is needed for additional process water. SC and concentrations of other constituents have increased in the last two years. If this goal of maintaining cleaner water in the pond can be accomplished and maintained, a good recharge source will exist that to provide groundwater to downgradient areas. Piping is also in place to route return water from the Units 1&2 B Pond to the Units 3&4 Wash Tray Pond. However, the Units 3&4 Wash Tray Pond is not utilized for this purpose but does periodically contain water from precipitation runoff. Additional investigation has been conducted, with additional work planned in this area to better define hydrogeological conditions (see Table 3-2, #112). Additional actions are planned which will include removal of residual flyash from the Units 3&4 Wash Tray Pond.

Shallow units in the Plant Site Area include alluvium, colluvium, Rosebud Overburden, Rosebud Coal, spoil, and Rosebud-McKay interburden. Alluvium and colluvium are not present near the Units 3&4 Wash Tray Pond but are present west of the Units 1&2 Cooling Tower Blowdown ponds.

Wash Tray Pond Wells

Wells 7R, 9M, 16SP, and 17SP, completed in the Rosebud coal or spoil around the Units 3&4 Wash Tray Pond, serve as downgradient wells to monitor changes in water quality that may be associated with the pond. In general, groundwater in this area showed an improvement in water quality starting between 1993 and 1995, about the time the pond was being tested, and eventually taken out of continuous service (Figure 3-22). One exception, was at well 16SP, where boron concentrations increased sharply after 1995 and have fluctuated at a higher than pre-1995 levels. More recently there has been a slight trend of declining water quality in the wells 7R and 17SP. Well 9M has also shown increasing concentrations of chemical constituents since 2005. Groundwater at 16SP has not shown the

same trend. These increases may be the result of additional precipitation that entered the pond.

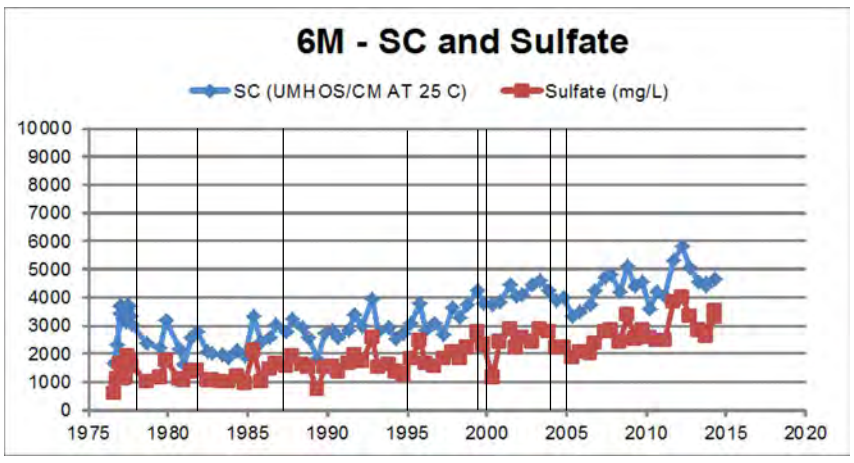
McKay water quality was declining until the removal of the Units 3&4 Wash Tray Pond from service. Water quality has remained relatively consistent or shown a very slight improvement since the removal of the pond from service. Water quality trends have been variable in the shallow units since removal of the Units 3&4 Wash Tray Pond from service in 1995. Recently, however, increases in indicator parameter levels have been observed at wells 7R, 17SP, 33S, and 6S. Sub-McKay groundwater has been consistent throughout the monitoring period.

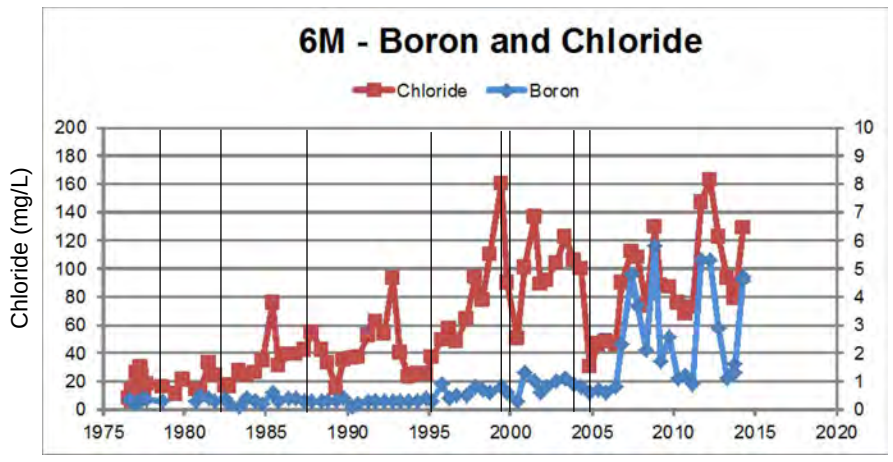
Wells 16M and 17M are completed in the McKay Coal east of the Units 3&4 Wash Tray Pond. Groundwater from these wells had increasing concentrations of indicator parameters between 1983 and about the 1993 to 1995 time period (trend graphs not included). Concentrations of chemical constituents have remained relatively consist at well 17M since that time while water at 16M has been variable, with a possible slight increasing trend. Boron concentrations at both wells have been shown a slight but steady decline at well 16M since 1993.

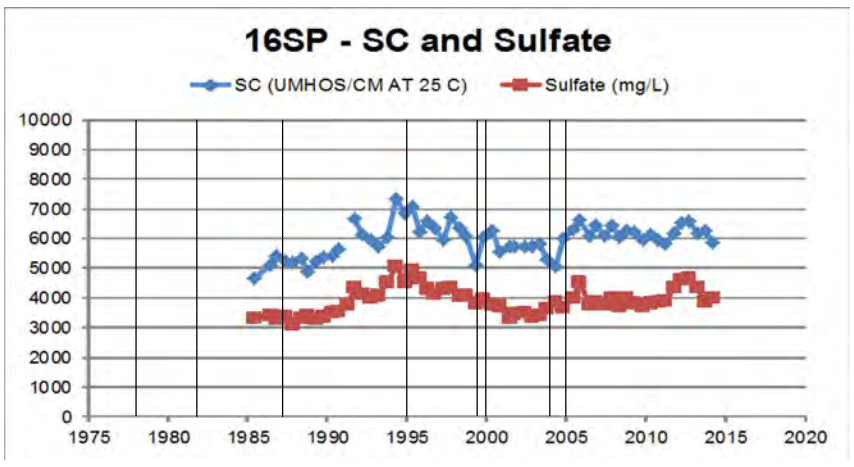
Units 1 & 2 Pond C North and Pond C South

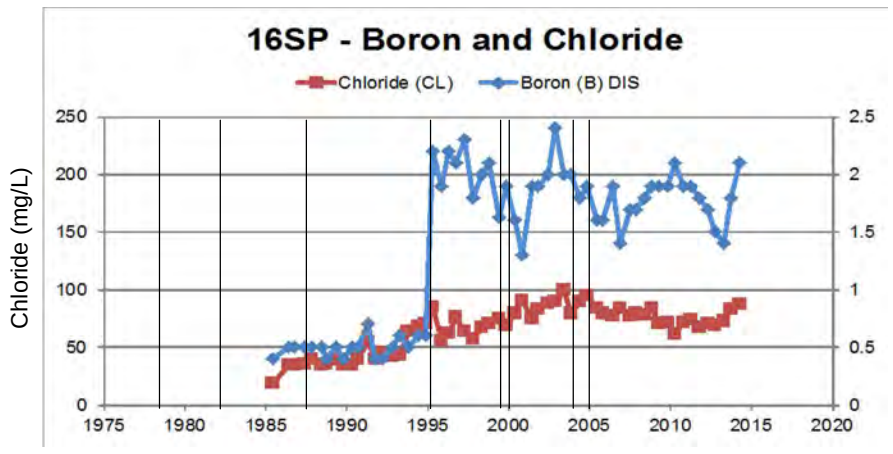
Groundwater quality at capture well 6M, located south of the Cooling Tower Blowdown Pond C South has been highly variable. Trend plots of typical process water indicator parameters at select wells in the Unites 3&4 Wash Tray Pond and Units 1 & 2 Cooling Water Blowdown Ponds area are included in Figure 3-22.

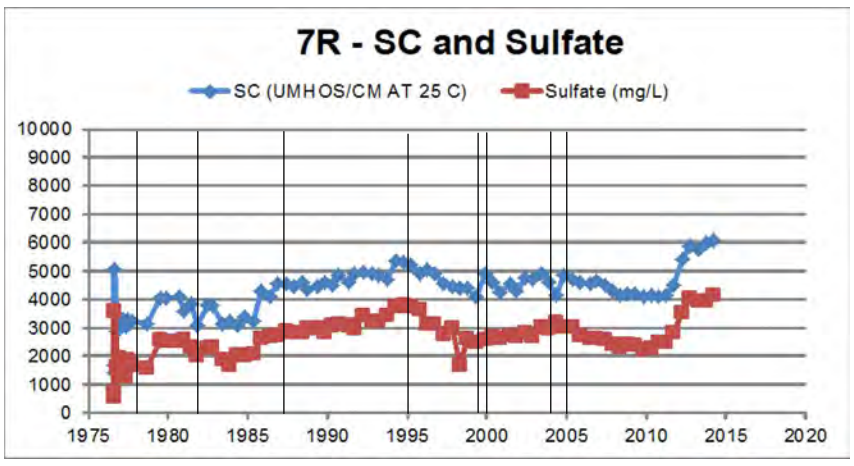
According to groundwater model simulations (Appendix A), groundwater flowing from the blowdown pond to the west and north is contained by downgradient wells near the northwest corner of the Units 1&2 Cooling Tower Blowdown Pond C North. This is in agreement with flow that would be predicted from potentiometric figures from May 2014 (Figure 3-15).

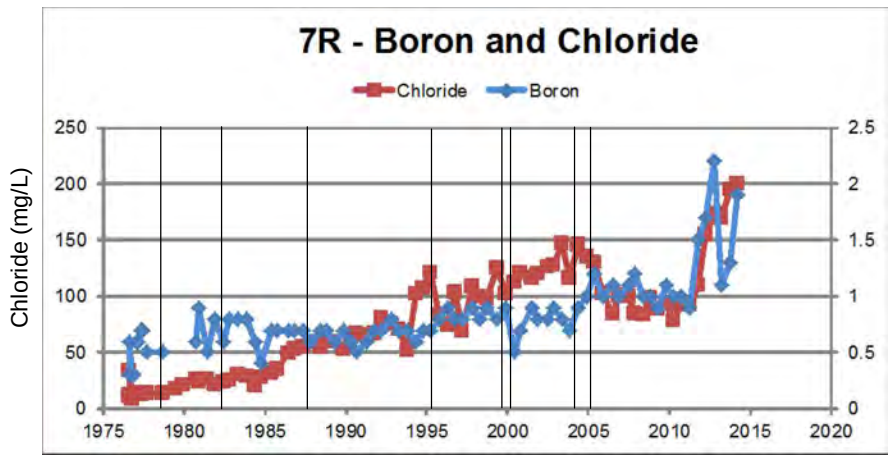


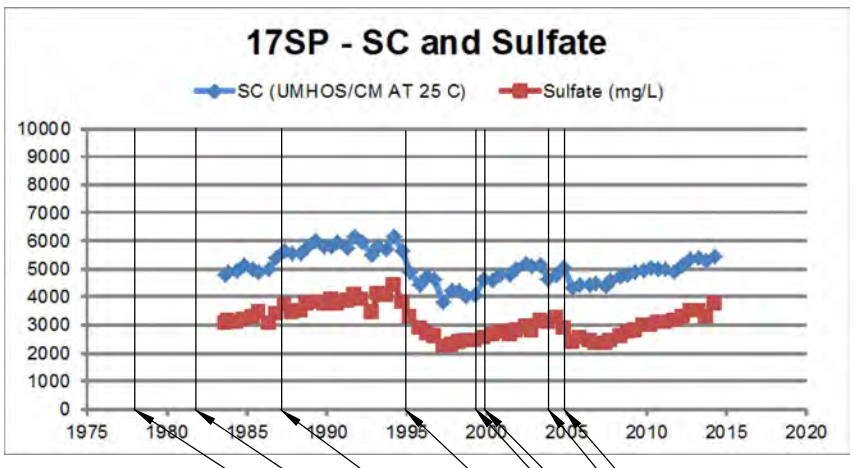


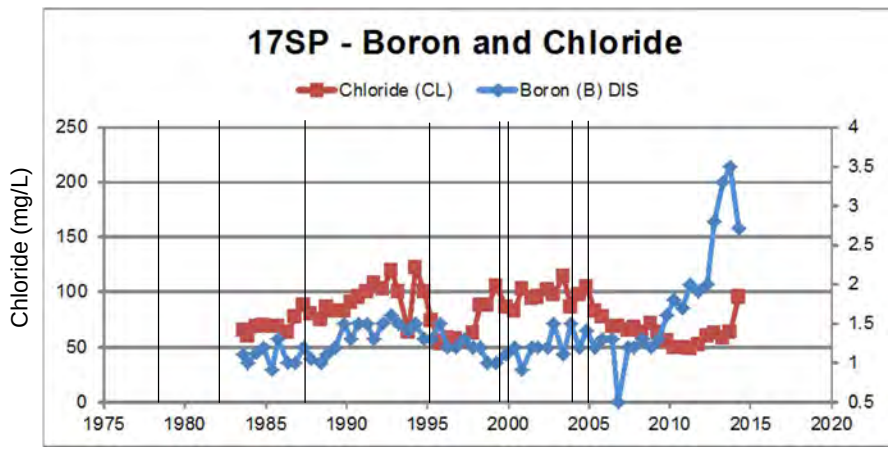












2005: Units 1 & 2 Cooling Tower Blowdown Pond (Pond C) North starts receiving raw & storm water
2004: Units 1 & 2 Cooling Tower Blowdown Pond (Pond C) North started receiving groundwater collection water
2000: Units 1 & 2 Cooling Tower Blowdown Pond (Pond C) South starts receiving raw & stormwater
1999: Units 1 & 2 Cooling Tower Blowdown Pond (Pond C) Groundwater Collection installed at south end
1995: Units 3 & 4 Wash Tray Pond Abandoned
1987: Units 1 & 2 Cooling Tower Blowdown Pond (Pond C) Split and Lined with Clay
1983: Units 3 & 4 Wash Tray Pond Enters Service
1978: Units 1 & 2 Cooling Tower Blowdown Pond (Pond C) Enters Service

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PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT PLANT SITE REPORT	**WATER QUALITY OF SELECT WELLS AT UNITS 3 & 4 WASH TRAY POND, UNITS 1 & 2 COOLING WATER BLOWDOWN POND AREA**	FIGURE **3-22**

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Potentiometric figures constructed using May 2014 data show a groundwater divide in the shallow units trending northeast to southwest that passes near the southeast corner of the Units 3&4 Wash Tray Pond. Flow on the west side of this divide would be west-ward and flow on the east side would be east-ward. Groundwater potentiometric figures for the McKay Coal indicate a flow direction to the northwest, without a distinct hydrologic divide (Figure 3-16). Additional data would be needed to the southeast to characterize where or if a hydrologic divide occurs throughout this portion of the Plant Site in the McKay Coal.

Additional investigation has been conducted in this area since the original issuance of this report in December 2012). A second phase is planned for 2015 which will further characterize the hydrogeologic conditions in the area and potentially lead to additional mitigation measures. This area is typically included in the evaluation of conditions west of the site (shown as part of the southern end of the Units 1&2 AB Ponds on Figures 3-21A, 3-21B and 3-21C). Water quality at capture wells 10S and 10M has shown progressive decline, partially resulting in this additional investigation. Well 98M was installed as a downgradient capture well and has shown relatively stable water quality. Well 68A, located southwest of the 10S and 10M has shown stable or very slightly improving water quality. Based on these observations, it appears that a narrow band of impacted water is flowing from the southern portion of the Plant Site towards wells 10S and 10M. The additional investigation is expected to further define this pathway. Data collected during the additional investigation were used in preparing the updated potentiometric figures shown on Figure 3-15 through 3-17.

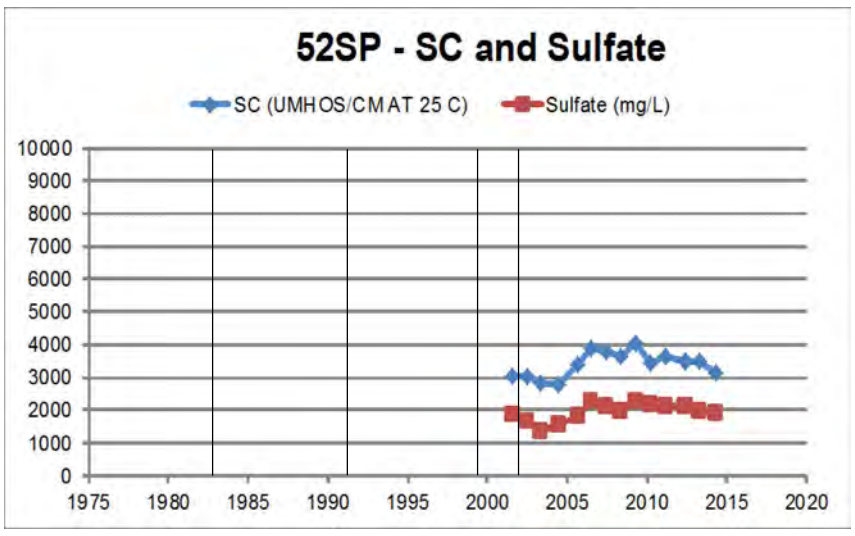
3.5.2 Units 3&4 Bottom Ash Ponds

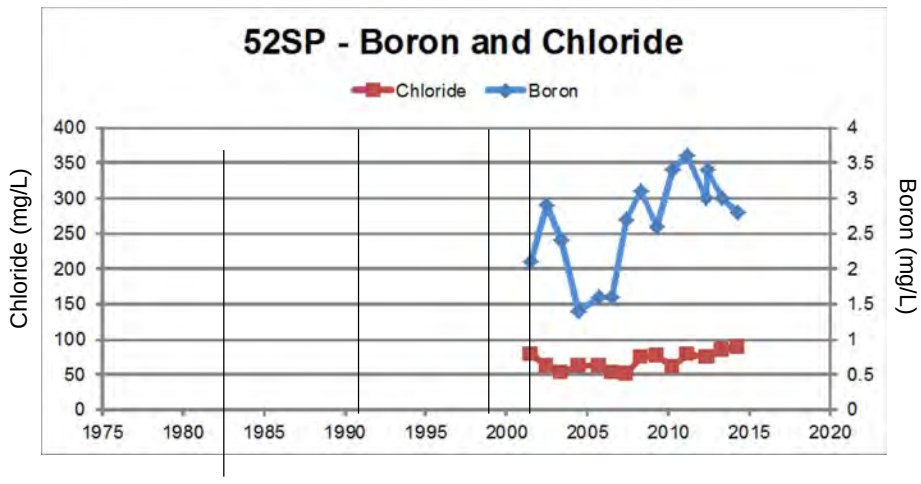
Actions have been taken in the Units 3&4 Bottom Ash Pond area to address source area control. These actions include the initial construction that included lining the pond bottoms with clay and by installing and operating groundwater capture wells around the along the south and northeast sides of the ponds (52SP, 53SP, 54SP, 54SP, 21SP) on Figures 3-15 through 3-17.

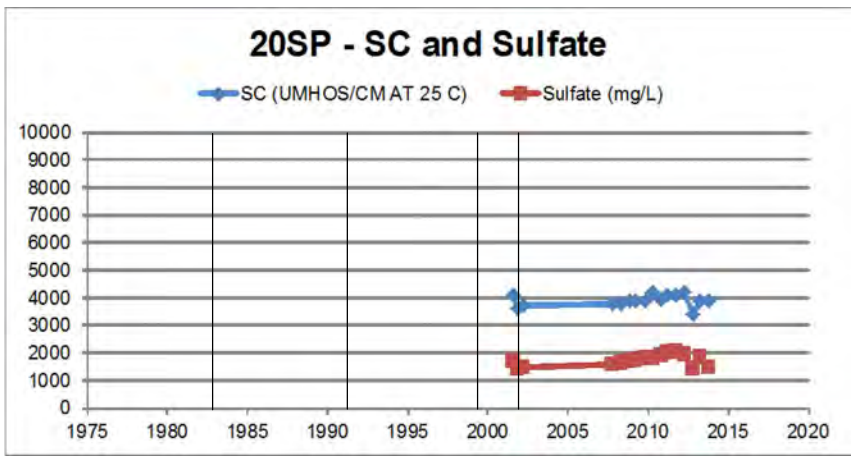
Spoil is the dominant deposit in the Units 3&4 Bottom Ash Ponds area. There are isolated areas of undisturbed bedrock near the well 20 battery. There is a small area where only a minor amount of spoil exists, which overlies overburden and coal. Groundwater flow in the area is dictated by the presence of spoil. Spoil in this area exhibits highly variable hydraulic conductivities and well yields reflect this. The WECO well and well 89SP for example yield in excess of 40 gpm, while other spoil wells in the area may only yield a few gallons per minute.

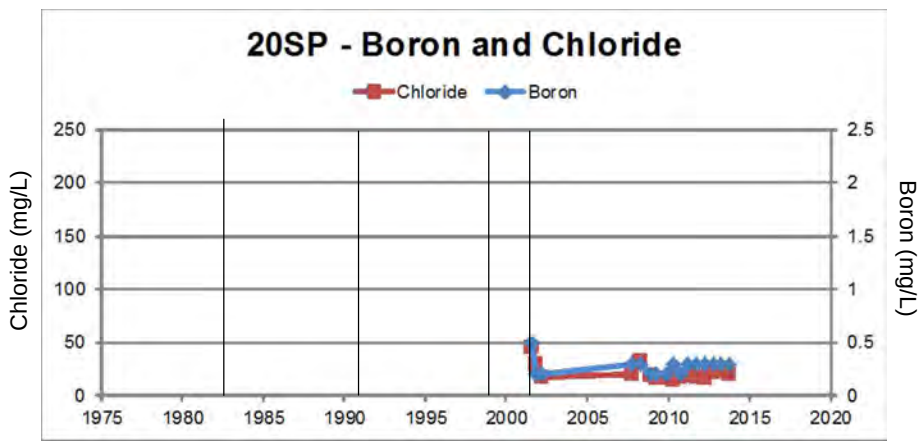
Wells located much farther downgradient to the northwest, north of the Plant Site proper near the wastewater lagoons (74A, 75A, 79A, 82A) are also in place to capture water seeping from this pond (Appendix H). Despite ongoing groundwater capture in 3&4 Bottom Ash Pond area, concentrations of solutes in groundwater have remained constant or increased in monitoring and capture wells (51SP, 52SP, 53SP, 54SP, and 21SP). This may be a function of capture wells inducing flow causing impacted groundwater to pass by monitoring wells as it flows to the capture wells. Note SC and sulfate levels are lower than BSL's. However, chloride and boron concentrations in the pumping wells 50SP and 54SP are above the BSL's. This is a function of the wells capturing water that has seeped from the ponds. Typical process water indicator parameters for select sites in the Units 3 & 4 Bottom Ash Ponds Area are included in Figure 3-23. Concentration graphs for these monitoring wells (20M, 22SP, 84SP, 89SP, WECO) are included in Appendix H. Water quality at these wells shows a slight overall improvement over time.

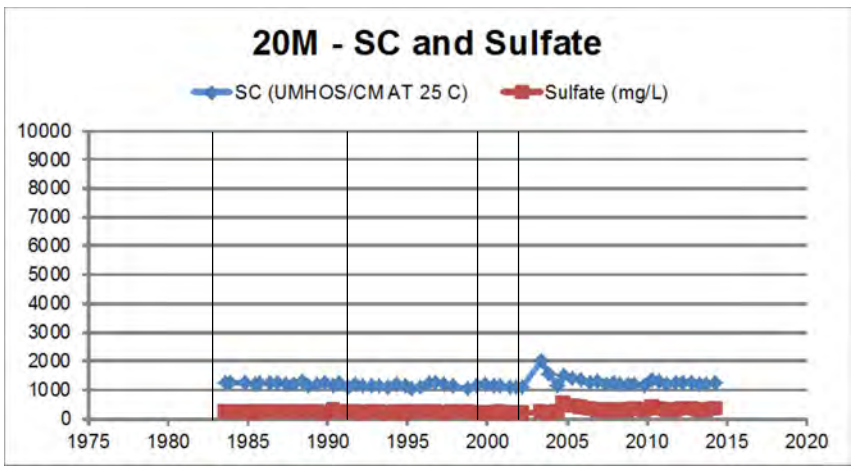
In addition to the PPL capture wells, the WECO well, owned and operated by the Rosebud Mine to lower water levels near a coal crusher, provides additional capture in this area. This well is completed in mine spoil. Water quality in the WECO well is similar to that of other wells in the immediate vicinity. Since 2008, water from the WECO well has shown an SC of 4,490 to 5,170 µmhos/cm, sulfate of 2,650 to 3,110 mg/L, boron of less than 1.7, chloride of 87 to 113 mg/L and a calcium to magnesium ratio near 1. Bromide concentrations of 4 to 5 mg/L have been detected in the water from the well since 2012. Analytical results for the WECO well are in Table 3-5.

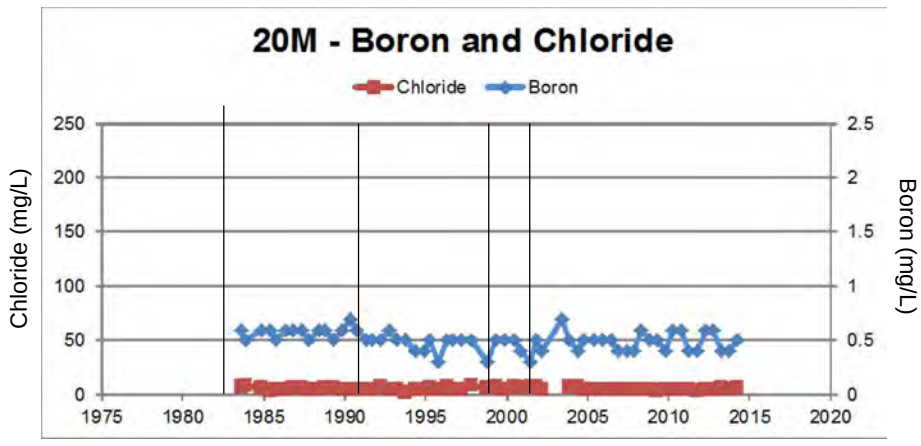


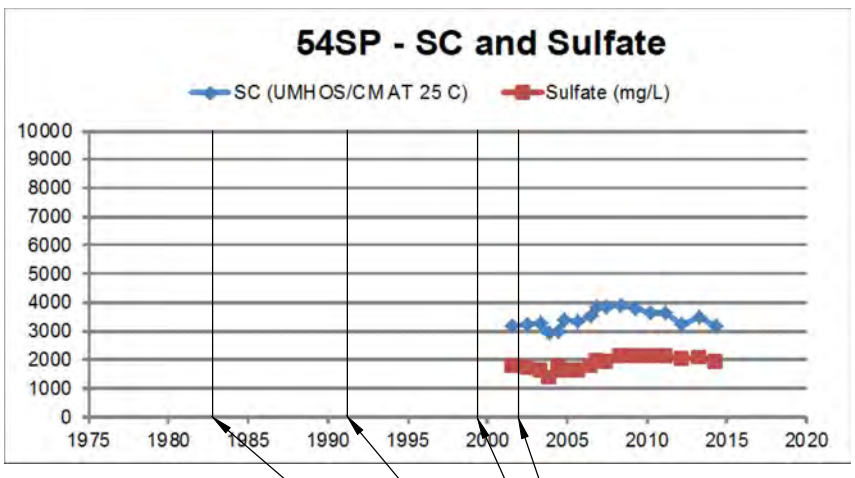


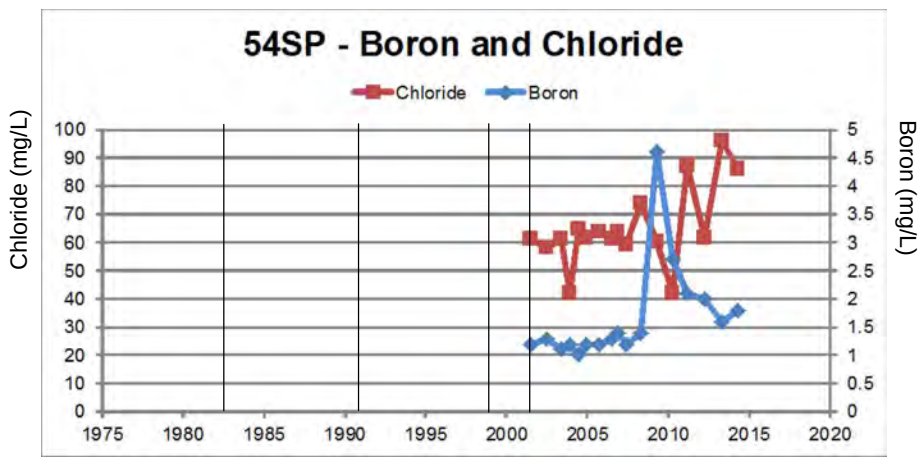












2002: UNITS 3&4 Bottom Ash Ponds Groundwater Collection System Expanded
1999: UNITS 3&4 Bottom Ash Ponds Groundwater Collection System Installed
1991: UNITS 3&4 Bottom Ash Ponds Re-lined with Clay
1983: UNITS 3&4 Bottom Ash Ponds Installed

PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT PLANT SITE REPORT	**WATER QUALITY OF SELECT WELLS AT UNITS 3 & 4 BOTTOM ASH PONDS AREA**	FIGURE **3-23**

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TABLE 3-5
WECO WELL WATER QUALITY DATA
UNITS: milligrams per liter unless noted

Sample date		08/09/94	12/27/94	12/28/94	05/03/95	02/28/00	11/14/06	06/09/07	04/12/08	04/22/09	04/12/10	03/29/12	3/29/12(D)	04/22/13
pH (Lab) standard units - s.u.		7.0	7.1	7.3	6.9	7.5	6.8	6.7	6.6	6.8	6.8	6.8	6.8	6.8
Spec. Cond. (µmhos/cm)		6080	5730	5440	4460	3850	5250	5230	5030	5170	5070	4520	4520	4750
TDS measured @ 180 ^{o} C		5930	6310	5730	4260	3540	4910	4980	4990	5100	4910	4790	4750	4730
Total Hardness as $CaCO_3$		3340	4200	3820	2610	1520	--	--	--	--	--	--	--	--
Acidity, Total as $CaCO_3$		--	--	--	<1	14	--	--	--	--	--	--	--	--
Alkalinity, Total as $CaCO_3$		439	822	840	716	106	572	597	584	556	572	535	548	530
Bicarbonate as HCO_3		536	1000	1020	874	129	698	728	713	679	697	653	669	647
Bromide (Br)		--	--	--	--	--	--	--	--	--	ND	4	4	5
Carbonate as CO_3		0	0	0	0	0	0	0	0	0	0	0	0	0
Chloride (Cl)		139	91	76	37	133	125	137	106	92	90	91	91	87
Sodium Adsorption Ratio		3.58	1.40	1.67	2.30	3.67	--	--	--	--	--	--	--	--
Sulfate (SO_4)		3580	3770	3310	2490	2030	2760	2900	2850	2850	3110	2900	3020	2740
Fluoride (F)		2.03	<0.10	0.10	<0.10	3.42	--	--	--	--	--	--	--	--
Nitrate+Nitrite as N		1.16	<0.05	<0.05	<0.05	1.98	--	--	--	--	--	--	--	--
Ortho-phosphate (PO_4- as P)		0.02	0.02	0.01	0.02	0.68	--	--	--	--	--	--	--	--
Aluminum (Al) Diss		<0.1	<0.2	<0.1	<0.1	0.1	--	--	--	--	--	--	--	--
Arsenic, Diss		--	--	--	--	0.048	--	--	--	--	--	--	--	--
Boron (B) Diss		1.1	0.7	1.0	0.5	1.0	1.3	0.9	1.5	1.3	1.4	1.3	1.3	1.0
Cadmium (Cd) Diss		<0.001	<0.002	<0.001	<0.001	<0.001	--	--	--	--	--	--	--	--
Calcium (Ca) Diss		601	632	349	403	386	462	479	438	452	458	461	463	448
Copper (Cu) Diss		<0.01	<0.02	<0.01	<0.01	--	--	--	--	--	--	--	--	--
Iron (Fe) Diss		0.04	<0.06	<0.03	0.56	<0.02	--	--	--	--	--	--	--	--
Lead (Pb) Diss		<0.01	<0.02	<0.01	<0.01	<0.01	--	--	--	--	--	--	--	--
Magnesium (Mg) Diss		447	636	718	390	134	449	475	434	440	454	413	412	392
Manganese (Mn) Diss		1.35	3.53	4.38	1.75	0.01	--	--	--	--	--	--	--	--
Mercury (Hg) Diss		<0.001	<0.001	<0.001	<0.001	--	--	--	--	ND	--	--	--	--
Nickel (Ni) Diss		0.03	0.03	0.05	--	--	--	--	--	--	--	--	--	--
Potassium (K) Diss		35	14	15	13	26	17	16	16	16	16	14	14	14
Selenium (Se) Diss		0.008	<0.005	<0.005	<0.005	--	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sodium (Na) Diss		476	209	237	270	329	329	326	322	310	337	322	326	325
Vanadium (V) Diss		<0.10	<0.10	<0.10	<0.10	--	--	--	--	--	--	--	--	--
Zinc (Zn) Diss		<0.01	<0.02	0.03	<0.01	0.02	--	--	--	--	--	--	--	--

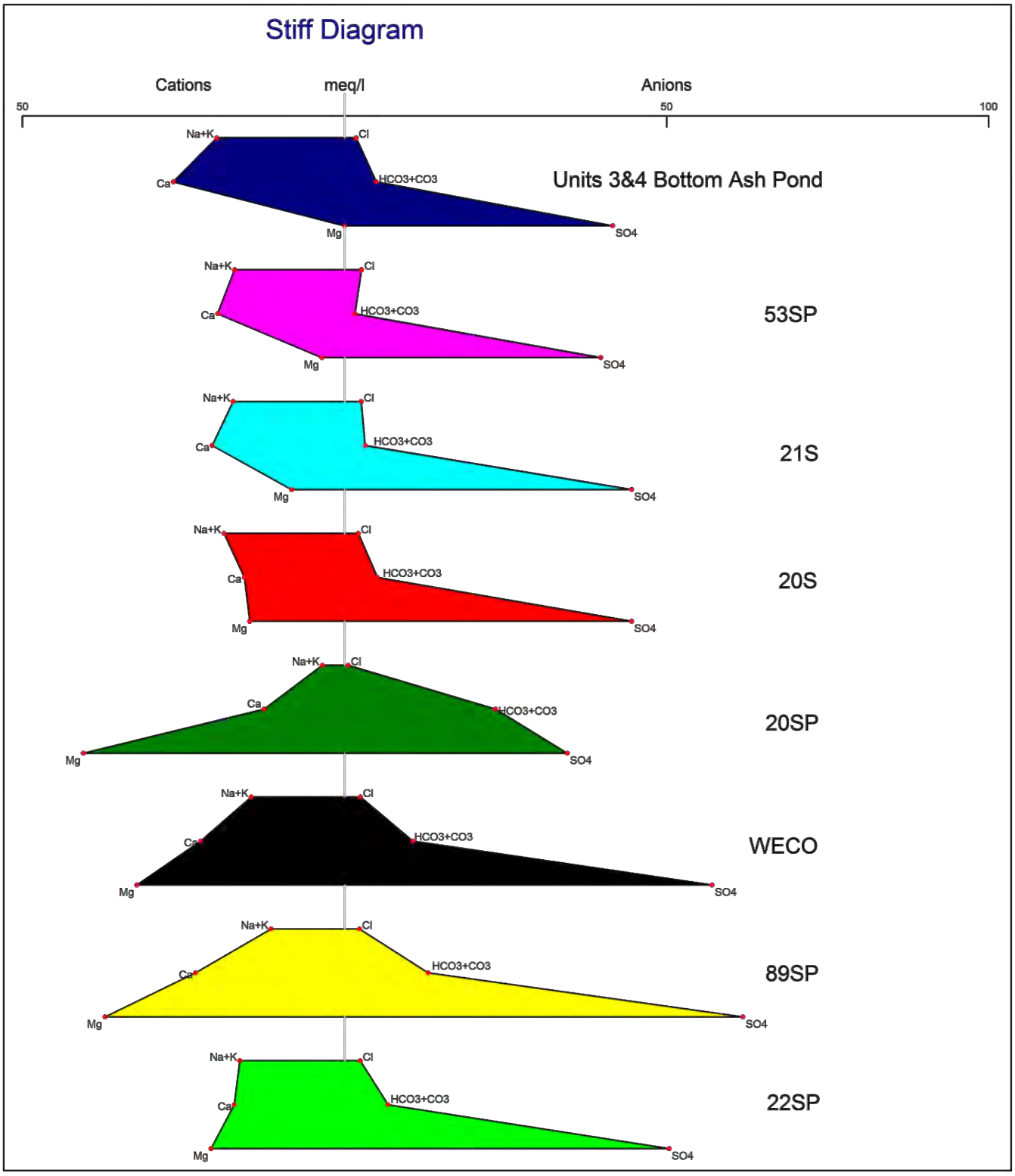
ND – Non Detect
-- = Not analyzed. Cells without data indicate the parameter was not included in the analysis.
Diss. = dissolved

The presence of low concentrations of bromide in downgradient wells suggests water from the ponds is seeping at low rates and being collected by the capture wells at these locations. Groundwater mounding is still apparent in this area, however, and groundwater model simulations suggest groundwater may be flowing past the capture systems to the east-southeast. Additional data to the southeast of the ponds have been collected to further characterize this area. A new well (138SP) was installed southeast of the ponds in 2014. Initial samples from the well were inconclusive as to process water impacts. Additional monitoring is recommended to further evaluate water quality trends at this well.

Wells 22SP, 84SP, and 89SP are located to the north and northwest of the Units 3&4 Bottom Ash Ponds. Water from 22SP does not show strong indicators of effects from the Units 3&4 Bottom Ash Ponds. Compared to the flyash ponds, water in the Units 3&4 Bottom Ash Ponds is rich in calcium as compared to magnesium, has a relatively low SC, and concentrations of sulfate, chloride and boron. Well 22SP is about 100 feet north of the Units 3&4 Bottom Ash Ponds. Water sampled from the Units 3&4 Bottom Ash Pond Clearwell has shown bromide levels as high as 21 mg/L. Water from 22SP has a calcium to magnesium ratio that is above 1 and chloride concentrations that are similar to those in the Units 3&4 Bottom Ash Ponds. Bromide has recently been detected at concentrations up to 9 mg/L in water from 22SP suggesting pond influences. However, concentrations of sulfate and boron are lower than those typically found in the ponds.

Groundwater from both 84SP and 89SP has been showing an improving trend since they were installed in 2008. Concentrations of sulfate and boron, and SC levels are higher than that in the Units 3&4 Bottom Ash Ponds.

Figure 3-24 contains Stiff Diagrams for several wells in the vicinity of the Units 3&4 Bottom Ash Ponds and the WECO well. Note that water from the Units 3&4 Bottom Ash Pond is a calcium-sulfate type water with a very high calcium to magnesium ratio (>11 for mean values). Well 22SP is located between the Units 3&4 Bottom Ash Ponds and the WECO well. Water at well 22SP is a magnesium-calcium sulfate water. SC levels and concentrations of sulfate and chloride are higher in the WECO well than in well 22SP.



PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT PLANT SITE REPORT	**STIFF DIAGRAM FOR SHALLOW WELLS NEAR THE WECO WELL**	FIGURE **3-24**

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Boron concentrations are similar and calcium to magnesium ratios are similar in both wells. However, magnesium is the dominant ion in the WECO well. When compared to water from 89SP, the WECO well has a slightly higher chloride concentration (avg. 89 mg/L vs. 78 mg/L), and slightly higher calcium to magnesium ratio of 1.02 vs. 1.14. Water from well 89SP has slightly higher SC, sulfate, and boron concentrations than the WECO well and a calcium to magnesium ratio of less than 1. Both of these wells however have distinctly magnesium-sulfate type water. Based on this comparison, water at the WECO well is likely sourced from the Units 3&4 Bottom Ash Pond area as well as the spoil near 89SP and spoil south of the well.

Wells 53SP, 21S, (capture wells) and monitoring well 20SP show water characteristics similar to the Units 3&4 Bottom Ash ponds. Water from 20SP is a magnesium-sulfate type water but has a relatively high bicarbonate signature. This water is dissimilar to the Units 3&4 Bottom Ash Pond water. Other indictor parameters are not indicative of process waters at this well. Little variation in water quality has been observed in this area. Drawdown induces limited capture around the wells and the WECO well extracts relatively large qualities of water from the spoil which underlie portion of the Units 3&4 Bottom Ash Pond system. Groundwater model particle tracking suggests some particles may be bypassing the ponds. This may be a function of particle placement for model simulations or actual bypasses. In general, water quality in these ponds is relatively good quality. Additional capture may be necessary to completely induce groundwater gradient control around these ponds.

3.5.3 Former Units 1&2 Brine Pond Area

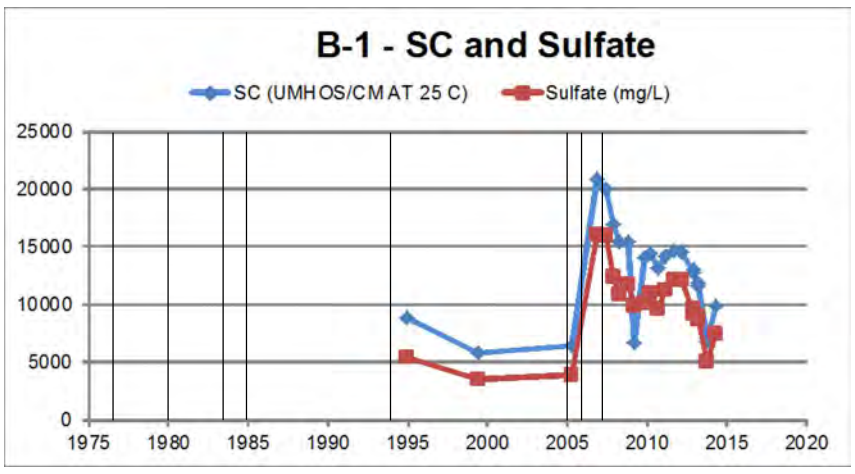
Actions have been taken in Former Brine Pond area to address source area control. These actions include the initial construction of the ponds using synthetic liners, installing and operating groundwater capture wells near the former ponds (B-1, B-2, B-3, B-4, B-5, 4S, 19SP, 26SP, 29SP, and 70SP), removal of the initial three cells (D-1 through D-3), removal of soil from below the former liners, removal of cell D-4, and the removal of materials from under the ponds (Figure 3-20A). A summary of events in this area is included in the second bullet of Section 3.4.4. Water quality graphs for area monitoring wells 18SP and 28SP,

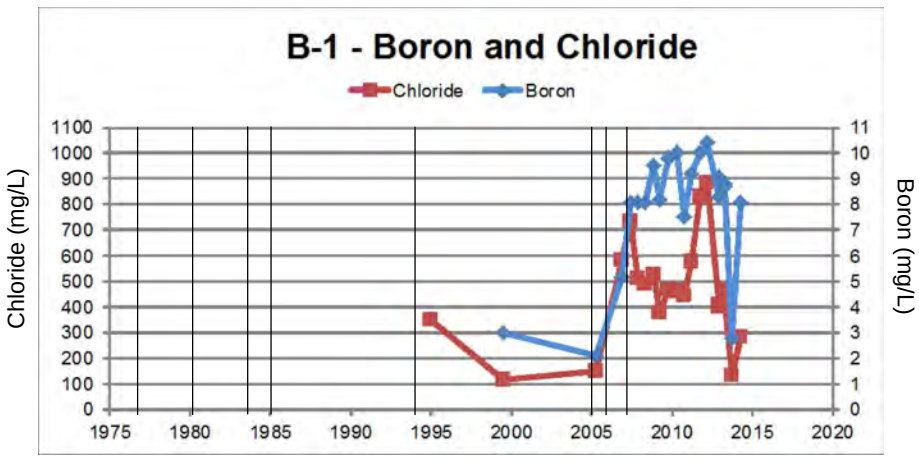
southeast of the original Brine Pond Capture System (wells B-1 through B-5), 25SP located directly north of the former D4 Brine Pond, and 12R-2 located north of the former brine pond area are in Appendix H.

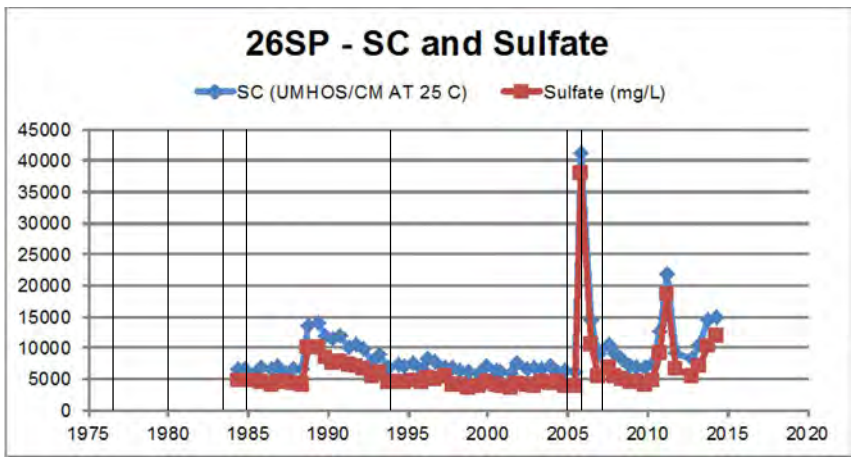
Spoil is the primary material east and south of the former Brine Ponds. Fort Union bedrock, consisting of overburden, Rosebud Coal, Interburden, McKay Coal and sub-McKay strata is present under the northwest portion of the former ponds. Groundwater flow in this area is either towards groundwater capture wells, or to the northwest and towards the Units 1&2 B Pond.

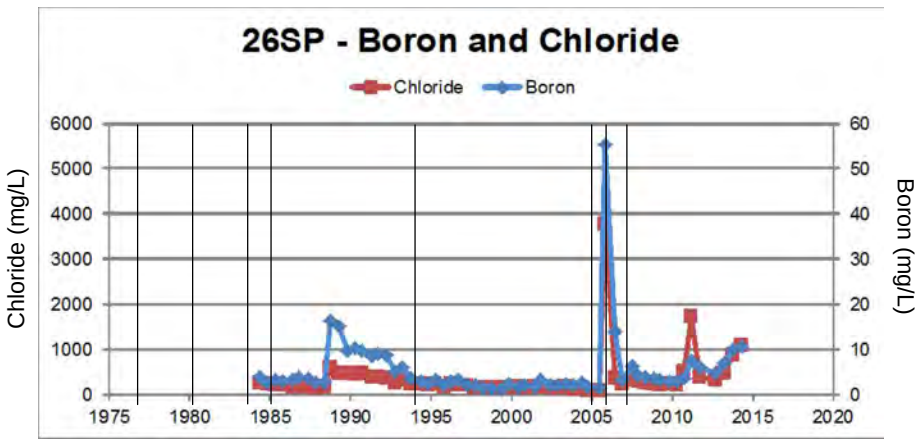
Groundwater capture systems were installed to address changes in water quality in downgradient monitoring wells attributed to losses of brine pond water. Wells B-1, B-2, B-3, B-4 and B-5 were installed following the D3 liner tear that occurred in the early 1980's. Water quality improved following installation of the capture wells as illustrated by the water quality graphs for wells B-1 and B-2 which are included in Figure 3-25.

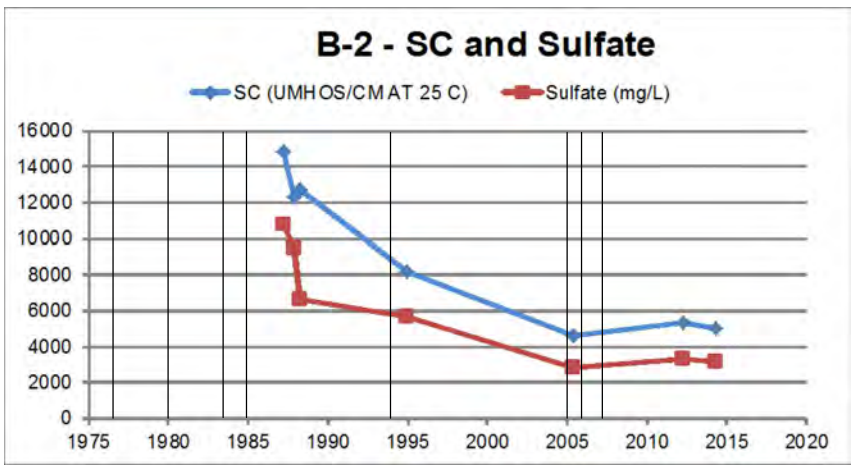
Water quality continued to improve at these capture wells and nearby monitoring wells until the D4 Liner failed late in 2005 due to subsidence of the spoil under the pond. Water was immediately removed from the cell. Solids above the liner were moved to the southwest corner of the cell and covered with a synthetic liner, covered with soil and reseeded. Since the initial submittal of this report in December 2012, the most highly salt laden soil from under the former D4 Brine pond has been removed and placed in the Units 3&4 EHP. Additional capture wells (70SP & 111SP) were installed and some existing monitoring wells (4S, 19SP 26SP, 29SP), were converted to capture groundwater. In addition, the existing brine pond capture system was upgraded with new pipe and pumps. As illustrated on the potentiometric map in Figure 3-15, a depression has been induced in the water table near the former brine ponds essentially containing impacted water near the source area.

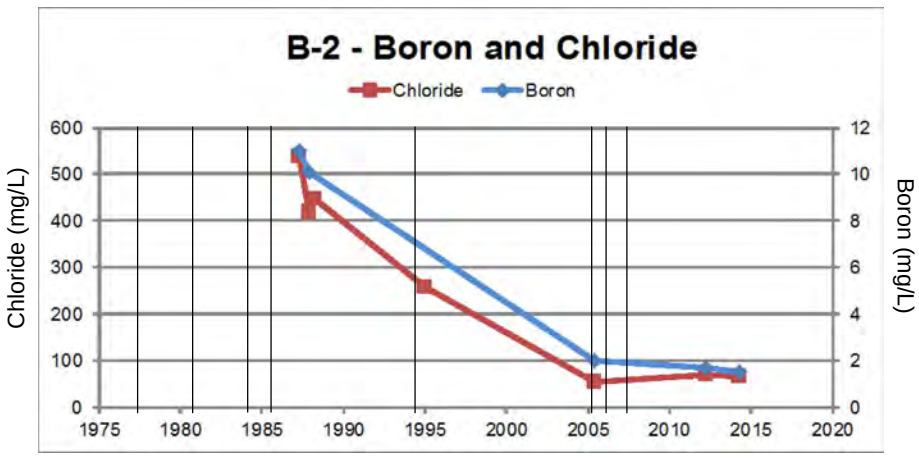


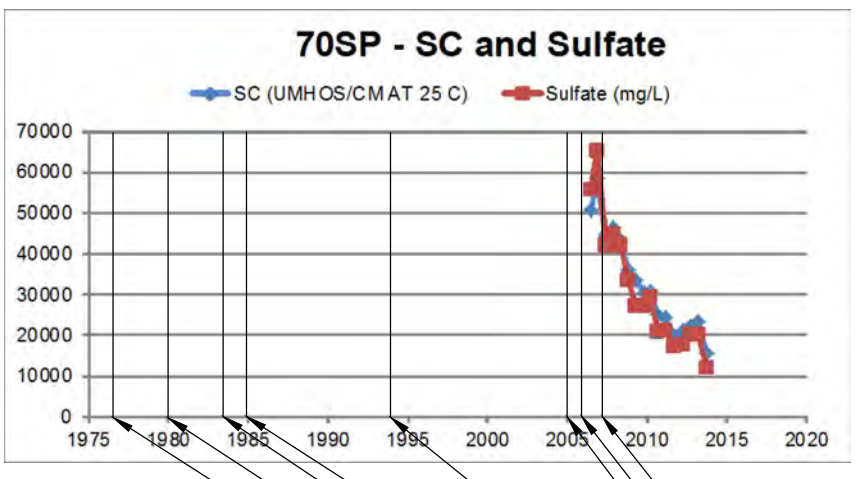


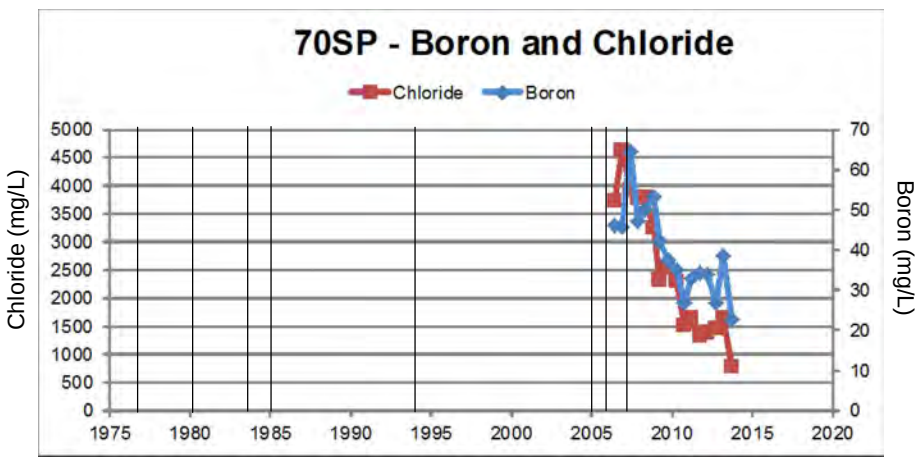












2007: Pond D4 Soil Cap
2006: Pond D4 Closed and Capped with RFP Liner
2005: Pond D4 Drained and removed from service
1994: Ponds D-1, D2, & D3 Closed
1985: Brine Pond Collection System Installed
1984: Pond D4 Entered service
1980: Pond D3 Entered Service
1976: Ponds D1 & D2 Entered Service

PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT PLANT SITE REPORT	**WATER QUALITY OF SELECT WELLS AT BRINE POND AREA**	FIGURE **3-25**

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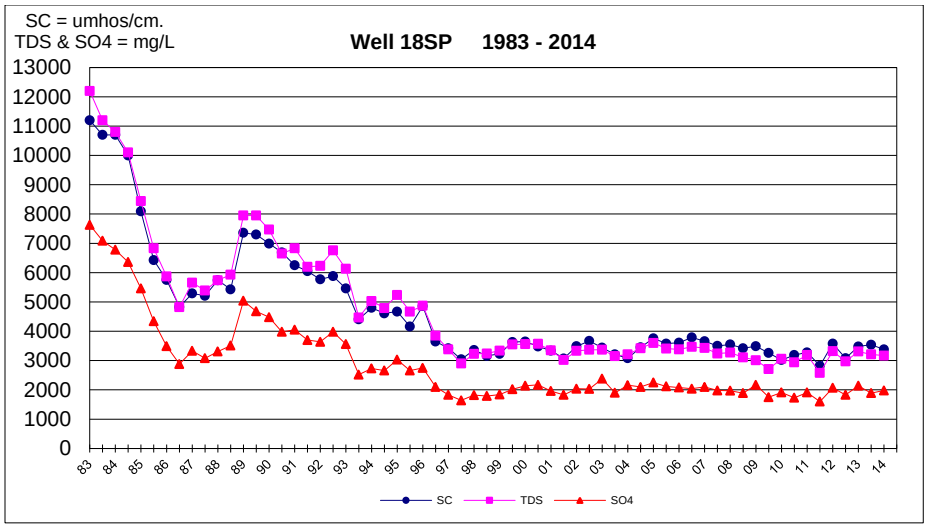
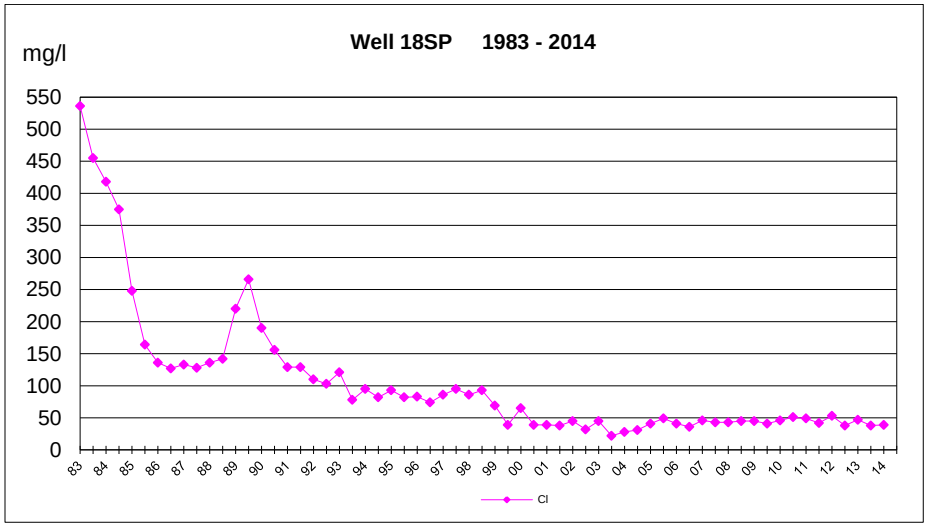
Groundwater quality has shown substantial improvement since these additional capture efforts were implemented and the D4 Brine Pond was drained and taken out of service. The exception is well B-1 which initially showed improvement but has shown variable water quality since late 2011. Water quality at downgradient wells B-6 and B-7 has stabilized, however, indicating that effective capture is occurring at B-1. The improvement at these wells demonstrates a reduction in source area materials. Typical process water indicator parameters for select sites in the Former Brine Pond Area are included in Figure 3-25.

Wells 71SP, 26M, 26SP, 29SP, 25SP, 4M, 4S, 12R-2, 12M, 19D-2, 19M, and 19SP are wells located near the former Brine Ponds. General water quality observations for these wells are as follows:

- 12M, 12R-2, & 71SP – slight gradual improvement;
- 19M, 19D-2, & 26M – stable water quality, no apparent impacts;
- 4S, 19SP, 26SP, & 29SP – significant improvement;
- 25SP – declined following liner problems but then improved after repairs were made. Water quality has been improving since 2005; and
- 4M – Variable water quality but no evidence of effects from Brine Pond liner tears.

Water quality in downgradient monitoring wells to the southeast of the former Brine Ponds also illustrates the effectiveness of groundwater capture related to the Brine Ponds. Well 18SP (completed in spoil) is considered the most representative well since water exiting the ponds would first enter the spoil. SC, TDS, sulfate, and chloride concentrations at well 18SP are used to illustrate this effectiveness. The charts below illustrate the high concentrations in TDS, sulfate, and chloride resulting from releases from the brine ponds in the early 1980s. Installation and operation of the Brine Pond Capture system resulted in water quality improvement until the quality was relatively stable in the late 1990's. The effectiveness of the remediation systems, rapid response by PPL, and expanded capture following the 2005 release from Pond D4 are demonstrated by the lack of increases in these parameters in the downgradient well.





Water quality trends for wells 18M and 18S are very similar to those shown above for well 18SP. Wells 27SP, 28SP, 35M, 35SP and 87SP are located east of the Brine Pond Capture wells. Water quality at well 27SP has shown steady improvement since the start of Brine Pond capture wells B-1 through B-5. Water quality at 28SP has been variable with no distinct long term trends. These wells are at the edge, or outside the capture zone for the Brine Pond capture wells. Water quality at wells 35M, 35SP, and 87SP has been relatively steady, showing no indication of process pond water impacts.

3.5.4 Units 1&2 A/B Flyash Pond Area

Multiple source area actions have been taken in the Units 1&2 A/B Flyash Pond area to address source area control. These actions include the initial construction of the Units 1&2

AB using clay liners, splitting the original pond into two individual ponds (A Pond and B Pond), maintaining the original clay liner under new A Pond, installing a double RFP synthetic liner system with leachate collection, removal of the Units 1&2 AB Pond Clearwell, relocating the Units 1&2 Bottom Ash Clearwell and constructing it with a double synthetic RFP liner and leachate collection, water management practices that result in routing of stormwater to the A Pond, and installation of multiple capture wells (Figure 3-20A).

The Units 1&2 A/B Pond and old Units 1&2 Bottom Ash Clearwell were removed from service. A new Units 1&2 Bottom Ash Clearwell was constructed at the former location of the Units 1&2 A/B Pond Clearwell. The new 1&2 Bottom Ash Clearwell was double lined with RFP. Underdrain systems were installed between the upper and lower liners and under the lower liner. Water escaping through the upper liner flows to a sump and is returned to the pond. The below liner system provides a secondary capture system in the event that water bypasses both liners and the between liner capture system.

The 1&2 B Pond was lined with one 35-mil and one 45-mil RFP liners and a leachate collection system installed between and under the liners in 2004. The underliner collection system intersects the groundwater table and serves to provide additional groundwater capture. The liner reduces the amount of water potentially seeping from the pond.

An extensive network of groundwater capture and monitoring wells are located east, west and north, (downgradient) of the ponds. Wells labeled as AB-## were installed to investigate the Units 1 & 2 A/B Ponds. These wells were sampled during the initial investigation. Many of these wells were recently added to the monitoring program and are scheduled for sampling once every three years.

Geology in this area includes shallow units including localized fill, alluvium, colluvium, shallow overburden bedrock, Rosebud Coal, Interburden, McKay Coal, and sub-McKay strata. East Fork Armells Creek has eroded through bedrock units as deep as the sub-McKay making the alluvium the receiving water for these units.

A summary of water quality trends for wells around the perimeter of the Units 1 &2 A and B pond system follows. Wells further to the west and downgradient of the ponds are discussed later in this section.

East of Units 1 & 2 B Pond – moving from south to north – upgradient of B Pond and downgradient from the former Brine Ponds

- AB19-SM – Four samples have been collected from this well since 1996. Water at this well shows a decreasing trend for SC and sulfate, slight decline in boron concentrations, increasing calcium to magnesium ratio, and increasing chloride concentrations. The decreasing trends of these parameters are possibly the results of pond relining and groundwater capture in the Former Brine Pond area.
- 72M – Installed in 2005, water from this well has shown gradual decrease in SC, sulfate and chloride concentrations. Boron and the calcium to magnesium ratio have remained steady.
- AB17-S – Three samples have been collected from this well (1996, 2012 & 2014). Comparison of the 1996 and 2014 samples show an increase of SC levels and sulfate concentrations, little change in chloride concentrations, and a large drop in boron concentrations. Calcium to magnesium ratios dropped. Data from this well is inconclusive. Changes in calcium to magnesium ration and increases in SC and sulfate may indicate influences from the former Brine Pond Area.
- AB16-S - Three samples have been collected from this well (1996, 2012 & 2014). When compared to 1996 data, water collected in 2014 had lower concentrations of indictor parameters, except for chloride, which increased. The decreasing trends of these parameters are possibly the results of pond relining and groundwater capture in the Former Brine Pond area.
- AB14-S - Four samples have been collected from this well since 1996. With the exception of chloride, indicator parameters have remained relatively steady. Chloride concentrations have increased.

Between Units 1 & 2 Pond A and Pond B – from south to north – between Units 1&2 A Pond and B Pond

- AB-29S - Four samples have been collected from this well since 1996. Concentrations of all indicator parameters dropped significantly between the first sample collected in 1996 and the second sample in 2008. Concentrations have remained relatively constant, albeit elevated, since 2008. Decreases in these indicator parameters suggest source area mitigation is having a positive effect on the underlying water quality.
- AB-27S - Four samples have been collected from this well since 1996. Concentrations of all indicator parameters are elevated at this location but have shown a decreasing trend since 2008, except for chloride, which has increased. Decreasing trends in chemical constituent concentrations are suggestive of positive mitigation effort affects.
- AB-25S - Four samples have been collected from this well since 1996. Concentrations of all indicator parameters dropped significantly between 1996 and 2008. Since 2008, indicator parameters have remained relatively constant or shown a slight decline, except for chloride, which has shown a slight increasing trend. Decreases in these indicator parameters suggest source area mitigation is having a positive effect on the underlying water quality.

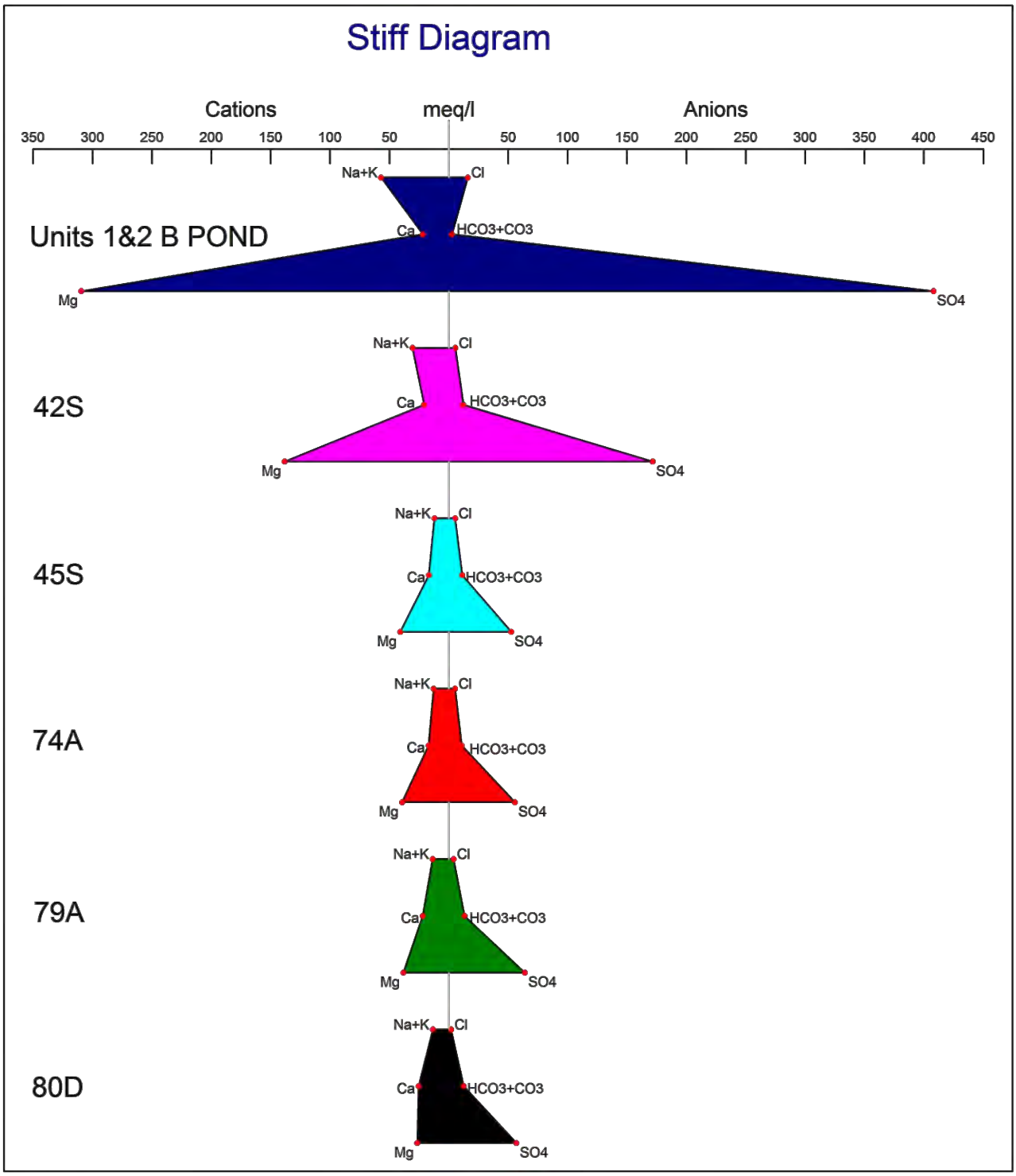
North of Units 1 & 2 Pond A and Pond B – west to east – downgradient of A Pond, B Pond, former Brine Pond Area

- AB-20S – Four samples have been collected from this well since 1996. Concentrations of all indicator parameters are elevated. Little change in parameters. May be result of residual area of highly elevated constituent concentrations.
- AB-22S - Four samples have been collected from this well since 1996. Concentrations of all indicator parameters have shown a decreasing trend since 1996. Calcium to magnesium ratios have increased to nearly 1. Slight increases in boron concentrations and chloride were observed in the 2014 sample. Concentrations of sulfate and boron remain elevated.

- AB-23S – Three samples have been collected from this well since 1996. Overall, water quality has improved. Boron concentrations were 12.4 mg/L in the spring 2014 sample from this well but other indicator parameters are not elevated.
- 13M – Well 13M has been sampled routinely since 1976. SC levels and sulfate and chloride concentrations have shown a slight increasing trend since then. Throughout this period, boron concentrations have remained less than 1 mg/L and calcium to magnesium ratios have been above 1.
- 13S - Well 13S has been sampled routinely since 1976. All indicator parameters, except for chloride have shown improvement since 1993. Chloride has remained relatively stable (21-62 mg/L).

Well 88M is located directly south of the Units 1 &2 B Pond. Water from well 88M does not show process water impacts. However, concentrations of most indicator parameters have shown a slight decline since the well was installed in 2008 possibly indicating positive effects of upgradient capture wells and removal of the D4 Brine Pond.

Additional capture has been installed west of the Plant Site since the initial submittal of the Plant Site report (wells 113M, 114S, 115M, 116M, 117A, 118A, 119A, and 122A). In addition, the discharge pipeline from wells 106A, 107A and 108A was replaced due to scaling that was restricting flow in the original pipeline. Water quality has shown a general improvement downgradient of the ponds. Significant improvement has been observed in some areas such as at 49S, where specific conductance has dropped from around 9,500 µmhos/cm to less than 4,400 µmhos/cm and boron concentrations have dropped from 21.6 mg/L to around 1 mg/L. Figures 3-26 and 3-27 are Stiff Diagrams showing common ion distributions for water collected from wells in 2014 in the vicinity of the Units 1&2 B Pond. The top Stiff Diagram in each figure represents the most recent water sample collected from the Units 1&2 B Pond. The figure illustrates the high milliequivents (meq/l) of magnesium and sulfate and the wide width of the diagram illustrates the high concentrations of these parameters in the pond water. Concentrations of the parameters in all of the wells are substantially lower than that observed in the ponds. Well 80D, completed in sub-McKay strata north of the main Plant Site, shows relatively low common ion levels but the water is a



PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT PLANT SITE REPORT	**2014 STIFF DIAGRAMS FOR SHALLOW WELLS NEAR THE UNITS 1&2 B POND**	FIGURE **3-26**

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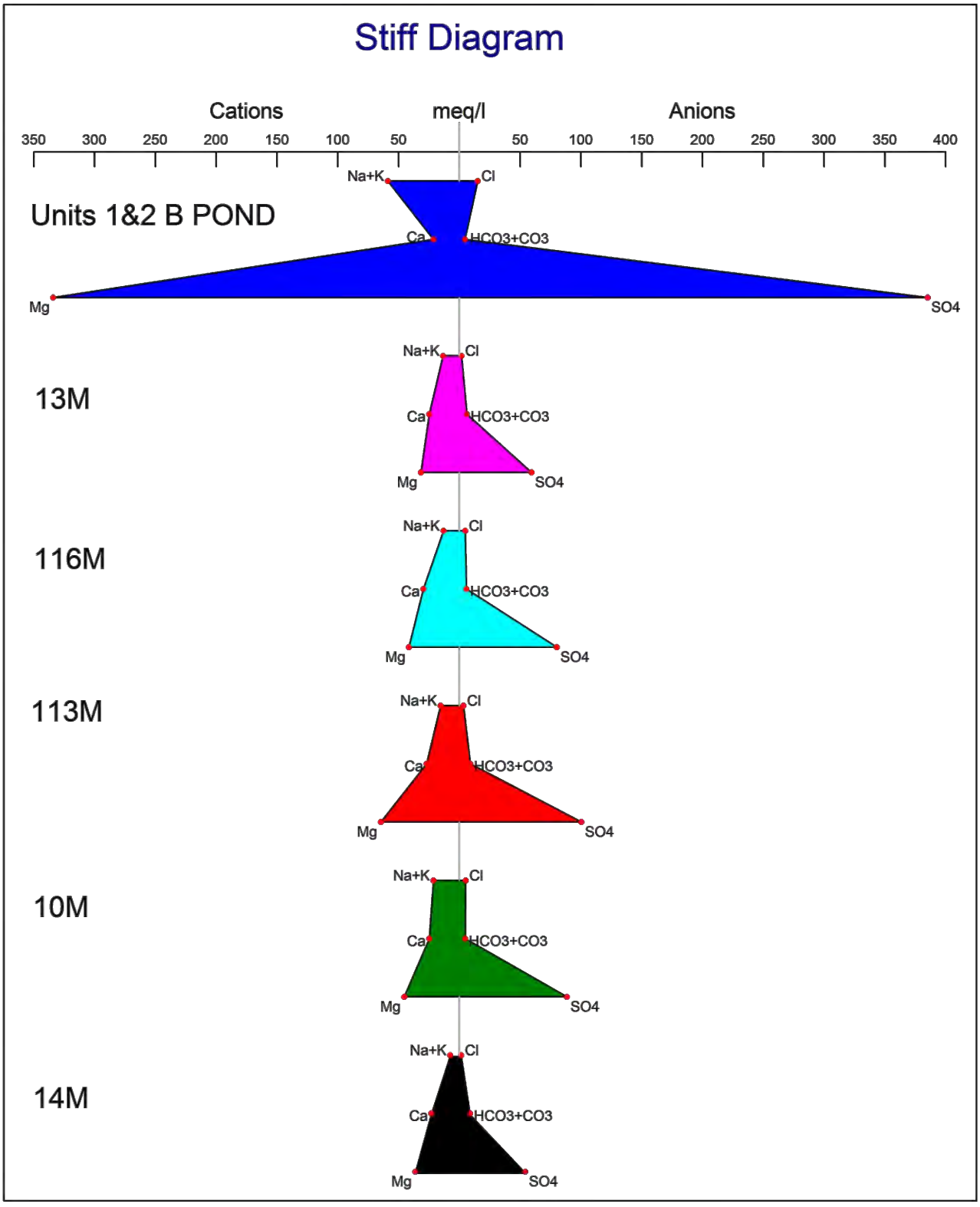

PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT PLANT SITE REPORT	**2014 STIFF DIAGRAMS FOR MCKAY WELLS NEAR THE UNITS 1&2 B POND**	FIGURE **3-27**

calcium-magnesium sulfate type water. Well 116M, shows very low common ion levels and is also a calcium-magnesium sulfate type water whereas other wells in the area are typically a magnesium-sulfate type water.

Monitoring wells 15S, 15D, 93A, 99D, 101A, 103D, 104A, 105A, 109A, are downgradient of the Plant Site ponds on the west side of the facility.

- Wells 15S and 15D are a paired set of sub-McKay bedrock wells located adjacent to the creek. The McKay Coal is absent at this location and only about 16 feet of unconsolidated sediments were logged. As described in Section 2.2.4, water in 15S is hydrologically connected to the shallow alluvial water, whereas that in well 15D is not. Well 15S has shown a gradual increase in most indicator parameters with the exception of dissolved boron, which has remained steady. No effects of groundwater capture have been observed at this well. Water quality at well 15D has remained steady throughout the period of record (1976 to current) and shows no process water impacts.
- Wells 93A and 105A are completed in the creek alluvium. Water at both of these wells have shown gradual improvement after startup of wells 106A, 107A and 108A. However, declining water quality was observed in early 2012. Evaluation of the system indicated that scaling was creating back pressure on the pipeline that was reducing the volume of water that could be pumped. This pipeline was replaced in 2013. Slight water quality improvements have been observed since replacement of the pipeline and restarting of the system.
- Wells 101A and 109A are located west of capture wells 106A, 107A and 108A and are completed in the the creek alluvium. Water quality at both of these wells has shown improvement in all indicator parameters since the pumping was initiated at capture wells 106A, 107A and 108A. The exception is the chloride concentrations in water from well 101A, which originally dropped but have recently shown slight increases.
- Wells 99D, 103D and 104A are located upgradient of the site. None of these wells show impact of process water or effects of groundwater capture.

Water in the creek has shown an improvement in water quality across the reach that passes the main Plant Site. Flows measured during synoptic runs indicate that the reach through Colstrip, including the area past the main Plant Site, is gaining (increases in creek flow). The gain in flow in the creek is attributed to groundwater flow into the channel. Removal of groundwater prior to reaching the creek results in a decrease in overall flow but also an improvement in water quality. Improvement in water quality in the reaches directly downstream of the main Plant Site (AR-5, AR-4, AR-3), are likely the result of mitigation measures employed at the site including groundwater capture, pond lining, and other water management measures demonstrating effectiveness of these actions.

SC values had typically increased in the reach next to the Plant Site during synoptic runs conducted in the intervals 1990 to 1999 and 2000 to 2009. SC values measured in the reach during 2010 through the spring of 2014 showed consistent water quality as demonstrated by Figure 3 of the Synoptic Run Technical Memorandum in Appendix C. It should be noted, however, that flow which typically has increased through this reach, expressed as a losing reach in 2011 and 2012. Note that site AR-4, located near the Willow Road crossing of the creek, was dry during the 2010 synoptic run and again in the fall of 2012. During the spring 2014 synoptic run, flow decreased directly upstream of the Willow Road creek crossing and decreased downstream of the crossing. Water quality in the creek continues to receive recharge downstream of this reach from both sides of the creek and from the relatively high quality treated sewage effluent ponds.

Water quality further downgradient of the westernmost capture wells has generally shown an improvement with lower SC. Water quality at monitoring well 109A (Figure 3-28) is an example of this improvement. However, groundwater from some wells has shown level or slight increasing trends in SC. Capture wells in this area have experienced scaling problems that have hindered their performance. PPLM has replaced the pipeline from the capture wells in this area and pumping volumes have increased. It is expected that improving trends will continue to be observed in this area.

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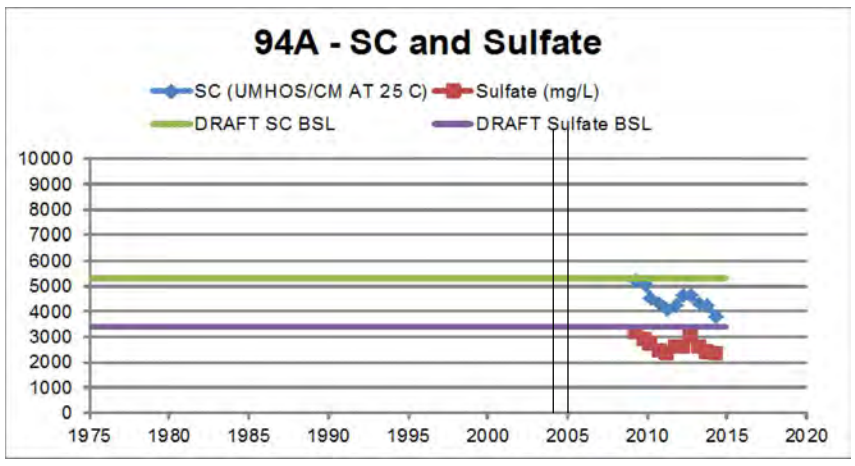

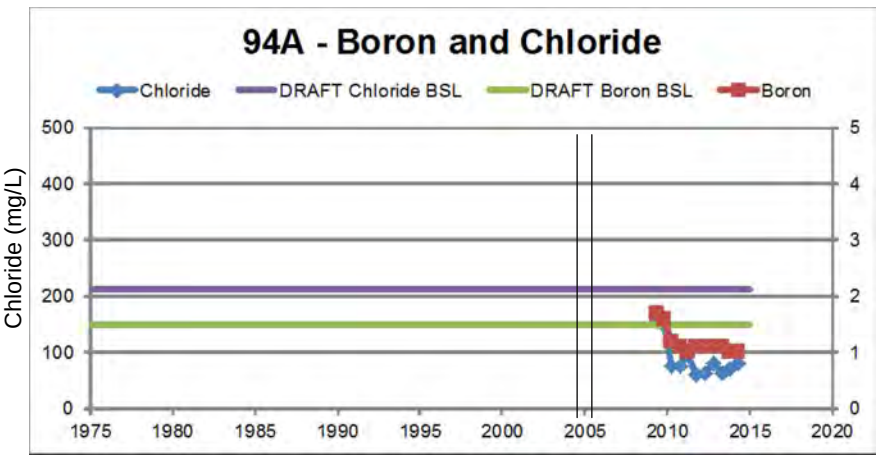

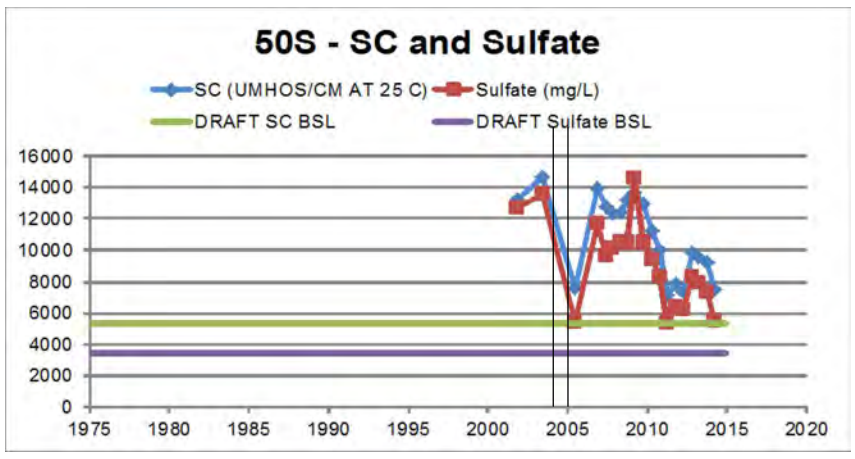

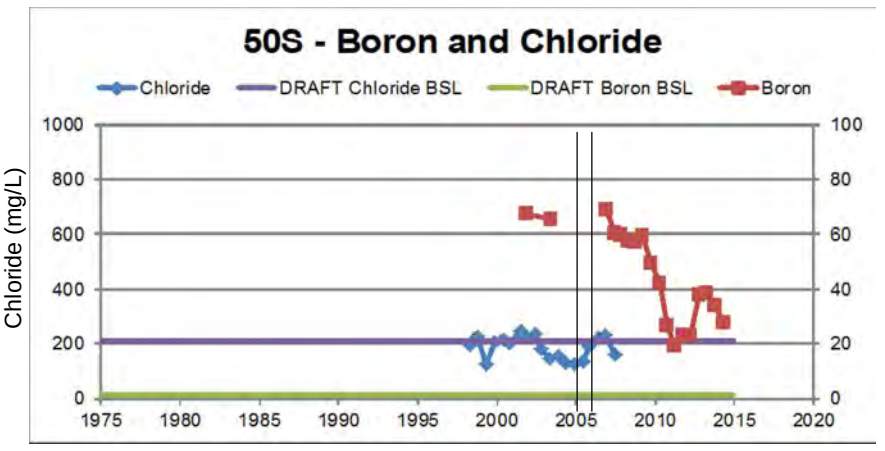

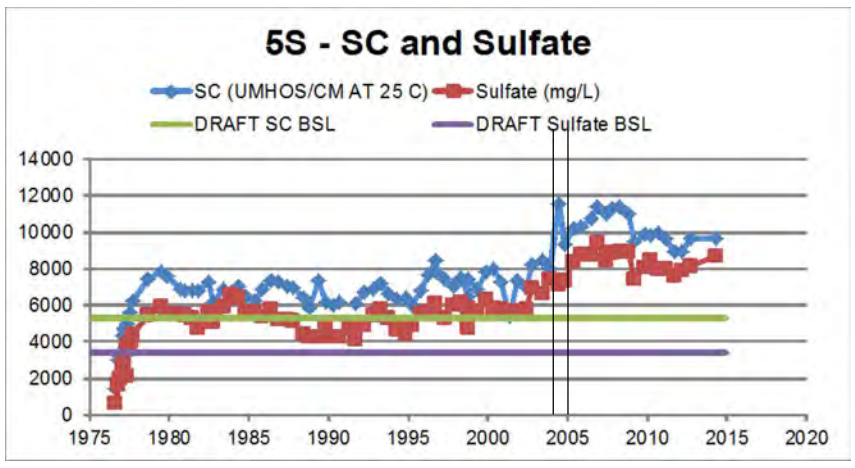

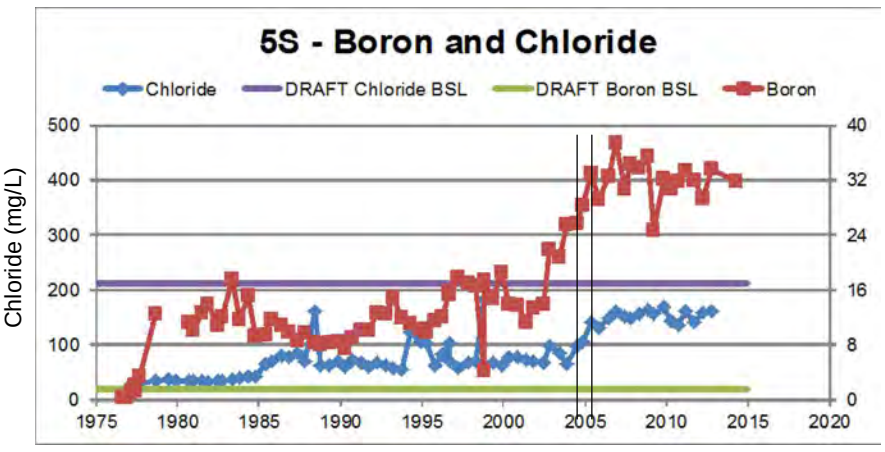

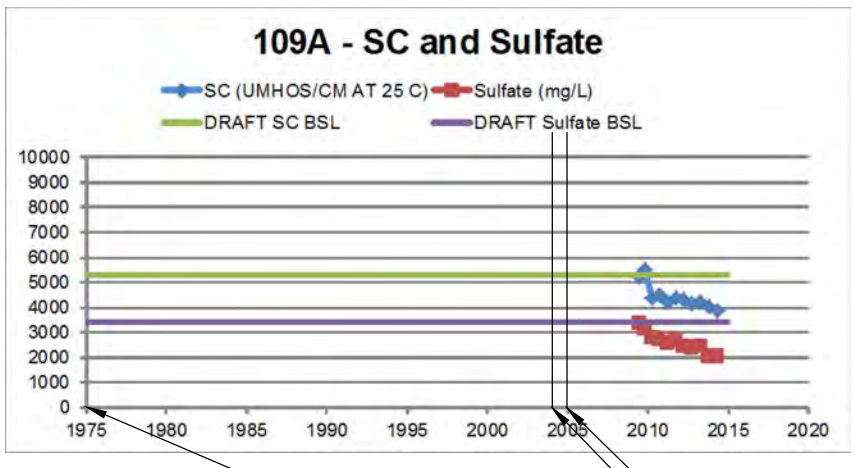

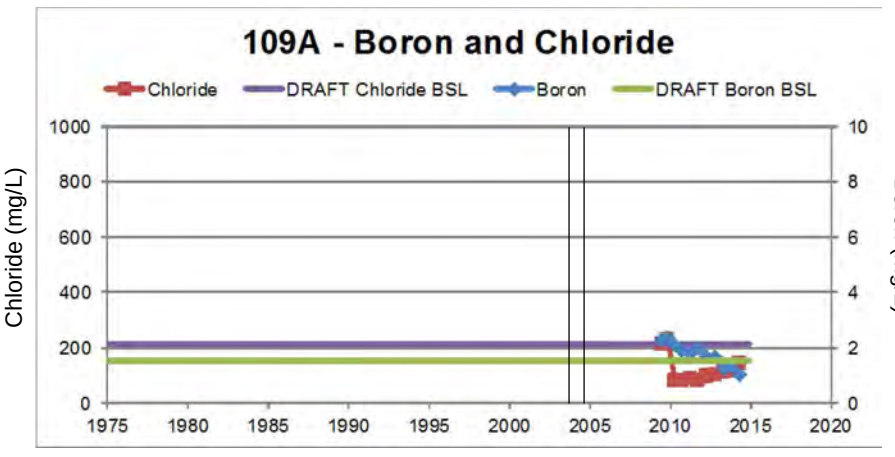

2005: A Pond Taken out of scrubber service
2004: B Pond Double Lined and Leachate collection system installed
1975: Units 1 & 2 Flyash Ponds Enter Service

NOTE: BACKGROUND SCREENING LEVELS (BSL) ARE UNDER REVIEW AS OF OCTOBER 2014

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PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT PLANT SITE REPORT	**WATER QUALITY OF SELECT WELLS AT UNITS 1 & 2 A/B FLYASH POND AREA**	FIGURE **3-28**

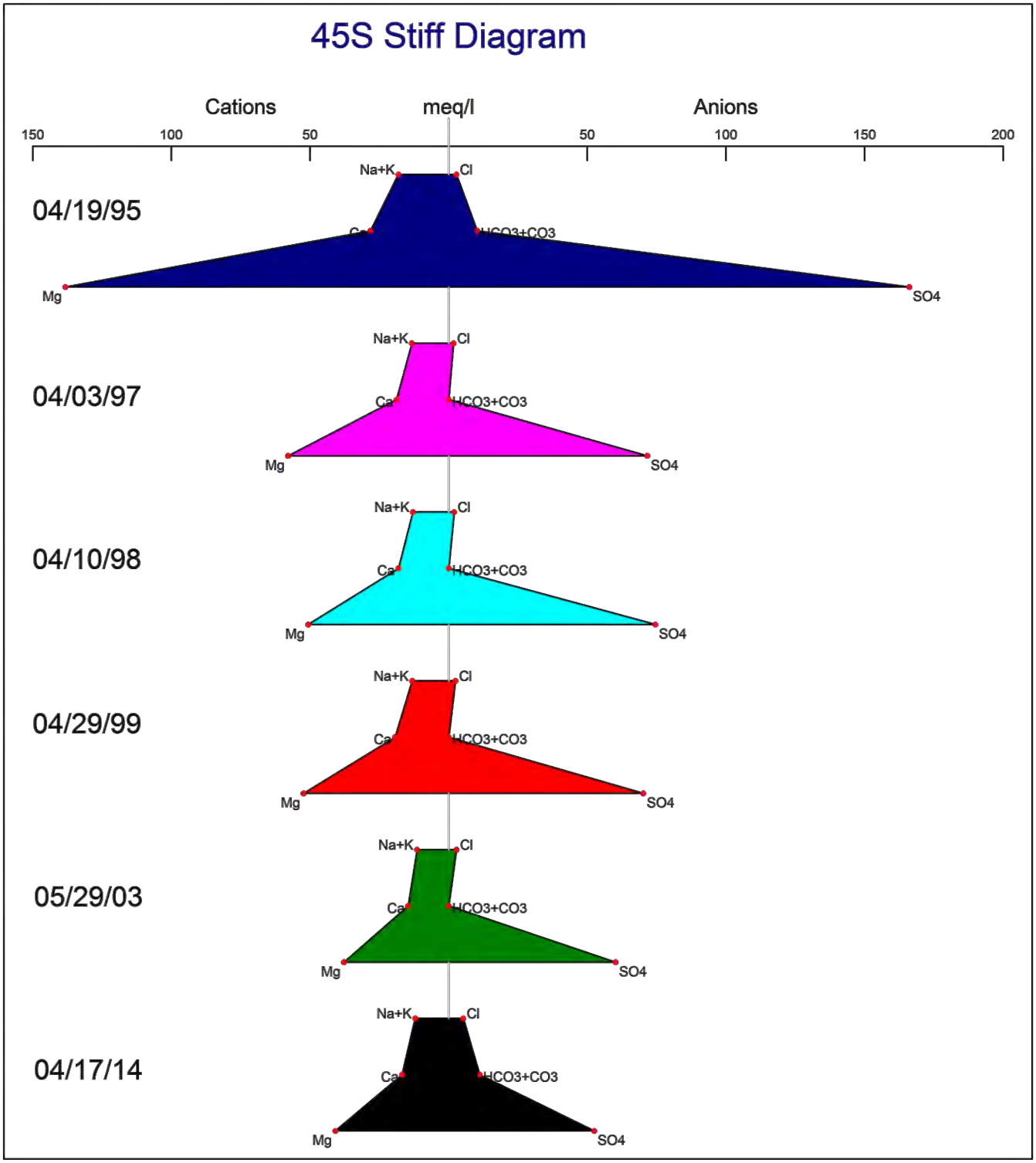
Well CA-19A had shown elevated SC. Passive capture was initiated at this well by bailing the well dry on a periodic basis. Approximately one-quarter of a gallon is removed before it is dry. Recharge is extremely slow. SC dropped rapidly, however, indicating the source is probably localized and not a larger pond related source.

Well 45S is a shallow well located downgradient of Units 1-4 Sediment Retention Pond capture wells. The well was installed prior to capture downgradient and north of the main Plant Site. Water quality at this well shows a substantial reduction in levels of all indicator parameters following the startup of the Units 1-4 Sediment Retention Pond capture wells. The Stiff Diagrams shown on Figure 3-29 also demonstrate the rapid reduction of chemical constituents following startup of the capture system.

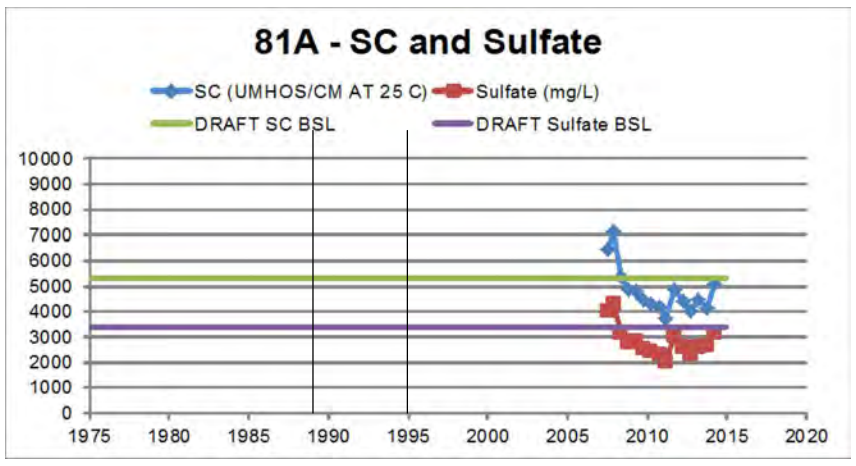
3.5.5 Northwest Area

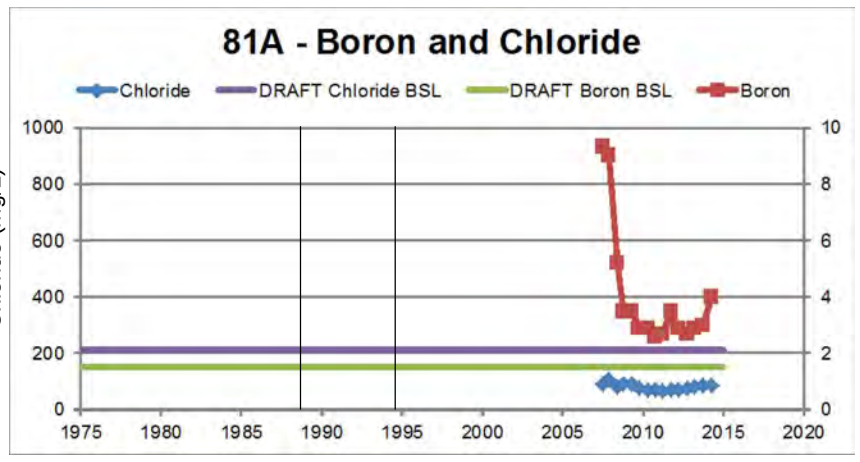
There are no known source areas in this part of the Plant Site. Rather, it is a downgradient area that potentially contains constituents released from ponds located to the south and southeast of this area. Source area actions mentioned in the previous sections apply to this area. Geology in this area is comprised of alluvium with colluvium on the flanks of the the creek floodplain. The alluvium generally has finer grained sediments near surface and coarser grained sediments near the base. Bedrock underlies the alluvium. In this reach, the ancestral East Fork Armells Creek has eroded downward through the McKay Coal so the alluvium is receiving water for the water from upgradient areas near the Plant Site and on the town side of the creek. Furthermore, groundwater in this area is derived from areas upgradient of the Plant Site and Colstrip.

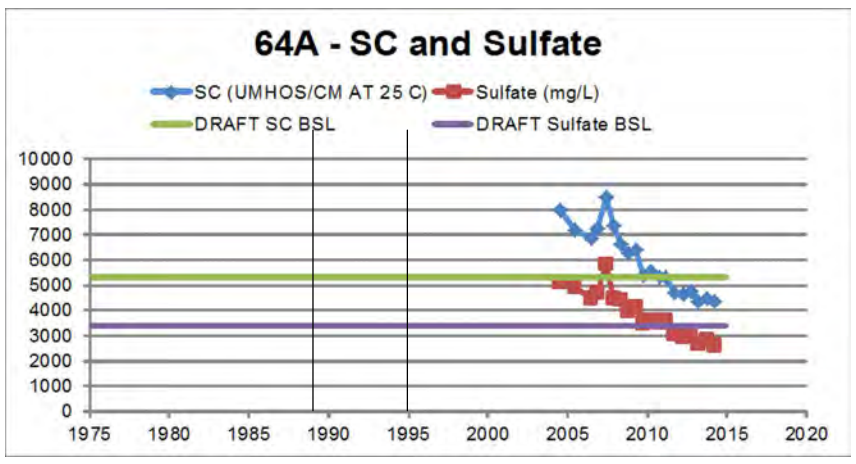
Typical process water indicator parameters east of the creek for select sites northwest of the main Plant Site are included in Figure 3-30. In general, water quality has improved in this area over time in response to groundwater extraction well operation at areas around the ponds. Groundwater remediation northwest and north of the main Plant Site has been aided by the same operational changes mentioned in the previous section.

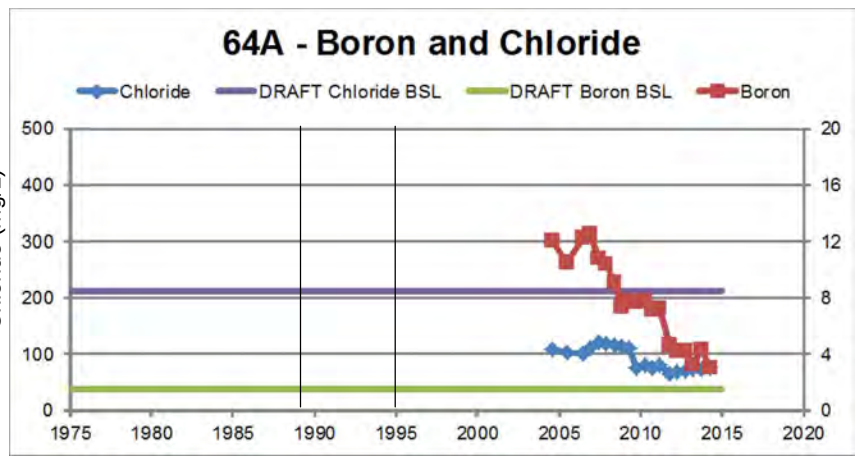


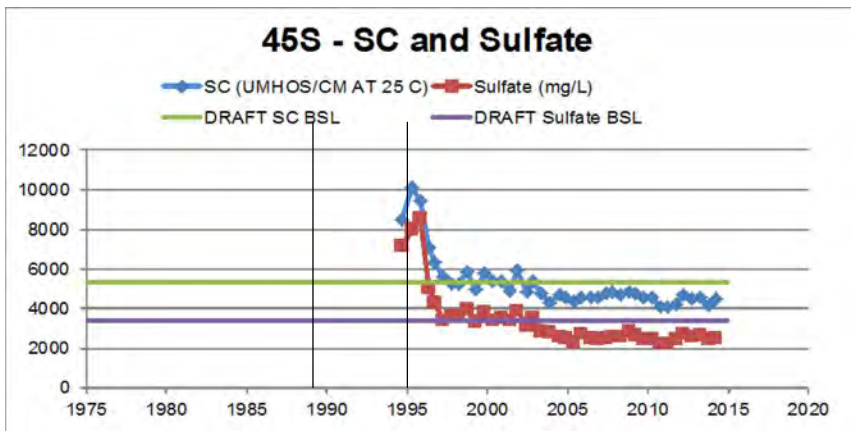
PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION ADMINISTRATIVE ORDER ON CONSENT PLANT SITE REPORT	**STIFF DIAGRAM FOR WELL 45S THROUGH TIME**	FIGURE **3-29**

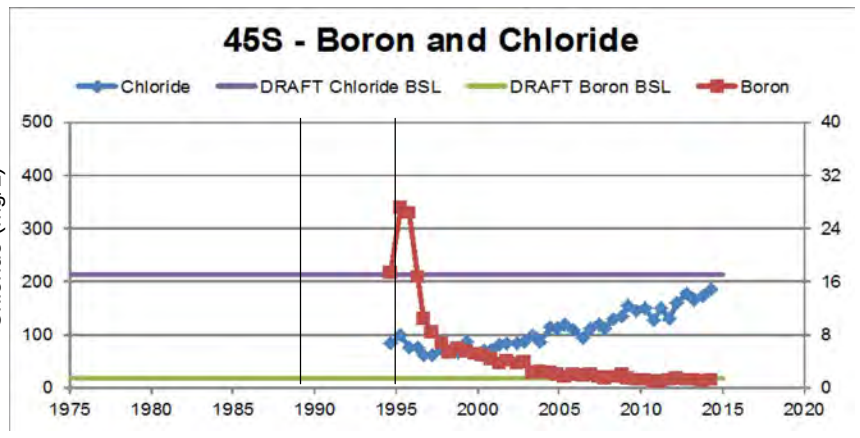


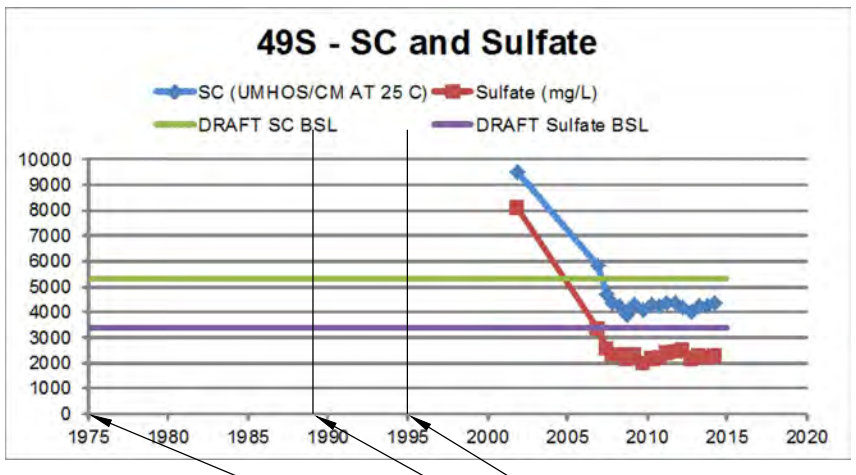


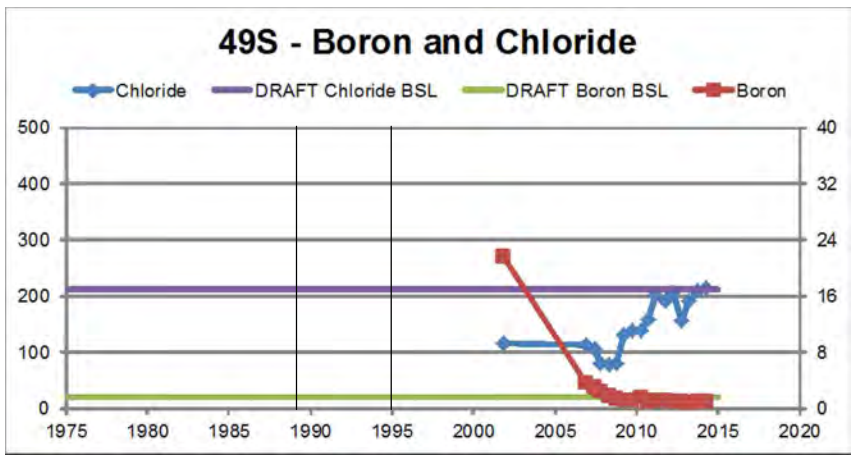












1995: Groundwater Collection System Installed in Area
1989: Sediment Retention Pond Lined with HDPE
1975: Sediment Retention Pond Enters Service

NOTE: BACKGROUND SCREENING LEVELS (BSL) ARE UNDER REVIEW AS OF OCTOBER 2014

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PLANT SITE REPORT

WATER QUALITY OF SELECT WELLS AT NORTHWEST AREA

FIGURE
3-30

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Operation of capture wells 43S, 78S, 119A, 74A, 75A, 79A, and 82A has resulted in a substantial reduction in concentrations of chemical constituents in groundwater in this area. For example:

- Water from well 64A has had a reduction of SC from 8,510 µmhos/cm to 4,340 µmhos /cm, reduction in sulfate from around 5,800 mg/L to around 2,620 mg/L, reduction of boron concentrations from about 12 mg/L to about 3 mg/L, and a reduction in chloride from 121 to 65 mg/L.
- At well 81A, a reduction in SC levels from 7,130 to 3,740 µmhos/cm, a reduction in sulfate from 4,270 mg/L to around 2,020 mg/L, reduction in boron concentrations from about 9.3 to about 2.6 mg/L and a reduction in chloride from 105 to 67 mg/L, has been observed.
- Trends for other wells east of the creek and northwest of the main Plant Site are similar to those shown. Exceptions are at wells 73A, 83A, 65A, and 79A which have shown little change except for fluctuations in chloride concentrations. These four wells also show little evidence of process water impacts. Improvements in water quality in the creek described in the previous section also apply in this area.

Note that chloride concentrations at wells 45S and 49S exhibit an increasing trend while other indicator parameters are stable or decreasing. The increase in chloride in these wells is the result of a hypochlorite release upgradient of the wells and is not related to process pond water.

Changes in water quality described previously in this section are attributed to separation of the Units 1&2 A/B Ponds and double lining the new Units 1&2 B Pond; removing the Units 1&2 A/B Pond Clearwell; moving and lining the Units 1&2 Bottom Ash Pond Clearwell; groundwater pumping; natural recharge, and inducing groundwater flow from unimpacted areas into affected areas.

Well OT-7, located west of the creek has not seen an improvement in quality. This well is completed in shallow fine-grained colluvium/alluvium above the main alluvial system. Passive capture is currently being performed at this very low yield well. Approximately one

quart of water is removed before the well is dry. An area near this well was used to stage sludge removed from the creek during a flyash slurry spill cleanup. Additional evaluation has been conducted in this area since the original December 2012 submittal of this report (Hydrometrics, August 2014). It was concluded from the investigation that hydrogeological conditions vary greatly from the upper alluvium to the deep alluvium. The upper alluvium consists of fine grained silts and clay and the deep alluvium consists of sub-angular to sub-rounded gravels and sands. However, the upper and deep alluvium are hydraulically connected. This is indicated by the similar groundwater elevations and response to pump tests in the upper alluvium during the deep alluvium pump test. Although hydraulically connected, flow between the two units is likely very small based on the minimal hydraulic gradients and very large difference in hydraulic conductivity.

Groundwater in the upper alluvium appears to have higher concentrations of chemical constituents than the groundwater found in the deep alluvium. The exception is well 137A which does not possess any chemical constituents above the BSL's (currently under review). Groundwater quality in the deep alluvium suggests the water may be slightly impacted from process water, while groundwater sampled from the shallow alluvium appears to be influenced by a more localized sources.

3.6 GROUNDWATER CAPTURE

As of December 2014, PPLM operated 52 capture wells, four underdrain systems, and received water from one Western Energy dewatering well (WECO well). Capture system volumes calculated for 2013 are in Table 3-6.

TABLE 3-6. CALCULATED CAPTURE SYSTEM PUMPING VOLUMES - 2013

Well #	Estimated Average Gallons per Minute[1]
Units 1 & 2 Brine Pond Area	
B-1	0.5
B-4	0.0
B-5	0.0
4S	1.0
19SP	0.5
26SP	2.6
29SP	5.3
70SP	3.0
111SP	5.1
Units 1-4 Sediment Retention Pond/Units 1 & 2 A/B Pond Dewatering System	
1D	2.0
5M	0.5
5S	0.3
10M	6.2
10S	2.3
55D	0.3
56D	12.9
58M	2.3
59M	0.2
113M	0.5
114S	0.9
115M	1.3
116M	2.9
117A	2.6
118A	0.4
122A	8.1
31M	1.1
SRP-1	0.2
SRP-2	0.5
SRP-3	9.8
SRP-4	6.2
SRP-5	10.3
SRP-6	0.5
SRP-7	0.5
SRP-8	3.5
Plant Site Area Trailer Park Collection System	
98M	6.1
106A	8.3
107A	5.4
108A	6.5

Well #		Estimated Average Gallons per Minute[1]
Units 1-4 Sediment Retention Pond		
	74A	11.7
	75A	11.1
	79A	42
	43S	0.6
	78A	7.7
	119A	3.7
	82A	8.3
	6M	0.5
	68A	2.1
Units 3 & 4 Bottom Ash Pond		
	21S	2.7
	51SP	4.1
	52SP	0.2
	53SP	7.4
	54SP	0.7
Units 1 & 2 Bottom Ash Clearwell Collection Sumps		
	Primary System[1]	1.1
	Secondary System[2]	0.1
B Pond Collection Sumps		
	Primary System[1]	38.5
	Secondary System[2]	6.2
WECO Well		54.9

[1] Groundwater below liners

[2] Water between liners

[3] Approximate - includes down time, not adjusted for pressure. Calculated flow rates adjusted by a factor of 0.75, except for the WECO Well, to compensate for pipeline back pressure effects during flow measurement. This calculation does not apply to underdrain systems.

3.7 SPECIFIC ACTIONS

Several activities such as pond liner upgrades have been conducted to reduce the potential for seepage of process waters to groundwater. Actual measurement of seepage changes and effects on the groundwater system cannot generally be quantified. This section contains a list of actions conducted on ponds and the probable effect of the lining. In some cases, the actions were proactive, conducted to preclude liner failure, prior to observing actual changes.

3.7.1 Relining of the Units 1-4 Sediment Retention Pond in 1989

This pond was relined with High Density Polyethylene (HDPE) to address gas bubbles that were causing the original Hypalon liner to rise and risk its integrity. Leakage attributable to the pond has not been identified.

3.7.2 Relining of the Units 3 & 4 North Plant Area Drain Pond

A tear was observed in the Hypalon liner in 1985 (see 1985 Water Resources Report). The liner was replaced with HDPE. Seepage from the pond has not been detected since the replacement.

3.7.3 Lining of the Units 3 & 4 Auxiliary Scrubber Drain Pond

The Auxiliary Scrubber Drain Pond was originally lined 1983 using Hypalon. The pond has recently been rebuilt using sulfate resistant concrete.

3.7.4 Abandonment of the former Units 1 & 2 Bottom Ash Ponds

The Units 1 & 2 Bottom Ash Ponds were originally constructed in 1975 east of current Units 1&2 B Pond with a clay liner. In 1988, the 1 & 2 Bottom Ash Ponds were relocated to the area just north of the 1&2 Flyash A/B Pond B side. The new pond also has a clay liner. The original pond area was backfilled and regraded. In 2006, the 1&2 Flyash Pond Clearwell was double-lined with 45 mil RFP (with leachate collection between the liners and below both liners) and converted to the new 1&2 Bottom Ash Pond Clearwell. Removal of the original ponds eliminated a potential source area for bottom ash water.

Downgradient wells that were present in 1988 include 1S, 1D, 13S and 13M. No changes were observed at 1S or 1D that could be attributed to the relocation of the pond. Well 13S has shown a gradual improvement in water quality since about 1981. This improvement started before the movement of the ponds. Boron concentrations did start to decline at 13S a few years after the ponds were removed. This change could be attributed to removal of the ponds. Water quality at 13M has been relatively consistent, with a few minor fluctuations in concentrations in indicator parameters. The exception is chloride which has shown an

increasing trend. Overall, indicators do not suggest that moving of the ponds had a significant effect on water quality downgradient of the original pond site.

3.8 ON-GOING/RECENT INVESTIGATIONS/ACTIVITIES

Operational monitoring, as discussed in Section 3.3.1, will continue. Also, the program will be revised as additional wells are installed or in response to additional monitoring needs.

- Additional Plant Site investigation/mitigation work was on-going at the time of the original submittal of the Plant Site Report northwest of the Units 1-4 Sediment Retention Pond near well 43S and in the area west of the Units 1&2 A Pond near well 5S. Nine new wells were installed in late November 2012 west of the A Pond. Five wells were completed in alluvium, three in the McKay Coal, and one in a deep area of fill, possibly spoil placed in an old mine pit access road. Groundwater quality samples were collected and it was concluded that seven of the wells would be converted for groundwater capture. These seven wells were converted into groundwater capture wells and are currently operational. The other two wells are currently being monitored.
- A soil investigation was conducted under the footprint of the former D4 Brine Pond in 2013. The project involved extensive direct push soil sampling of soil below the former D4 Brine Pond, bench-top testing, and laboratory analysis of sediments. The purpose of the sampling was to characterize spatial variability of salinity in soil below the footprint of the former pond. Four borings were completed outside of the former brine ponds. It was concluded that soil within the D4 Pond footprint had elevated levels of salts compared to similar substrates outside of the pond footprint. Most of the soils were comprised of unconsolidated mine spoil, however, a remnant of the Rosebud Coal was also present. Salinity levels in the Rosebud Coal were generally not indicative of D4 Pond impacts. Based on the characterization, PPLM removed soil down to near the water table in the fall of 2014.
- Since the original submittal of the Plant Site Report, three additional synoptic runs have been conducted on the creek; one in the spring of 2013; one in the spring of 2014; and one in the fall of 2014. Sampling during the fall 2014 event included

surface water sampling, flow gaging, groundwater sampling, measurement of groundwater levels relative to the adjacent creek, and collection of sediment samples from the creek bed. Appendix C contains a technical memorandum prepared following the spring 2014 synoptic run. Data collected during the fall event are currently being evaluated.

- Three new wells (119A, 123A-P, and 124A-P) were installed in shallow alluvium near well 43S. Wells 123A-P and 124A-P were completed as one-inch diameter piezometers because it was necessary to use a PowerProbe to safely access the area under power lines. As stated in the Work Plan "New Well Installation and Capture Conversion – 43S Area PPL Montana LLC, Colstrip Steam Electric Station" (Hydrometrics, Inc., October 2012), each of the three new wells were installed expressly for conversion to capture wells; however, the wells were only to be converted if process water impacts were evident and well yield was sufficient for long-term pumping. As noted previously, wells 123A-P and 124A-P were completed as one-inch piezometers; and water quality at these sites was not overall indicative of process water impacts. Well 119A has more than sufficient yield to accommodate long-term pumping; but water quality at this well is ambiguous with respect to process water impacts. Well 119A was converted to a capture well and is currently operational.
- Further investigation was conducted in 2013 in the south Plant Site Area in the vicinity of North Cooling Tower Blowdown Pond C, the South Cooling Tower Blowdown Pond C and the Units 3&4 Wash Tray Pond. Work was conducted in accordance with the interim response action work plan *Monitoring Well Installation and Potential Capture Well conversion near Well 6M, PPL Montana's Colstrip Steam Electric Station – Plant Site Interim Response Action Work Plan Outline* (Hydrometrics, 2013). The work included installation, sampling and testing of eight monitoring wells. It was concluded that hydrogeological conditions of the shallow intervals are highly variable and include alluvium, fill, spoil, overburden (above the Rosebud Coal), and Rosebud-McKay interburden. These units are not laterally continuous and groundwater typically flows laterally between the shallow units. The McKay Coal and sub-McKay sedimentary rocks are continuous across the site with

beds typically dipping to the south-southeast, although gentle folding and steeper dips are present locally. Groundwater in both the shallow and McKay units has a general flow direction to the northwest. Localized groundwater low areas are evident near groundwater capture wells. Higher concentrations of chemical constituents are present in the shallow and McKay intervals below the ponds, and oriented with the direction of groundwater flow. The majority of these chemical concentrations do not exceed BSL's (currently under review as of October 2014). Capture wells are located downgradient of these areas. Deeper intervals do not show any process water impacts.

- Additional evaluation has been conducted in the vicinity of well OT-7, located on the west side of the the creek near the railroad tracks. Results of the investigation for this area were integrated into Section 3.5.5.

4.0 GROUNDWATER MODEL RESULTS AND INTERPRETATION

Development of a groundwater model for the Plant Site is required by the AOC. As such, a numerical groundwater flow model that was originally developed for the Plant Site Area of the Colstrip SES in Colstrip, Montana, has been periodically updated to meet the AOC requirement. Development of the groundwater model is intended for use of evaluating hydrogeological conditions, evaluating groundwater flow scenarios, evaluating groundwater capture, and to evaluate potential groundwater capture scenarios.

Maxim Technologies originally developed a conceptual groundwater model for the Plant Site Area. The Preliminary Conceptual Model Report (Maxim 2004) includes a characterization of process ponds, hydrogeological conditions, and statistical analysis of baseline groundwater quality. The report also discusses transport pathways and receptors.

Initial development of a numerical groundwater flow mode for the Plant Site was presented in a 2006 report (Geomatrix, 2006). The initial model was developed using Modflow 2000 (Harbaugh, et. al., 2000). Modpath, a USGS transport module, was used to simulated advective transport of constituents. Pre and post processing was accomplished using Groundwater Vistas© software. In 2008, the model was updated using new hydrogeologic information including: hydrogeologic data obtained from new well installations and testing, calibration using data obtained from water levels near the D4 Brine pond following the liner breach in 2005, new groundwater level information, capture well pumping information, and water quality data.

Analysis of existing groundwater capture systems was conducted and it was concluded that additional information was needed for model input to allow more accurate simulation of groundwater flow and solute transport. Based on the evaluation, a work plan was developed outlining steps that could be taken to further refine the Plant Site Model (AMEC Geomatrix, Inc., 2009).

The model was further refined between 2009 and late 2012, a version that was included as an appendix in the original December 2012 submittal of the Plant Site Report. NewFields (2015) has recently completed a further update of the Plant Site Model. Appendix A contains a copy of the latest groundwater modeling report.

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. Data gaps identified in the Groundwater Model report contained in Appendix A have been included.

- Groundwater model simulations (NewFields, 2015 suggest groundwater capture systems are intercepting the vast majority of groundwater impacted by process pond water. Areas with groundwater with apparent groundwater impacts from process waters that are not currently being captured include:
  - The shallow alluvial groundwater around OT-7 and the Sewage Lagoons, north of the main Plant. However, reverse particle tracking indicates groundwater in this area is not sourced from the Plant Site ponds. This area should continue to be monitored and evaluated for capture if future trends indicate the need. This well is a very low yield which is currently having water purged on a regular basis. Less than one half gallon is typically removed before the well goes dry during these purging events.
  - A small area in the interburden and McKay around the Units 3&4 North Plant Area Drain Pond,
  - Spoil in the area around the Units 3&4 Bottom Ash Ponds, and
  - An area of spoils, Rosebud, interburden and McKay near the southern end of the Units 3&4 Cooling Tower Blowdown Pond. This area is currently under further evaluation.
- Western Energy Co. (WECO) operates a capture well to lower water levels near a coal crusher, located north of the Units 3&4 Bottom Ash Pond. This well is also capturing water seeping from the nearby ponds. Water level data from this well have not been used in evaluation of potentiometric surfaces in the area. Data from this well would be helpful in allowing additional analysis of groundwater capture effectiveness in this area. Water level data from the WECO well would also allow more refined calibration of the model in the area north of the Units 3&4 Bottom Ash Ponds and upgradient of the Units 3&4 North Plant Area Drain Pond (North Pond).

Personnel at the Rosebud mine have been contacted regarding access to the well to obtain these data. The well is covered and has pumping equipment installed restricting the access.

- Fifty-four wells are currently operational as part of PPL Montana's groundwater mitigation efforts. In addition to these wells, the underdrains at the Units 1&2 B Pond and Units 1&2 Bottom Ash Ponds collects groundwater potentially impacted by process pond seepage. Currently, flow rates are measured from the majority of capture wells at the well heads. This method results in an overestimation of actual amount of water captured since pumping pressures tend to reduce pump performance. Unfortunately, many of the wells exhibit scaling problems making use of inline flow meters impractical. More accurate measurement of flows is necessary to better evaluate system performance. Methods that are available to improve the accuracy of flow from capture wells include:
  - installation of flow meters in areas that don't have substantial scaling issues,
  - installation of pressure gages at wellheads that do have scaling issues
    - this will allow a flow to be estimated based on the pump curve and pressure measurement –
    - note that the accuracy of this method will decrease with pump wear and is highly dependent on the state (pumping or not pumping) of other pumps on the pipeline.
  - Non-contact flow meters have been used in the past with variable success.
    - These instruments measure the velocity of a fluid (groundwater in this case) which is multiplied by the area of the pipeline to obtain a flow rate. Scaling of pipelines reduces the inside diameter of the pipe. Measurements calculated assuming the original pipe thickness is inaccurate in scaled pipe. Furthermore, the ability of the non-contact instrument is inhibited by scale buildup.
    - Reproduction of measurements using these instruments was inaccurate and the method was not employed.
    - Newer non-contact flow meters may be available that would provide better reproduction of flow velocities in pipes that don't exhibit scaling issues.

- Manual flow measurements are sometimes conducted. This involves turning off an entire system and starting one well at a time and then measuring a flow from the discharge end of the pipeline. This provides accurate measurement for one well with only that well operating. The degree of accuracy diminishes as additional pumps are started. Empirical adjustment of capture volumes will continue to be used until more dependable methods become available. Note that specific adjustments of individual systems may be possible to increase the accuracy of the empirical approach.
- West of Units 1&2 A Pond – The original bullet under this item from the original December, 2012 report read "additional hydrogeological data are needed to further evaluate the effectiveness of groundwater mitigation efforts in this area and to identify areas possibly requiring additional capture. Work in this area is currently being conducted under an interim work plan." Additional investigation activities west of the Units 1&2 A pond has been completed. Results of this work is summarized in Table 3-2 (revised original Table 3-1) under *Capture System Construction, Startup, And Performance In The 5M Area -- Colstrip Steam Electric Station* (Hydrometrics, June 2013) and in Section 3.8.
- Units 1-4 North Plant Sediment Retention Pond Area - additional data are needed for further evaluation of groundwater mitigation efforts in this area. Additional data will provide quality and water level information which can be used to further refine groundwater capture efforts in this area, if necessary. Data from wells 23S, 23M, and 24S would be used in any evaluation of this area; specifically water level and water quality data.
- South-east region of the Plant Site Area - In the original December 2012 submittal of the Plant Site Report this bullet read "Additional data are needed to evaluate the Units 3&4 Wash Tray Pond and Units 1&2 Cooling Tower Blowdown Pond C areas, this would include the area around 6M and to the west". Additional data have been collected from the area as summarized in Table 3-2 (Interim Report - Monitoring Well Installation And Potential Capture Well Conversion Near Well 6M, PPL Montana's Colstrip Steam Electric Station – Plant Site - Hydrometrics, May 2013) and Section 3.8. Based on data collected following the 2013 investigation of this area, groundwater is flowing towards the northwest. Additional investigation is planned

for this area and a work plan (Interim Response Action Phase II Work Plan Monitoring Well Installation and Potential Capture Well Conversion Near Well 6M PPl Montana's Colstrip Steam Electric Station – Plant Site, Hydrometrics, December 2014) has been submitted to MDEQ.

- Hydraulic conductivity values for the clay lined ponds are not current. Several factors can affect clay liner hydraulic conductivity. These include the following.
  - The quality of the installation of the clay liner.
  - Desiccation cracks can damage a liner due to drying.
  - Freeze and thaw effects on exposed areas.
  - Water quality in relation to liner composition. Placement of highly saline water can alter the characteristics of clay materials, including liners. The affects can either increase or decrease the permeability. Clays are broadly classified as montmorillonite, illite, or kaolinite depending upon the lattice structure (basically the way the particles are aligned). Simply stated, the amount of sodium that a clay can hold is determined by its structure. Hydraulic conductivity can be higher in clays that are able to hold high amounts of sodium, such as montmorillonite. High salt content water tends to reduce the amount of swelling that will occur with a bentonite clay. Bentonite, a clay commonly used for liners, is a montmorillonite clay. Kaolonite clays are less affected by sodium. Contact of montmorillonite clays with water rich in calcium and magnesium, such as is common in the process waters, can result in ion exchange – replacement of sodium cations with calcium or magnesium cations within the clay structure. The reduction in sodium can lead to higher permeability.
- Limited depth samples are available for the Plant Site ponds. Many of the ponds experience high pumping rates that would be expected to result in mixing resulting in similar water quality near the surface of the pond and at depth. However, stratification within the ponds may be possible, due to circulation, chemical concentrations, or thermal gradients. A subset of samples from varying depths in select ponds would allow variations in water quality with depth to be evaluated. Additional data can be collected if significant variations in water quality are

discovered. Note that for relative percent difference (RPD) of 20% or less between the samples will be considered as the same water quality. A RPD of 20% is generally an accepted standard for duplicate samples.

- Ground water quality and ground water level measurement data in the following areas:
  - Southwest of the 3 and 4 Bottom Ash Ponds; and
  - East of the 3 and 4 Bottom Ash Ponds.
- Pond elevation data at the WECO Ponds, particularly PO-151, PO-10A, and PO-10B.
- Chronologic documentation of conditions at the Units 3 and 4 Wash Tray Pond.
- A synoptic groundwater level measurement event including Plant Site wells, Townsite wells and Western Energy wells. This should include dry season/low water season (October- March) stream flow measurements.

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 background levels be considered for periodic shutdown. However, it is further recommended that the wells be maintained as operational capture points and if water quality deteriorates, indicating further process pond impacts, be restarted. Data obtained from the monitoring systems are continuously providing data for ongoing site characterization.
- 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 of this dynamic system. Continue to evaluate potentiometric surface for both high and low groundwater conditions.
- Continued groundwater quality monitoring of capture systems.
- Make necessary repairs to groundwater capture systems as they are identified.
- Best management practices - BMP's -
    - Continue to further educate employees regarding the importance of process water management. Process water management, as referred to in this bullet, means procedures that are used to route water (this would include opening and closing valves so water goes to the correct locations and/or is stopped being routed to an area after sufficient water has been transferred, transferring water from ponds, reuse alternatives, and other methods to continue to reduce the amount of process waters on site.
    - Maintain higher quality stormwater runoff water in Units 1&2 A Pond to provide good quality recharge water.
- Continue refining and updating the groundwater model. Model refinements would include periodically incorporating hydrogeological data that has become available

since the previous model was updated. Incorporate new wells, water levels, and recalibrate following these refinements. Re-evaluate groundwater simulated flow patterns and capture effectiveness.

- Continue responding to apparent changes in water quality identified through operational monitoring by conducting further evaluation, monitoring, or investigation.
- Continue investigating the interaction between the creek and groundwater in the Plant Site Area. Continue conducting annual synoptic runs on the creek. Parameters for this evaluation should be refined. An expanded suite of chemical constituents have been analyzed during multiple events. Use of the normal PPLM analytical suite includes all of the indicator parameters and are sufficient to evaluate changes in water quality within the creek as it relates to the Plant Site. As indicated in the groundwater model report, additional data should be collected regarding streamflow, and groundwater levels during the fall. Some of this data have already been collected. Additional wells should be measured for water levels including Montana Bureau of Mines and Geology wells located on the Rosebud Mine upstream of Colstrip.
- Measure water levels in ponds on the Rosebud Mine, particularly PO-151, PO-10A, and PO-10B. An elevation datum should be established to correspond with that of the Colstrip SES.
- Collect additional water quality and level information in the vicinity of the Units 3&4 Bottom Ash Ponds.
- The original submittal of this report recommended additional evaluation in the vicinity of well OT-7. That work was conducted and is summarized in Section 3.5.5 and Section 3.8. The area around OT-7 should continue to be monitored and the data specific to this area evaluated.
- Continue refinement of water balance. The purpose of refining the water balance is to reduce the amount of water held at the facility. Because of the large volume of water used at the site, accurately measuring water at various locations, inputs of groundwater from capture systems, and evaporation effects, either forced or natural are difficult to quantify with a high degree of precision. However, general

observations can be made. A water balance is a method of quantifying or describing the amount of water flowing into or out of a system. Inputs to a water balance may include precipitation, water pumped into a facility from outside sources, and inflow of groundwater and surface water. Out puts include infiltration to groundwater, outflow of groundwater, evapotranspiration, surface water flow out, etc.

- One of the recommendations contained in the original submittal of this Plant Site Report in December 2012 was "further evaluate the Well 40SP area". Since that submittal, a single well, 138SP, has been installed, tested and sampled in the area between the Units 3&4 Bottom Ash Ponds and well 40SP. Data from well 138SP will be helpful in further evaluating groundwater quality and flow in this area. Furthermore, data from an investigation into this area will provide additional data for groundwater model calibration. A brief discussion of the well installation is included in Section 3.5.2 of this report.

- Further evaluate process solids from the Units 3&4 Wash Tray Pond (see section 3.4.4) - PPLM has plans to conduct this activity in the future. Additional investigation was conducted in this area in 2014 and is summarized in Table 3-2 (see Interim Report - Monitoring Well Installation And Potential Capture Well Conversion Near Well 6M, PPL Montana's Colstrip Steam Electric Station – Plant Site, (Hydrometrics, May 2014) and Section 3.8.

- Further evaluate process solids in the Units 1&2 Pond A - If this pond is be used for process fluids in the future, an underdrain system and lining should be considered when the pond is drained for solids removal (see Section 3.4.4 Bullet 3).

- Continue to address changes in water quality identified during operational monitoring and in associated with spills or other releases. Further study capture systems that experience scaling problems (Trailer Park, West of A Pond, Brine Pond) and alter systems, if possible, to minimize this problem to improve capture system effectiveness. Consider converting well 105A to a capture well if well 106A continues to have problems or additional capture in the area is necessary. Well 106A is an important well in this area that collects water flowing from the main Plant Site Area westward. Colstrip and East Fork

Armells Creek are located west of the Plant Site. East Fork Armells Creek is a hydrologic divide that keeps water from the east side of the creek from crossing beyond the alluvial deposits. Well 105A is about 100 feet south of Well 106A and could supplement capture in this area, if necessary. Note that not all wells in this area currently experience scale problems. Section 2.1.3 contains additional information in regards to scaling. For these specific wells, anti-scalant and a biocide is added to the wells at the pump intake to reduce scaling at the pump intake and downstream pipelines. Scaling problems are caused by a combination of water quality and pressure changes.

- Additional wells east of the Wash Tray Pond, southeast of the Units 3 & 4 Bottom Ash Ponds and West of the Units 1-4 North Plant Sediment Retention Pond were recommended in the original submittal. Since that time, additional wells have been installed in the Wash Tray Pond area and southeast of the Units 3 & 4 Bottom Ash Ponds should be considered. Additional wells are proposed for the Units 3&4 Wash Tray Pond and Units 1&2 North and South Pond area. Additional monitoring is suggested for the new well installed by the Units 3&4 Bottom Ash Pond. Based on model recommendations, additional wells and sampling should be evaluated for this area. In addition, wells west of the North Plant Sediment Retention Pond are recommended. The purpose of these wells would be to evaluate groundwater quality in these areas to determine if further groundwater capture should be considered.

  It is recommended that WECO be approached about possibly altering access to the well head at the WECO well to allow water level measurement on a routine basis. A tube, preferably 3/4 -inch diameter or larger is recommended. This will allow manual measurement or installation of instrumentation for continuous monitoring.

  As constructed, the well cannot be accessed without removing the sanitary seal and possibly damaging the well head and equipment near the well head. The intent of well head alterations would be to allow easy and safe access for water level measurements while eliminating the possibility of causing operational

problems that could occur if water gaging equipment is placed in the well. These alterations may require changing the type of well head to one with multiple access ports through the top. WECO has been contacted about possibly gaining better access to the well. Access to this well is currently very difficult. Additional inquiries will be made to determine acceptable options to obtain water level measurements.

It is recommended that use of flow meters at individual wells, or alternative methods of flow measurement be established. This would allow more accurate calculation of groundwater capture volumes and would be helpful when evaluating water balance problems. Multiple types of flow meters may have applicability at the site. However, meters will be chosen to reduce operation and maintenance that is associated with scaling problems often associated with the wells. In addition, wells will be selected for flow monitoring which have not had a history of scaling or only minor scaling issues. Wells that have shown a history of scaling problems will continue to be gauged for flow using volumetric measurements at the well head.

- Conduct an evaluation of all capture systems for quality. Those with water quality at or below BSL's (note that background screening levels are under review as of October 2014) should be evaluated for shut down. Any wells shut down following the evaluation should continue to be monitored and restarted if water quality at the sites, or in the area, begins to decline.

- Evaluate current permeability of Plant Site pond liners so more accurate estimates of pond seepage can be made. Clay liners would require sampling for laboratory analysis. Detailed evaluation of the pond liners would be required to better define the concentration of possible defects that may increase the permeability of the pond liners.

- 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, PPLM should continue to evaluate its pond and process water

systems so areas with seepage affecting groundwater quality can be identified and mitigated. Construction of future ponds, or alterations of existing ponds, should consider the use of liners that allow capture of seepage water if liner leaks or excessive seepage occurs. The Units 1&2 B pond and Units 1&2 Bottom Ash Pond Clearwell currently have double liners with underliner capture systems. In addition, PPLM should continue to practice water management which provides storage of better quality storm water that is routed to exterior or interior locations which will provide a better quality water if seepage occurs from these areas.

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APPENDICES A THROUGH H ARE INCLUDED AS ATTACHMENTS

APPENDIX A

GROUNDWATER MODEL REPORT
(Submitted as a separate bound document)

APPENDIX B
PLANT SITE POND GRAPHS AND PIPER DIAGRAMS; PROCESS POND DATA

APPENDIX C
2014 SPRING SYNOPTIC RUN TECHNICAL MEMORANDUM

APPENDIX D

ARCADIS 2007 DATA ANALYSIS AND STATISTICAL EVALUATION OF UNIMPACTED GROUNDWATER QUALITY

APPENDIX E

PPL MONTANA, LLC COLSTRIP STEAM ELECTRIC STATION, WATER RESOURCES MONITORING PLAN – SEPTEMBER 7, 2011

APPENDIX F
ANALYTICAL PARAMETERS WITH ASSOCIATED STANDARD METHOD DETECTION AND REPORTING LIMITS

APPENDIX G
WECO WELL LOG

APPENDIX H
WATER QUALITY TREND GRAPHS