EP Minerals, LLC

Baseline Characterization Report for the Celatom Mine Drewsey, Oregon

Volume 1 of 2 (Text and Figures)

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CERTIFICATION

The findings and conclusions presented herein are based upon the agreed scope of work. SRK makes no warranties or guarantees as to the accuracy or completeness of information obtained from others. It is possible that information exists beyond the scope of this investigation. Additional information, which was not available to SRK at the time of writing the report, may result in a modification of the conclusions and recommendations presented. The services performed by SRK have been conducted in a manner consistent with the level of care ordinarily exercised by members of our profession currently practicing under similar conditions.

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1. INTRODUCTION

This report has been prepared to provide the results of field investigation activities conducted by SRK Consulting (U.S.) Inc., (SRK) as part of the planning and site characterization for the expansion of the Celatom Mine in eastern Oregon (Figure 1-1). The Celatom Mine is an industrial minerals mine site, owned and operated by EP Minerals, LLC (EPM). Currently, EPM is in the process of permitting an expansion of the mining operations to previously disturbed as well as undisturbed areas. The U.S. Department of the Interior, Bureau of Land Management, Burns District (BLM) has indicated that, in order to complete the permitting process, the potential for acid generation from mine waste and pit wall surfaces needs to be thoroughly evaluated, and a detailed hydrologic evaluation needs to be conducted to effectively define site conditions and provide a baseline for future monitoring activities.

This report was originally contracted and initially prepared for the firm formerly known as EaglePicher Minerals, Inc. That name was changed to EaglePicher Filtration & Minerals, LLC upon exit from Chapter 11 protection on August 1, 2006. The firm legally changed its name to EP Minerals, LLC on September 5, 2006.

1.1 Purpose and Scope

This report provides baseline information, and to a limited extent, analyses and interpretations related to climate, geology, surface water occurrence and quality (including springs and seeps), water rights, groundwater occurrence and quality, geochemistry and acid rock drainage (ARD) characteristics, potential hydrologic impacts, and potential pit lake development. In addition, a Screening Level Ecological Risk Assessment (SLERA) has been completed for the Celatom project to evaluate the ecological risk posed by the seasonal accumulation of meteoric water in the open pits.

The information in this report is intended to meet the data adequacy standards for the Celatom EIS, and follows guidance related to baseline water resource data provided by the BLM in the Nevada BLM *Water Resource Data and Analysis Policy for Mining Activities* (2004). Some of the elements from this BLM guidance document are not applicable to the site conditions, or are impractical for the Celatom Mine. The rationale for not including certain data or analyses specified in the guidance is provided in the respective sections of this report. Other aspects of the guidance not related to baseline water resource data (e.g., geologic hazards) are not included in this report.

The primary objective of this study was to establish current surface water and groundwater conditions, of both a physical and chemical nature, in the vicinity of the diatomite deposits, and immediately downgradient of existing and proposed mining operations. Several field investigations have been conducted to meet this objective. These studies are described in this report and include the following:

- Review of existing groundwater elevation and chemistry data;
- Baseline inventory of surface water features in the hydrologic study area defined by the BLM for the Celatom Mine;
- Establishment of existing (baseline) water quality for surface water features identified during baseline inventories;

- Drilling of 23 drill holes and installation of 14 monitoring wells and 6 piezometers to provide monitoring points for the hydraulic testing and groundwater sampling programs;
- Establishment of baseline groundwater chemistry using data collected from the monitoring wells and piezometers and collection of water quality samples on an annual basis; and
- Hydraulic testing programs conducted to determine hydraulic conductivity of the diatomite and underlying volcanic rocks as well as to determine the specific yield of the aquifers.

A secondary objective of this study was to characterize geologic materials that are anticipated to be exposed during future mining activities, and assess the potential for these materials to affect groundwater and surface water sources within the hydrologic study area. In order to accomplish this secondary objective, field work (including logging and field testing) and laboratory geochemical characterization tests were conducted on waste materials and potentially exposed pit wall materials. This information will be used to characterize potential impacts from existing and proposed mining operations. The two main issues addressed by this baseline geochemical characterization program are:

- Acid generation due to oxidation of sulfide minerals, which can potentially lead to development of ARD; and
- Potential for leaching of metals (e.g., arsenic and manganese) and salts (e.g., sulfate).

The processes of acid generation and metals/salts leaching can operate independently from each other, although the development of acidic conditions enhances the leachability of many metals. Characterization activities included:

- Review of existing data from the previous ARD assessment (SRK, 2004);
- Collection of core samples from drill holes within disturbed and undisturbed areas;
- Screening assessment using field contact tests to select samples for static testing;
- Collection of in-situ backfilled waste in the Kelly Field Pit and Beede Desert areas;
- Collection of mineral process waste from the Vale Plant that is hauled to the site for disposal; and
- Static laboratory testing of core samples, backfilled waste and mineral process waste.

1.2 Previous Studies

In 2004, a geochemical investigation into the source of low pH runoff water collecting in the Celatom open pits was conducted by SRK. The results of this study are summarized in the report, *Geochemical Evaluation of the EaglePicher Diatomite Mine, Drewsey, Oregon (SRK, 2004),*provided in Appendix A. Data from the previous geochemical evaluation that have been incorporated into the current study include the following:

1. Contact test results [pH, electrical conductivity (EC), sulfate and iron] for 27 samples collected from the Kelly Field and Section 36 pit areas;
2. Static test results [Meteoric Water Mobility Procedure (MWMP), Acid-Base Accounting (ABA), and Net Acid Generation (NAG)] for 10 samples collected from the Kelly Field and Section 36 pit areas to determine the acid generation/neutralization and constituent leaching capacity of common rock types; and

3. Mineralogical analyses of two unoxidized diatomite samples by X-Ray Diffraction (XRD) and Scanning Electron Microprobe (SEM) techniques.

Other sources of data that were used in the development of this report include:

1. Groundwater elevation data (collected irregularly) for the nine EP test wells installed in 1985;
2. Groundwater chemistry results from the EP test wells from the July 2004 sampling event;
3. Geological reports and general geological maps;
4. Drill logs from the project exploratory drilling programs that provide lithologic information on the deposit, limited groundwater elevation data, and limited data regarding the volcanic basement (i.e., substrate below diatomite deposit);
5. Drill core and logs from recent exploratory drilling programs that provide lithologic information on the volcanic basement; and
6. Cross-sections developed by EPM for mine planning and development that illustrate subsurface geology within the mine areas, along with estimated water elevation and projected pit boundaries.

Previous versions of this baseline report have been submitted to the BLM and include:

1. Findings Report for the 2005/2006 Characterization Program for the EaglePicher Celatom Mine, Drewsey, Oregon (February 2007); and
2. Baseline Characterization Report for the Celatom Mine, Drewsey, Oregon (March 2009).

The data and analyses contained in this report supersede the data provided in these previous reports.

1.3 Regulatory Context

The Celatom Mine is located on both private land controlled by EPM, and public lands administered by the BLM. The Malheur and Harney County line divides the mining operations, with the majority of the site located within Harney County (Figure 1-2).

The BLM is the lead regulatory agency for activities conducted on public lands, and in accordance with the Title 43 of the Code of Federal Regulations, Section 3809 (43 CFR § 3809), EPM is required to follow procedures and standards to prevent unnecessary and undue degradation of the land and reclaim disturbed areas. These procedures include submitting a mine plan of operations (MPO), including a reclamation plan, cost estimate and financial guarantee, public review and environmental analysis of the MPO, obtaining BLM's approval before beginning operations, modifying the MPO before making any changes to the operations described in the approved MPO, and addressing impacts from newly discovered circumstances, such as development of acid drainage.

The Oregon Department of Geology and Mineral Industries (DOGAMI) is the lead State agency for mining activities on private and state lands, and, through the Mineral Land Regulation and Reclamation Program, is a cooperating agency for activities on federal lands. In accordance with state regulations regarding mining and reclamation, EPM is required to follow procedures and standards including submitting a MPO, providing a financial guarantee of reclamation, and operating under a state permit. BLM and DOGAMI coordinate in reviewing plans of operation, inspections, and financial guarantees. In

addition, DOGAMI has primacy to implement the federal Clean Water Act General Stormwater Permit and the state Water Pollution Control Facility Permit at mine sites, based upon an agreement with the Oregon Department of Environmental Quality.

SRK Consulting Engineers and Scientists	PREPARED FOR: EP Minerals™ AN EAGLEPICHER COMPANY		DRAWING TITLE: SITE LOCATION MAP	
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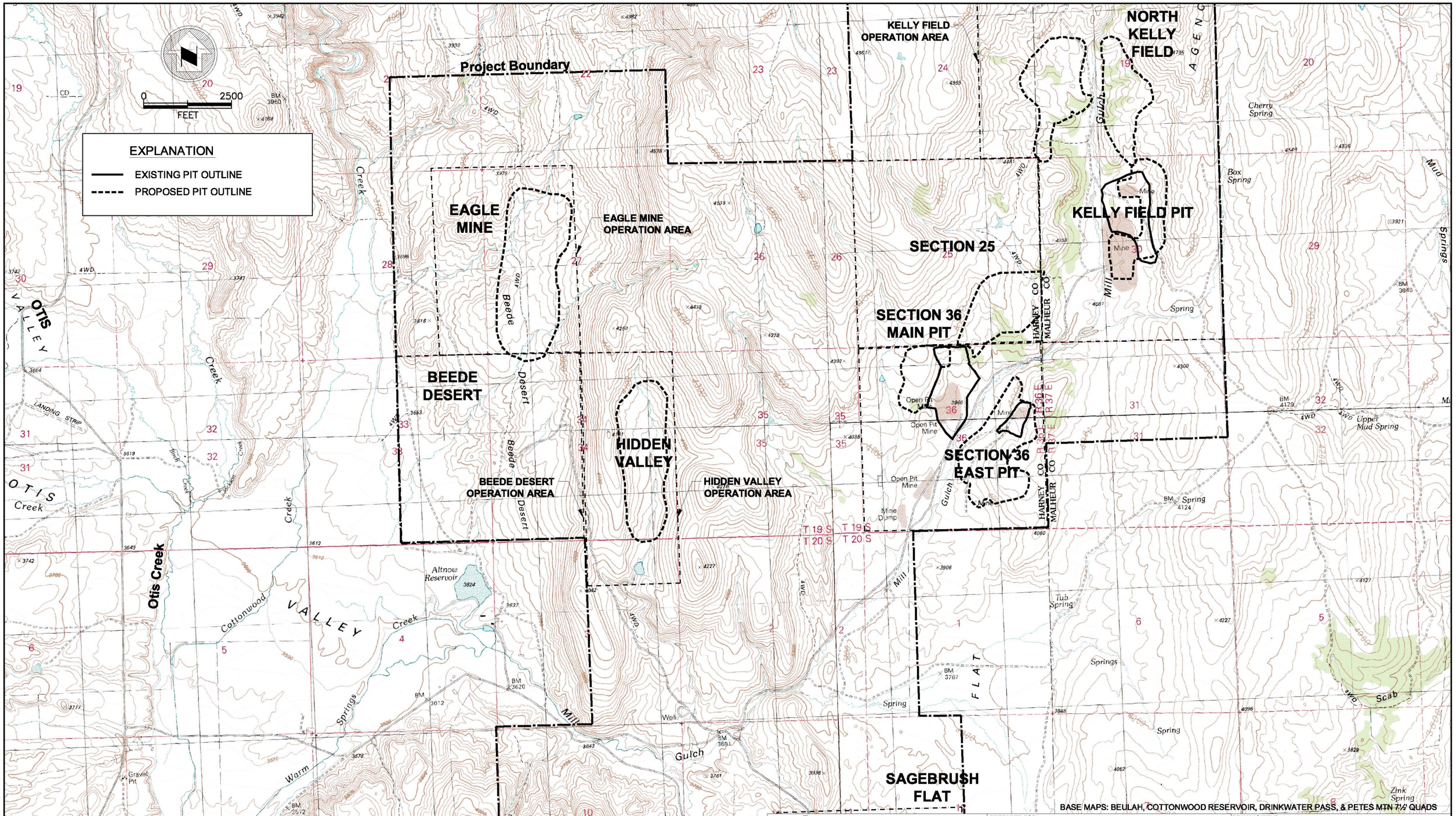

SRK Consulting
Engineers and Scientists

PREPARED FOR: EP Minerals™ AN EAGLEPICHER COMPANY

DRAWING TITLE: SITE PLAN AND FACILITY LAYOUT

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CHECKED: -	APPROVED: AP	DATE: 01/04/2010	
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CELATOM MINE
BASELINE CHARACTERIZATION REPORT

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2. CELATOM PROJECT DESCRIPTION

The Celatom Mine is currently owned and operated by EP Minerals LLC; a Nevada-based mining company licensed to operate in Oregon. Exploratory drilling of the Celatom ore deposit began in the late 1970's, and mining operations began in 1985. The Celatom Mine operates seasonally in the late spring, summer, and early fall. Diatomite ore is mined from open pits and stockpiled until the ore has dried sufficiently prior to being hauled to the EPM's processing plant in Vale, Oregon, located 70 miles east of the mine. The processing facility operates twenty-four hours per day, 365 days per year. Mining activities at the site rely upon wind and solar radiation to dry the stockpiled ore. This is made possible by site conditions typical for Harney and Malheur Counties, where evaporation exceeds precipitation by a ratio of 4:1 on an annual basis.

There are three main types of diatomite found in the Celatom Mine area including oxidized diatomite, transitional diatomite, and unoxidized diatomite. These different types of diatomite are described in detail in Section 3.3.3 below. Currently, diatomite ore is being mined from three open pits within the Mill Gulch drainage, including (from north to south) Kelly Field Pit, Section 36 Main Pit, and the smaller Section 36 East Pit.

Surface water that collects in the pits is ephemeral and limited to precipitation and snow melt during the winter months, when the effects of evaporation are minimal. In the spring, prior to re-initiation of mining activities, any water that has collected in the pits is pumped to a series of unlined evaporation ponds located downgradient from the active pit areas. These evaporation ponds dispose of the water through normal evaporation during the summer months, and by about August of each year, the evaporation ponds are dry. During operational months, no further pumping is required to keep the pits dry. EP Minerals reports that no appreciable water has accumulated in the pits since 2005 and as a result no water has been pumped to the evaporation ponds prior to reinitiating mining activities in the spring.

Mine waste material, including beds of clay, volcanic ash, and low-grade diatomite is selectively removed during mining and placed in stockpiles for use during reclamation, along with waste materials generated during processing and backhauled from the Vale Plant site. This process waste material is comprised of low grade diatomite, clay, sand and small amounts of crushed volcanic material, along with small amounts of soda ash (anhydrous sodium carbonate – Na_2CO_3) that is added to the ore stream as a fluxing agent. Off-spec finished filter aid is occasionally added to the inventory of backhauled waste materials. This material is composed of calcined diatomite, very minor amounts of clay, sand and synthetic gypsum. Waste stockpiles are placed in areas of no known ore potential in close proximity to the open pits. This material is used as pit backfill material during pit development and final reclamation activities. Stockpiled waste not used as pit backfill material will be reclaimed and seeded.

The proposed mine operations include the vertical and lateral expansion of existing facilities, as well as the development of new areas. However, the methods of mining will remain the same. Furthermore, the expanded areas will encounter the same material types that have previously been encountered. The existing and proposed mining areas are described in the following sections.

2.1 Active Mine Areas

The Celatom Mine is comprised of three active mine areas including: Section 36, Kelly Field, and Beede Desert. The Section 36 and Kelly Field operations are both located within the Mill Gulch area. Each of these mine areas are described below.

2.1.1 Mill Gulch Operations

2.1.1.1 Kelly Field Mine

The current Kelly Field operation is located in Section 30, Township 19S, Range 37E, in Malheur County, on the east side of the Mill Gulch drainage. All three types of diatomite are present at this location, and are currently being mined from the Kelly Field operation. The Kelly Field Pit is currently the largest pit in the Celatom complex, with a total disturbance area of 190 acres. The final Kelly Field Pit will be approximately 1,600 feet wide and 3,350 feet long. The eastern pit wall of the Kelly Field Pit will be approximately 200 feet high and have a final pit wall angle of 30 to 60 degrees. The final pit wall angle of the western wall will range from 70 to 85 degrees. The central portion of the Kelly Field Pit has been backfilled during concurrent reclamation activities with waste material consisting of a mixture of onsite waste and mineral process waste.

In 2003, a highwall failure occurred along the eastern edge of the Kelly Field Pit at the base of Agency Mountain. This slide took place along the contact between the ore and a weathered volcanic rock and was a classic rotational failure caused by excessive precipitation. Work to remediate this area, and to establish a stable final pit wall in the basaltic rock of the Agency Mountain, is currently underway.

2.1.1.2 Section 36 Mine

The mine shop, mine office, equipment staging and fueling areas, mine camp, and two open pits are all located in Section 36, Township 19S, Range 36EWM, in Harney County. There are two pits in the Section 36 mine area; the Main Pit and the East Pit. All three types of diatomite are found in this location and have been mined from the Section 36 pits.

The Main Pit is located in the western half of the section and is going to be expanded to the north (toward Section 25). Based on current mine plans, the expanded pit will have a final width of approximately 1,000 feet and a length of 2,600 feet. The southern portion of this pit is currently 90 feet deep and is at or near the groundwater table. In this area, water will collect during unusually high precipitation months and sometimes needs to be dewatered in the spring before EPM can commence mining. Once the meteoric water is removed, the pit remains dry water during the summer/fall months.

Photograph 1 in Appendix B was taken on April 6, 2004 and shows meteoric water that has accumulated in the lowest bench in the Main Pit after a wet winter. During wetter seasons, enough water will accumulate in the bottom of the pit to allow the water to be pumped into a sediment basin. Following pumping, the bottom of the pit can be very saturated and muddy. However, by early summer the pit bottom will be completely dry and mining can continue. Over the past few years, very little water has accumulated in the bottom of the Main Pit (2-3 feet deep in one corner). This water has been left undistributed (i.e., too shallow to pump) and by early June had evaporated. By late June the pit was dry enough to drive on the lowest level of the pit.

The East Pit is in the initial stages of pit development and is currently a shallow excavation. Based on the current mining plans, the East Pit will be 2,000 feet wide and 3,500 feet long. Due to surface topography, there will be a minimal pit wall along the western side of the pit and the eastern pit wall angle will range from 30 to 70 degrees.

2.1.2 Beede Desert Operations

The Beede Desert operation is located in Sections 33 and 34 of Township 19S Range 36EWM in Harney County. Beede Desert is located along the eastern side of Otis Valley and is smaller than the other two mine areas with a total of 115 disturbed acres. The diatomite ore deposit located at the Beede Desert mine has been a very important ore source since the plant was first constructed in 1986. Nearly all of the ore is oxidized and it demonstrates unique water flow characteristics with low trace elements in comparison to the materials in the Section 36 and Kelly Field pits. A small amount of unoxidized ore is located at the Beede Desert mine; however, EPM is not currently planning on mining this material in this location.

The shallow nature of the Beede Desert ore deposit lends itself contour mining, where the pit excavations are backfilled with a combination of mine waste and mineral process waste, to an elevation approximating the original topography. Due to the shallow depth of the Beede Desert Pit, and the practice of backfilling the pit with waste material, pit dewatering has never been required at this location. The sediment basins are cleaned out when needed with the excavated material being used either for reclamation purposes or placed in the waste stockpile.

The resulting surface disturbance in the Beede Desert mine area has been partially reclaimed including backfilling of the pit with waste materials and the regrading of waste dump areas. The only remaining evidence of past mining includes growth medium stockpiles, a few small portable out-buildings, and well maintained haul roads. Vegetation has reestablished on most of the reclaimed surfaces.

2.2 Proposed Mine Areas

Additional ore reserves have been identified in Hidden Valley to the west of the Section 36 mine areas; north of Beede Desert in Section 27 (i.e., Eagle Mine); north of the Kelly Field Pit in Section 19 and 24 (i.e., North Kelly Field), and north of the Section 36 Main Pit (i.e., Section 25). The extent and grade of ore in these areas has been defined by exploration campaigns conducted by EPM. However, no mining activity, other than exploration, has occurred within these areas. Each of these proposed mine areas are described in the following sections. Past exploratory drilling in the Sagebrush Flat area indicated the potential for a viable diatomite deposit. However, at this time substantial exploration drilling and sampling will be necessary to better define and characterize this diatomite deposit. Therefore, the proposed activities in the Sagebrush Flat area are limited to exploration and this area has not been included in the baseline characterization studies with the exception of the surface water survey.

2.2.1 Hidden Valley

The Hidden Valley deposit is located in the eastern half of Section 34, Township 19S, Range 36EWM, and lies directly east of the current Beede Desert Pit, and west of the Section 36 mine area, in a narrow north-south oriented valley. The ore deposit in this area is

approximately 1,000 feet wide with a 4,500 feet strike length and deepens to the north, where the pit is estimated to extend to approximately 100 feet deep.

The ore deposit has very similar properties to the Beede Desert deposit, and is unsaturated, highly oxidized and relatively free of trace elements. The ore contained in the Hidden Valley ore body will be required as a replacement to the depleted Beede Desert Pit. No unoxidized diatomite has been identified in the Hidden Valley deposit. Based on exploration drilling, the mine life for Hidden Valley is expected to be 10 to 20 years using open pit mining methods. Located at the south end of Hidden valley is a BLM stock water reservoir; this pond is fed from a small drainage that flows only in response to precipitation events.

2.2.2 Mill Gulch Area

2.2.2.1 North Kelly Field

The North Kelly Field deposit is located in Section 19, Township 19S, Range 37EWM, in Malheur County, and is a continuation of the ore body in the Section 36 and Kelly Field mine areas to the north. This deposit is very similar to the Kelly Field deposit, and is characterized by highly oxidized ore in the upper portion of the deposit, transition ores directly below the oxidized ore, and a thick layer of unoxidized ore within the lower portions of the deposit. The majority of the deposit is comprised of unoxidized ore.

Two pits will be developed in the North Kelly Field mine area; one on the eastern side of Mill Gulch and one on the western side. Each pit will be approximately 1,500 feet wide and 3,500 feet long. The eastern pit will ultimately connect with the Kelly Field Pit to the south.

2.2.2.2 Section 25

The Section 25 mine area is located on private land west of the Mill Gulch drainage and sits directly north of the Section 36 Main Pit and west of the Kelly Field Pit. Mining in Section 25 will occur as the Section 36 Main Pit advances north into the southeastern portion of Section 25.

This deposit is very similar to the Section 36 and Kelly Field deposit, and is characterized by highly oxidized ore in the upper portion of the deposit, transition ores directly below the oxidized ore, and a thick layer of unoxidized ore within the lower portions of the deposit. The majority of the deposit is comprised of unoxidized ore. A thick layer of overburden consisting of weathered basalt covers most of the Section 25 area, and will need to be stripped before mining of the diatomite.

The pit is planned to extend to a minimum of 60 to 100 feet from the current surface topography. Based on exploration drilling, the diatomite deposit in Section 25 thins to the west, and clay content within the diatomite increases, limiting the potential for an ore grade diatomite deposit in the western portion of Section 25.

2.2.3 Eagle Mine

The Eagle Mine is located in Section 27, Township 19S, Range 36EWM, directly north of the current Beede Desert mine area and north-northwest of the Hidden Valley area. Based on exploration drilling, the geology for the Eagle Mine is similar in nature to that of the Beede Desert deposit. The ore deposit is 25 to 125 feet thick, and all three ore types are found in this location. Approximately 50 percent of the deposit consists of oxidized ore that varies in thickness from 10 to 40 feet. The transitional ore is below the oxidized ore and above the

unoxidized ore and ranges from 20 and 40 feet thick. The underlying unoxidized ore contains ash seams and ranges from 35 to 50 feet thick.

The diatomite ore located within the Eagle Mine area will serve as a supplemental ore body for both Hidden Valley and North Kelly Field. Market conditions will determine the quantity of material required from the Eagle Mine annually. The high quality oxidized ores, as well as the unoxidized ores found in the Eagle Mine, will all be excavated for use at the plant.

2.3 Estimated Waste Rock Volumes

There are two main types of waste rock associated with the project including oxidized waste and unoxidized waste. Oxidized waste consists of oxidized diatomite with high levels of interbedded clay and ash/tuff. The unoxidized waste consists of unoxidized diatomite with high levels of clay and ash/tuff. The volumes of waste rock that will be generated from the proposed operations have been estimated by EPM and are summarized for each mine area in Table 2-1 below. The volumes of waste rock were calculated using an ore recovery factor estimated for each mine area. The resulting waste rock volumes are reported in units of bank cubic yards (BCY) where 1 BCY is equal to 1 cubic yard of material in its natural/undisturbed state.

Table 2-1: Estimated Waste Rock Volumes

Mine Area		Interbedded Waste[1] (BCY)		
		Oxidized Waste	Unoxidized Waste	Total
Mill Gulch Pits	Section 36	60,000	873,742	933,742
	Kelly Field	60,314	632,787	693,101
	North Kelly Field	677,025	1,512,000	2,189,025
	Section 25	2,100,000	1,400,000	3,500,000
Hidden Valley		305,125	--	305,125
Eagle Mine		304,688	984,375	1,289,063
Total		**3,507,152**	**984,375**	**8,910,056**

[1] Waste volumes calculated from an ore recovery factor estimated for each mine site.

As shown in Table 2-1, the majority of the waste rock from the Mill Gulch pits (Section 36, Section 25, Kelly Field and North Kelly Field) and the Eagle Mine will consist of unoxidized waste and all of the waste from the Hidden Valley deposit will consist of oxidized waste. The estimates of waste rock volumes in Table 2-1 are estimates and are based on the current mine plans. These volumes are likely to be adjusted as the mine plans evolve during operations.

2.4 Mine Coordinate System

Survey data, including horizontal coordinates and elevations, have been collected by EPM mine personnel in support of the baseline studies. The current coordinate system used for Celatom Mine survey data is NAD 83, State Plane Oregon South, U.S. Feet. However, measurements taken before 2006 were surveyed by Trimble equipment using ArcPad 6.2 software with WGS 1984 coordinates. In 2006, ArcPad v 7.0 software was used with NAD 83, State Plane Oregon South, U.S. Feet coordinates. Relative measurements remain unchanged, but pre-2006 survey elevations were dropped from the WGS84 ellipsoid to the NAD83 ellipsoid (i.e., -59.78 feet). Survey points presented in the previous version of this report (submitted to the BLM on February 15, 2007) were collected prior to 2006 and were based on the WGS 1984 datum. In this report, all pre-2006 survey points have been adjusted to the NAD83 data, and are consistent with the coordinate system of the topographic maps and cross-sections provided by EPM. To the best of our knowledge, all survey data provided by EPM and presented in this report are based on the same datum (i.e., NAD 83, State Plane Oregon South, U.S. Feet).

3. GENERAL SITE DESCRIPTION

3.1 Location

The Celatom Mine is located in eastern Oregon approximately 7 miles northeast of Drewsey, Oregon in Harney and Malheur Counties. The project area is divided into three separate mining areas including (from east to west); Mill Gulch, Hidden Valley and Beede Desert. The highest point within the project area is in the upper reaches of Mill Gulch in Section 19 at an elevation of approximately 4,300 feet above mean sea level (amsl). The mine site topography steps down to the west from Mill Gulch to Hidden Valley and then to Beede Desert, where the lowest point within the subject area is located at an elevation of approximately 3,600 feet amsl on the floor of the Otis Valley.

3.2 Climate

The regional climate is semi-arid, with hot, dry summers and cold winters. Summer high temperatures average between 85 and 95 degrees Fahrenheit (^{o}F), and it is not uncommon for temperatures to exceed 100 ^{o}F. Average low winter temperatures are around 20 ^{o}F, and are commonly below 0 ^{o}F. The majority of the precipitation occurs during the winter as snow, and average precipitation levels vary across the area depending upon location and elevation. During the remainder of the year, this area is prone to high intensity, short-duration precipitation events that result in significant runoff and erosion. Flooding in the town of Drewsey is common, occurring as often as every 10 years.

Site climate data (i.e., statistically summarized precipitation, temperature and evaporation records) have been obtained from the Western Regional Climate Center (WRCC) for three meteorological stations located in close proximity to the mine site (Figure 3-1) including:

- Drewsey, Oregon Meteorological Station No. 352415;
- Beulah, Oregon Meteorological Station No. 350723; and
- Juntura 9 ENE, Oregon Meteorological Station No. 354357.

Table 3-1 provides a summary of the historical average monthly precipitation obtained from these three meteorological stations. As shown in Table 3-1, the area receives an annual precipitation of approximately 10 inches, which is mostly in the form of snow. The mine site is located at a higher elevation than all three meteorological stations, and probably receives more precipitation as a result.

No pan evaporation data have been collected at the Celatom Mine. Therefore, pan evaporation data were obtained from the WRCC for the Warm Springs Reservoir Meteorological Station, the closest station to the mine site with recorded evaporation data. This station is located 20 miles south of the mine at an elevation of 3,330 feet amsl which is slightly lower than the lowest point within the mine site. Pan evaporation data were collected from 1931 through 1974. Assuming the evaporation pan at this station was installed above ground, the values provided by the station are likely an overestimate due to the effects of solar radiation and heating of the pan. In order to more closely estimate the actual shallow-pool evaporation, the pan totals were adjusted by multiplying the recorded value by 0.80 (www.wrcc.dri.edu). This results in an estimated open-water evaporation rate of 42.32 inches per year. The average monthly reported evaporation values are summarized in Table 3-2 and show the greatest amount of evaporation in this area occurs during the months of July and August.

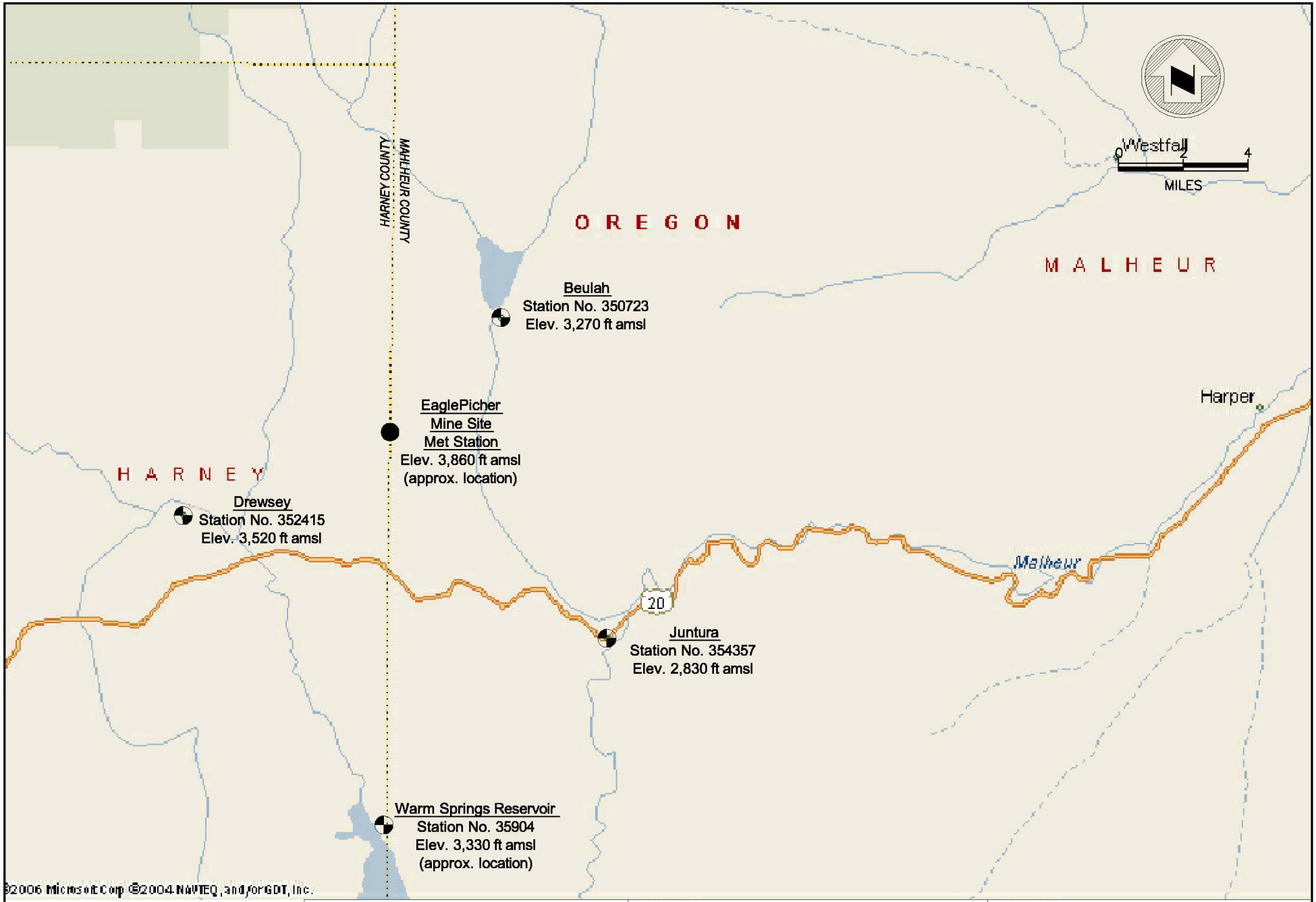
Table 3-1: Average Monthly Precipitation for the Drewsey, Beulah and Juntura, Oregon Meteorological Stations

Month	Drewsey, Oregon Station No. 352415 Elevation – 3,520 ft amsl		Beulah, Oregon Station No. 350723 Elevation - 3,270 ft amsl		Juntura 9 ENE, Oregon Station No. 354357 Elevation - 2,830 ft amsl	
	Avg. Monthly Precipitation (inches)	Avg. Monthly Snowfall (inches)	Avg. Monthly Precipitation (inches)	Avg. Monthly Snowfall (inches)	Avg. Monthly Precipitation (inches)	Avg. Monthly Snowfall (inches)
Period of Record (years)	35	35	57	57	33	33
January	1.33	8.3	1.44	9.6	1.25	6.5
February	0.99	5.4	0.98	4	0.83	1.9
March	1.07	1.4	1.07	1.8	0.93	0.5
April	0.84	0.3	0.81	0.3	0.83	0.1
May	1	0	1.12	0.1	0.98	0
June	0.74	0	0.93	0	1.09	0
July	0.38	0	0.38	0	0.44	0
August	0.46	0	0.44	0	0.51	0
September	0.47	0	0.47	0	0.48	0
October	0.65	0	0.75	0.1	0.67	0.2
November	1.27	3.1	1.37	3.1	1.32	2.1
December	1.39	8.9	1.57	8.8	1.5	7.2
Annual	**10.6**	**27.5**	**11.33**	**27.8**	**10.83**	**18.4**

Table 3-2: Average Pan Evaporation for Warm Springs Reservoir, Oregon Meteorological Station

Warm Springs Reservoir Meteorological Station No. 35904 Elevation – 3,330 ft amsl		
Month	**Pan Evaporation (inches)**	**Open-water Evaporation (inches)**
January	0	0
February	0	0
March	0	0
April	4.86	3.89
May	7.21	5.77
June	8.66	6.93
July	11.73	9.38
August	10.19	8.15
September	6.77	5.42
October	3.49	2.79
November	0	0.00
December	0	0.00
Annual	**52.9**	**42.32**

Period of Record - 1931 through 1974 (44 years)



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DRAWING TITLE: **METEOROLOGICAL STATION LOCATIONS**

DESIGN: AP	DRAWN: ML/JQG	REVIEWED: -	
CHECKED: -	APPROVED: AP	DATE: 01/04/2010	
FILE NAME: Bsln_Fig3-1_Meteorologic_Stations_ML_JQG_20100104.dwg			

CELATOM MINE BASELINE CHARACTERIZATION REPORT

DRAWING NO. **FIGURE 3-1**

SRK JOB NO. **152500.05**

REVISION NO. **A**

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3.3 Geology

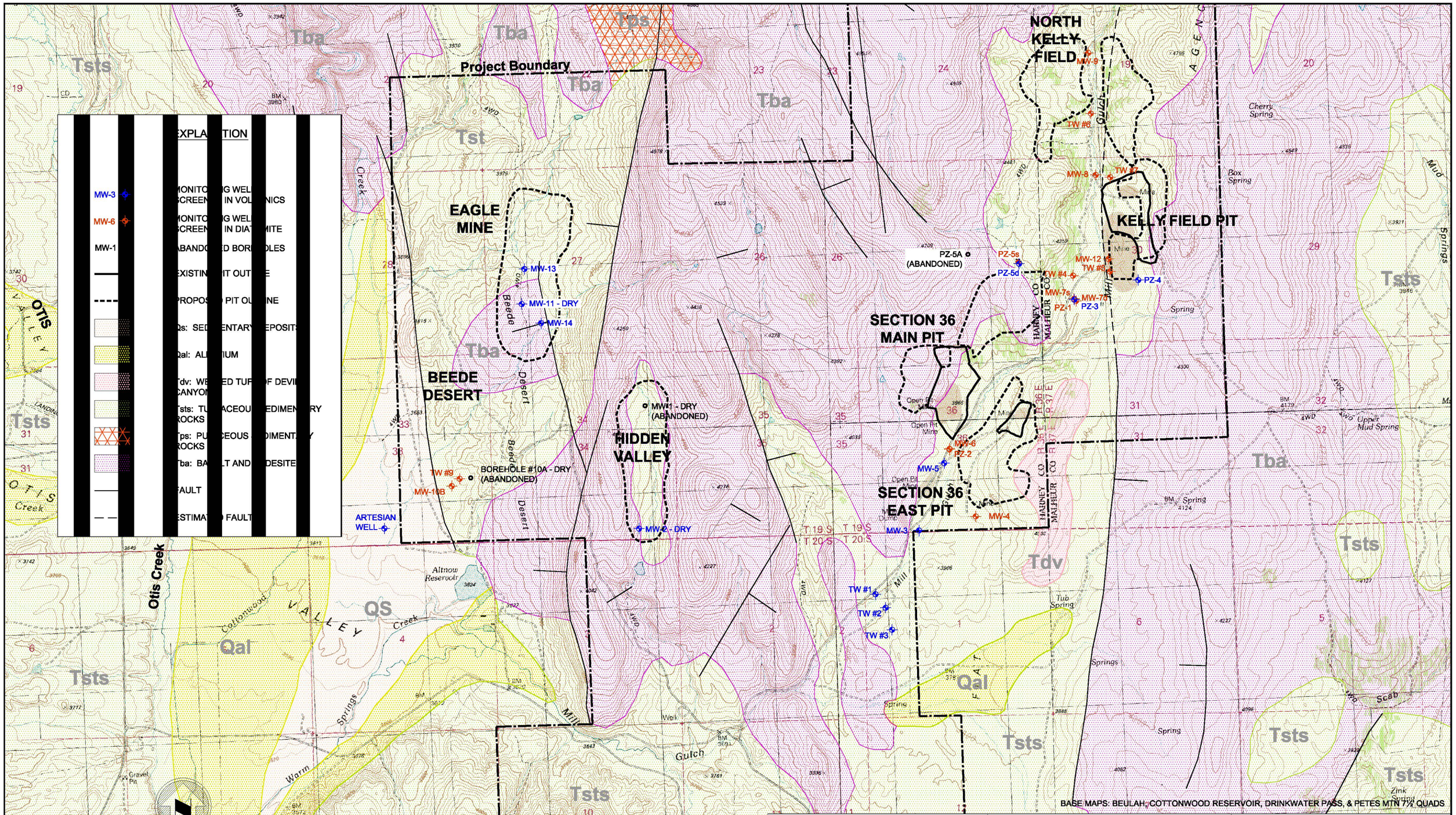
3.3.1 Regional Geology

The area being reviewed is at the north end of the Basin and Range physiographic province. This area is characterized by gently sloping plateau highlands separated by river valleys and basins. The geology of the area was mapped and described by Bowen (1956), Gray (1956), Shotwell et al. (1963) and mapped by Greene et al. (1972). The following discussion is based on their observations and interpretation of the Juntura Basin evolution. A generalized geologic map of the project area is provided in Figure 3-2 and is based on mapping completed by Greene (1972). The project area is located within the Juntura and Otis basins that were the site of lacustrine sediment deposition during late Miocene and early Pliocene. Basalt flows of the Columbia River Basalt Group disrupted drainage systems resulting in the development of locally expansive, diatom-bearing freshwater lakes.

These lake sediments were deposited on an irregular erosional surface of a volcanic rock complex emplaced during the Miocene. During this period of time, significant volcanic activity in the area resulted in favorable conditions for the proliferation of diatoms (i.e., high silica content). Diatomite deposits formed as a result of the accumulation of the skeletal remains (i.e., frustules) of diatoms, which are unicellular aquatic plants related to algae. Diatomite deposits range in thickness from a few inches to hundreds of feet and are interbedded with volcanic ash and to a lesser extent sedimentary deposits associated with lacustrine deposits (e.g., clay, sandstone). The thickness of the diatomite deposit varies significantly depending upon the topography of the underlying formations, conditions within the lake that controlled the proliferation of diatoms, and post depositional erosion (Brittain, 1986).

Tertiary lake sedimentation in this area is represented by the Juntura Formation and Drewsey Formation. The Juntura Formation consists of three distinct members, an upper, middle, and lower member. The lower member of the Juntura Formation consists of thick ash beds indicating volcanic activity was prevalent during the early filling of the basin. Tuffaceous agglomerate and basalt flows occur within the upper part of the lower member and a thin palagonite basalt flow marks the transition to the middle member of the Juntura Formation. The middle member of the Juntura Formation is mainly comprised of a thick sequence of diatomite with minor ash seams, indicating that large freshwater lakes were stable during a period of decreased volcanic activity. As a result, thick deposits of ore-grade diatomite were deposited in the center of the basin. It is this unit that is the main source of diatomite ore being mined by EPM. The upper member of the Juntura Formation marks an increase in volcanic activity and disappearance of a stable lacustrine environment as evidenced by the significant ash content that characterizes this member. The ash dominated diatomite beds are replaced by poorly consolidated tuffaceous material and volcanic sands higher in the section, indicating deposition within a predominately fluvial environment.

The Drewsey Formation overlies the Juntura Formation and consists of a mixture of volcanic tuff, agglomerates, ash and basalt flows and sedimentary units, some of which were derived from reworking of the underlying Juntura Formation. The Drewsey Formation was deposited in a northwest trending syncline that lies east of the town of Drewsey. Where exposed, the contact between the Drewsey and Juntura Formations is an angular unconformity.



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DRAWING TITLE: CELATOM GEOLOGY MAP

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FILE NAME: Bsln_Fig3-2_Geology_ML_JQG_20100325.dwg			

CELATOM MINE
BASELINE CHARACTERIZATION REPORT

DRAWING NO. FIGURE 3-2

SRK JOB NO. 152500.05

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According to Shotwell (1963), a cap of nearly horizontal olivine basalt, the Drinkwater Basalt overlies the sediments of the Juntura Formation and Drewsey Formation. The Drinkwater Basalt was deposited during the late Pliocene to early Pleistocene on an erosional surface that developed on the Juntura and Drewsey formations (Shotwell, 1963). The Drinkwater basalt consists of a single basalt flow that covered the area as a continuous blanket at one time. Following deposition, the basalt cap was dissected by a series of northwest trending faults with little displacement. In areas where the basalt has been fractured or removed by erosion of streams into the "soft" underlying formations has resulted in the topography that exists today. The geologic map prepared by Shotwell (1963) shows the Drinkwater Basalt partially covering the project area; however, according to mapping done by Green (1972) the Drinkwater Basalt does not occur within the project area as shown in Figure 3-2.

3.3.2 Structural Geology

Faults within the project area are shown on Figure 3-2, and are based on mapping completed by Greene (1972). As described by Shotwell et al. (1963), two major faulting events are evident throughout the area. First, faulting of the basement volcanic complex occurred before deposition of the Juntura Formation (i.e., diatomite). The resulting normal faults trend northwest and are consistent with faulting patterns observed throughout eastern Oregon. Development of the Juntura Basin is attributed to this faulting event. Following deposition of the Juntura Formation, but prior to deposition of the Drinkwater Basalt, another faulting event produced a series of north-south oriented faults. The resulting normal faults displace sediment of the Juntura Formation and resulted in significant scarp development on the west side of the Beulah Reservoir. The trace of a large fault attributed to this event is located along the Mill Gulch drainage (Figure 3-2). The youngest of the faulting events is superimposed on the two major fault trends in a repeating northwest trending fault pattern that cuts the Drinkwater Basalt. However, this faulting event did not result in any significant displacement of the rock units.

3.3.3 Diatomite Deposit Characteristics

The chemical composition of the diatomite is dominated by the siliceous composition of the diatom frustules. Chemical analysis indicates amorphous silica can comprise almost 90 percent of the diatomite. Other elements that occur within the diatomite include aluminum, carbon and iron. Minor percentages of calcium, sulfur, magnesium, potassium and sodium are also observed.

The Celatom diatomite deposit is composed of a variety of lacustrine sediments, with the majority of the material comprised of frustules of centric diatoms. Other components of the deposit consist of clastic sediments such as siltstone, mudstone, clay and sandstone from the weathering of the surrounding volcanic terrain. These sediments occur as thin interbeds within the deposit. Air-fall volcanic ash and tuff seams are also common interbeds within the diatomite deposit. Minerals commonly associated with the diatomite include iron sulfides (e.g., pyrite, mackinawite), gypsum, iron oxide minerals (e.g., goethite). However, these minerals are sparsely distributed throughout the deposit and comprise a very small percentage of the total volume. These minerals are commonly found as a coating on fractures, interstitial coatings or as finely disseminated mineral grains within the deposit.

The majority of the iron sulfide in the Celatom diatomite deposit is most likely biological in origin. The same lake environment that supported the prolific population of diatoms would have supported iron fixing bacteria and sulfur reducing bacteria that actively collected iron and sulfides in the anaerobic environment at the lake bottom. This process resulted in bacterial iron sulfide grains being deposited along with the diatoms and sediments during deposition. Sulfide minerals commonly associated with lake sediments consist of iron monosulfides, such as amorphous iron sulfide (FeS) and mackinawite that oxidize rapidly when exposed to oxygen. These minerals are often referred to as acid volatile sulfides (or AVS). Alteration products produced by the oxidation of iron sulfide (e.g., goethite) are commonly found in the upper portions of the deposits that have been oxidized. Near the oxidation boundary, iron sulfide nodules demonstrate alteration halos.

The Celatom diatomite deposit contains different species of diatoms as well as various levels of weathering. The upper portion of the diatomite deposit contains “oxidized” diatomite that has undergone substantial weathering. The lower portion of the deposit contains “unoxidized” diatomite that has undergone little to no weathering. Separating the upper and lower portions of the deposit is the “transitional diatomite” that has undergone moderate levels of weathering. These zones of weathering do not correlate with changes in the diatom speciation.

The oxidized diatomite is found in the upper portions of the deposit and is bright white in color and typically contains little moisture. Decomposed ash and clay seams are common throughout the oxidized zone. Very little sulfur or iron is found in the oxidized diatomite although trace amounts of minerals such as iron pyrite (FeS_2), gypsum ($CaSO_4 \cdot 2H_2O$), goethite [FeO(OH)], and disseminated amorphous ferric hydroxide [$Fe(OH)_3$] do occur.

The transition diatomite zone is normally tan in color and contains mild to moderate iron staining. Higher concentrations of iron, sulfur, and gypsum are typical of the transitional diatomite strata; moreover, decomposed ash and clay seams are found within this zone.

Unoxidized diatomite commonly is found in the lower portions of the deposit and is dark green or nearly black in color due to the higher level of organics. In the unoxidized diatomite, sulfide speciation is dominated by monosulfides (i.e., AVS) with a general chemistry of FeS_x, where $x<2$. The unoxidized diatomite also contains organic sulfur that can be identified from the odor emitted from a broken fresh face. The carbon, iron, calcium, and sulfur present in the unoxidized diatomite have undergone little alteration since their deposition. Gypsum has migrated with the meteoric water flow and is found as micro coatings in the fault zones of the underlying strata. Iron sulfide has agglomerated into random nodules that are sparsely distributed throughout the unoxidized diatomite. The iron sulfide minerals have also coated some of the high angle fault surfaces, and on rare occasions, have formed small nodules around fossil nuclei. Near the transitional diatomite boundary, the sulfide nodules contain halos of alteration of varying degrees ranging from goethite to amorphous hydrous ferric hydroxide. The unoxidized diatomite retains much of the organic material from the diatoms, and as a result, contains much higher moisture content than either the oxidized or transition diatomite zones. Ash seams are also a very common feature in the unoxidized diatomite zone.

3.4 Surface Water Hydrology

Surface water features that occur within and adjacent to the Celatom property are shown in Figure 3-3 and are generally ephemeral, only flowing in response to heavy snowmelt or high precipitation storm events. The closest perennial streams within the region are the:

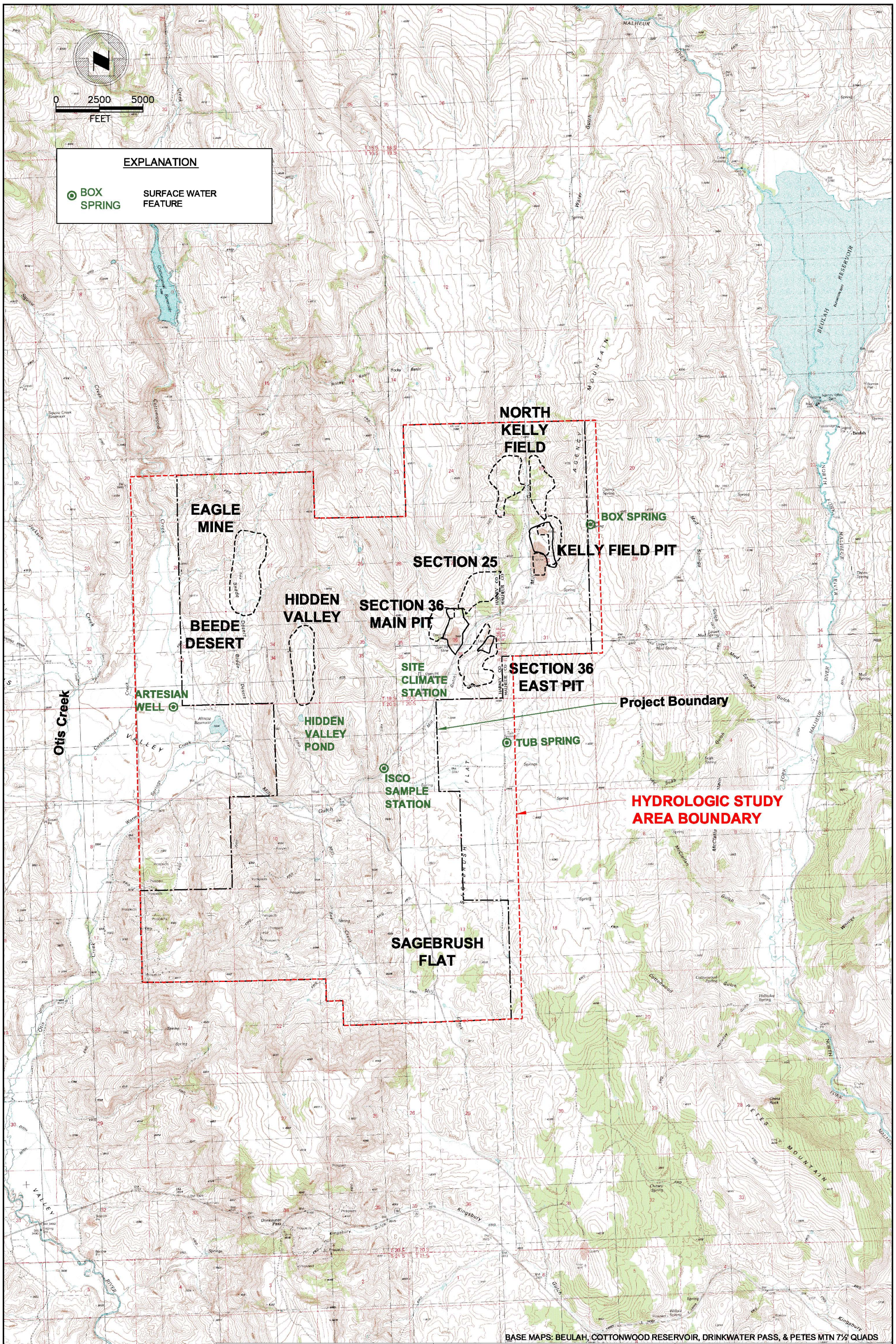
- North Fork of the Malheur River, located about three miles to the east of the Mill Gulch;
- Cottonwood Creek and Altnow Ditch, located west of Beede Desert;
- Warm Springs Creek, Stallard Ditch, and Otis Creek, located south-southwest of Beede Desert; and
- Middle Fork of the Malheur River, located approximately 5 miles southwest of Beede Desert.

Mill Gulch is an intermittent stream that runs through the eastern portion of the mine. It is dry during the summer months and for most of the year. Water flow comes mainly from surface runoff during significant precipitation events. Runoff entering Mill Gulch travels south-southwest and eventually joins Warm Springs Creek. Warm Springs Creek and Otis Creek flow into Cottonwood Creek, and Cottonwood Creek flows into the Middle Fork of the Malheur River toward the Warm Springs Reservoir. The Mill Creek drainage flows north from the Sagebrush Flats area and converges with the Mill Gulch drainage prior to flowing into the Warm Springs Creek.

In all disturbance areas of the mine, drainage control ditches and settling/evaporation basins have been constructed to prevent sediment from migrating off site. The catchment basins have been constructed below grade and collect and store surface water runoff from the active mine areas during the wet season. The basins in Kelly Field and Section 36 were constructed to reduce sediment loading in the surface water flow prior to being discharged to Mill Gulch. An automated sampling station was installed downgradient of the mine area near the confluence with the Sage Flat drainage. This gauging station consists of a Stevens recorder that can continuously monitor the water level and an ISCO sampler that can collect a water sample at a specified time each day for a month. Samples were collected on a monthly basis during the mining season and analyzed for EC, pH and total dissolved solids (TDS). However, as a result of dry stream conditions during the mining season over the past couple of years, sampling has been discontinued.

Hidden Valley lies two miles west of Mill Gulch and, like Mill Gulch, evaporation and transpiration exceed precipitation for the majority of the year. Hidden Valley contains an intermittent drainage that flows in response to runoff from precipitation. The catchment area for this drainage is limited to an area less than 1 mile wide and 2 miles long. Any surface water flow in the drainage is trapped within the lower reaches of the valley, where an earthen dam transects the drainage to create a water source for livestock in the area.

The Beede Desert area is situated on the eastern edge of the Otis Valley basin. Several incised drainage channels transect the Beede Desert area from east to west and empty into the Cottonwood Creek drainage within Otis Valley. Catchment basins were constructed downgradient of the Beede Desert mine operations in order to prevent any sediment from the mining disturbance from reaching the Altnow Ditch and Altnow Reservoir.



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DRAWING TITLE: **SURFACE WATER HYDROLOGY FEATURES**

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CELATOM MINE BASELINE CHARACTERIZATION REPORT

DRAWING NO. FIGURE 3-3

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Numerous springs and seeps are located in and around the project area. Surface water sources are typically captured and developed as permanent water sources for wildlife and cattle, but do not supply sufficient water for agricultural uses.

3.5 Groundwater Hydrogeology

In general, regional groundwater flows from the high mountain ranges into the basins and valley floors. The primary aquifers in the mine area occur in the underlying volcanic bedrock and the overlying diatomite deposit. The occurrence and direction of groundwater flow in the bedrock is controlled by fractures/faults and the hydraulic conductivity of the various volcanic rocks. Groundwater in the diatomite aquifer is unconfined, appears to mimic topography, and is in communication with groundwater in the bedrock aquifer.

A number of wells in the Otis Valley immediately downgradient of the Beede Desert area are artesian, and have historically supplied water to ranchers in that area. These artesian wells feed the Altnow Reservoir that drains into the Warm Springs Creek.

3.6 Water Rights

The Celatom Mine is located in the Malheur Lake Basin. Surface and subsurface water rights on private land are managed by the State, and typically correspond to the owner of the private land. Private lands within the hydrologic study area are owned by the following:

- John and Suzanne Moon;
- Jeff and Sherri Hussey;
- Diatomite Products Co.; and
- EP Minerals, LLC.

EP Minerals owns the southwest quarter of Section 30 and a portion of Section 25 and holds all water rights for this private land.

The BLM manages the water rights on all public land. However, some are rights reserved by the federal government on the public land and other water rights are held without severance or acknowledgment by the Board of Education in Section 36. In some cases, local ranchers hold the water rights to the springs in the area that are located on public land. These springs were initially located by the government and distributed to local ranchers during the time of homesteading as an incentive to settle the area. The segregation and distribution of spring water rights predates the establishment of the BLM. Ranches have specific surface water rights to streams draining from reservoirs. For instance, property owners John and Suzanne Moon hold the water rights to the drainage of the Cottonwood Reservoir.

4. DATA ACQUISITION AND SAMPLING ACTIVITIES

4.1 Surface Water Surveys

4.1.1 Preliminary Surface Water Inventory

An initial inventory of springs within the area was conducted during December 2005. During this initial field investigation, SRK located and sampled three (3) major surface water features identified from the United States Geological Survey (USGS) topographic map in the vicinity of the Celatom operations. These features included two developed springs and one man-made pond in Hidden Valley. The sample sites are shown in Figure 3-3 and photographs (taken at the time) are provided in Appendix B.

Locations where vegetation or soil moisture suggested the presence of shallow groundwater were also identified, even though no surface water was apparent during the survey. These include two locations within Mill Gulch; an upper location where flow has been documented in the past, and near an ISCO sampler located at the confluence of Mill Gulch and Sagebrush Flat drainages. Measurable surface water flow in these locations is most likely to occur only during wetter conditions (i.e., spring freshet).

Field data collected at each surface water location includes:

- Global Positioning System (GPS) coordinates;
- Estimated flow rates from the initial field investigation using a stopwatch and calibrated collection vessel (where possible); and
- Field parameters including pH, temperature, EC collected using an ULTRAMETER™ 6P, and iron and sulfate concentrations determined using the FerroVer Method (8008) SulfaVer 4 Method (8051) for the HACH DR/890.

Following the initial investigation, additional data acquisition activities were conducted during October 2007, June 2008 and May 2009 to document any change in conditions at these locations. Samples collected for laboratory analysis were placed in an insulated cooler and sealed with a signed custody/security seal and shipped via overnight courier to ACZ Laboratories in Steamboat, Colorado. All coolers were accompanied with Chain-of-Custody documentation. A summary of the data collected during these sample events is provided in Section 6.

In addition to the data collected above, surface water samples were collected by EP Minerals in April 1995 and again in February 2010 from water that collected within the Sections 36 Pit and Kelly Field Pit after the spring freshet. These samples were collected to characterize the water chemistry and to determine the best management practices for handling and disposing of the water collecting in the pits. The results for these samples are provided in Appendix H and are presented and discussed in Section 6 below. Laboratory data sheets associated with these samples are provided electronically on the enclosed CD only. The April 1995 samples were not filtered prior to analysis and therefore, the reported results represent the total fraction. The laboratory sheets for the April 1995 samples do not include a quality control report and the laboratory has not retained this information.

4.1.2 Comprehensive Surface Water Inventory

In August 2009, a comprehensive baseline surface water inventory was conducted to identify surface water, seeps and springs, as well as riparian areas that occur within the designated hydrologic study area boundary. This investigation extended beyond the areas examined in previous investigations, and resulted in the identification of a number of additional surface water features within the hydrologic study area. Prior to the field investigation, a work plan was submitted to the BLM that defined the scope of the surface water inventory and a map was provided showing the proposed hydrologic study area. Upon approval by the BLM, topographic maps (USGS) and aerial photographs were reviewed for evidence of ephemeral, intermittent, and perennial drainages, open water, possible riparian vegetation, and seeps/springs within the hydrologic study area. The potential sites of interest identified from the pre-field desk study were visited and confirmed during the field reconnaissance phase of the investigation, along with additional sites identified while the team was in the field. Ground verification, data collection, and water quality sampling, was performed from August 6 through August 19, 2009.

The identified ponds, springs, and seeps were documented with field notes and photographs. The drainages were documented at various points including at the top of the drainage where possible, at the bottom of the drainage, and at points where the drainage characteristics changed significantly. Field notes included the following information:

- Date and time;
- Waypoint name;
- Coordinates (UTM NAD 83, Zone 11) and elevation in feet;
- Type of site;
- Presence of water;
- Impacts and improvements;
- General condition of the drainages relative to Waters of the United States (WoUS) criteria; and
- View and file number of photographs.

If water was present and suitable for sampling, a sample was collected and the following information was also recorded:

- Field parameters for temperature, pH, EC, and TDS;
- Distance of sample from source; and
- Flow measurements (where attainable).

Field parameters were collected with an ULTRAMETER™ 6P that was calibrated each morning prior to use. Flow measurements were taken either with a cutthroat flume, pygmy flow meter, or with a pipe and a one-liter measuring cup depending on the flow and stream characteristics. If the pipe and cup method was used, three consecutive measurements were taken and averaged together for a final result.

Prior to the field work, Analytical Request Forms (ARFs) were developed to ensure that the data collected, specifically the parameters analyzed and their respective analytical detection limits, meet the objectives of the program. The first step in ARF development was to identify current and potential future beneficial uses of surface water in the area. The Celatom Mine is located in the Malheur Lake Basin. The designated beneficial uses listed for the Malheur River Basin in OAR 340-041-0201 include: water supply (domestic,

irrigation and industrial), livestock, fish and aquatic life, wildlife and hunting, fishing, boating, water contact recreation, and aesthetic quality. However, State of Oregon promulgated standards for these beneficial uses are not available. Therefore, the only standards considered during the selection of analytical parameters and methods were the Oregon Maximum Contaminant Levels (MCLs) for drinking water, regulated by 333-061-0030, along with non-regulatory wildlife toxicity criteria and general geochemistry parameters.

For the streams and water bodies within the hydrologic study area that may support aquatic life (i.e., perennial surface water), beneficial uses associated with fish and aquatic life were included during the selection of analytical parameters. The ARFs developed for the project were sent to the Oregon-certified laboratory to notify the laboratory of the required detection limits in order to select which of the available and appropriate laboratory method(s) would be most suitable to meet the requirements.

Based on the ARF development, two types of samples were collected during the field program and analyzed for different suites of analytes including:

- Surface water samples; and
- Aquatic life samples.

The aquatic life samples included the analysis for low-level mercury, which were collected using the “clean hands – dirty hands” technique. Surface water samples were collected in labeled one-gallon containers and placed in a cooler with ice as soon after collection as possible. Gloves were worn during sampling and processing, and care was taken to avoid potential contamination. The sample water was then transferred into labeled bottles and filtered and/or preserved as required the same day as collection. Fresh tubing and filters were used for each individual sample. Some samples not requiring filtering were filled in the field directly from the source. The samples were shipped to ACZ Laboratories, Inc. in coolers with chain-of-custody seals and accompanied by chain-of-custody forms.

The sites were recorded in field books and as GPS waypoints using the following nomenclature for each type of site: Seep or Spring (SE), Drainage (DR), and Pond (PD).

Each site was given a number preceded by a letter identifying the handheld GPS unit it was recorded on. For example, the first seep or spring site documented and surveyed with the “C” GPS unit was called SE-C01. Formal names from the USGS map were used as names for sample points on reservoirs and streams.

During this investigation, SRK also conducted a preliminary WoUS jurisdictional determination survey within the hydrologic study area boundary to assess the location and extent of potential jurisdictional resources as regulated by the U.S. Army Corp of Engineers (USACE). The field survey included an examination of major drainages in the area to determine if ordinary high water mark (OHWM) indicators, as defined by the USACE, were present, and determine if connectivity or a significant nexus exists between non-navigable drainages and the closest jurisdictional waterway.

A field report summarizing the results of the 2009 field survey is provided in Appendix C and a summary of the main conclusions are presented in Section 6.

4.2 Hydrogeologic Investigations

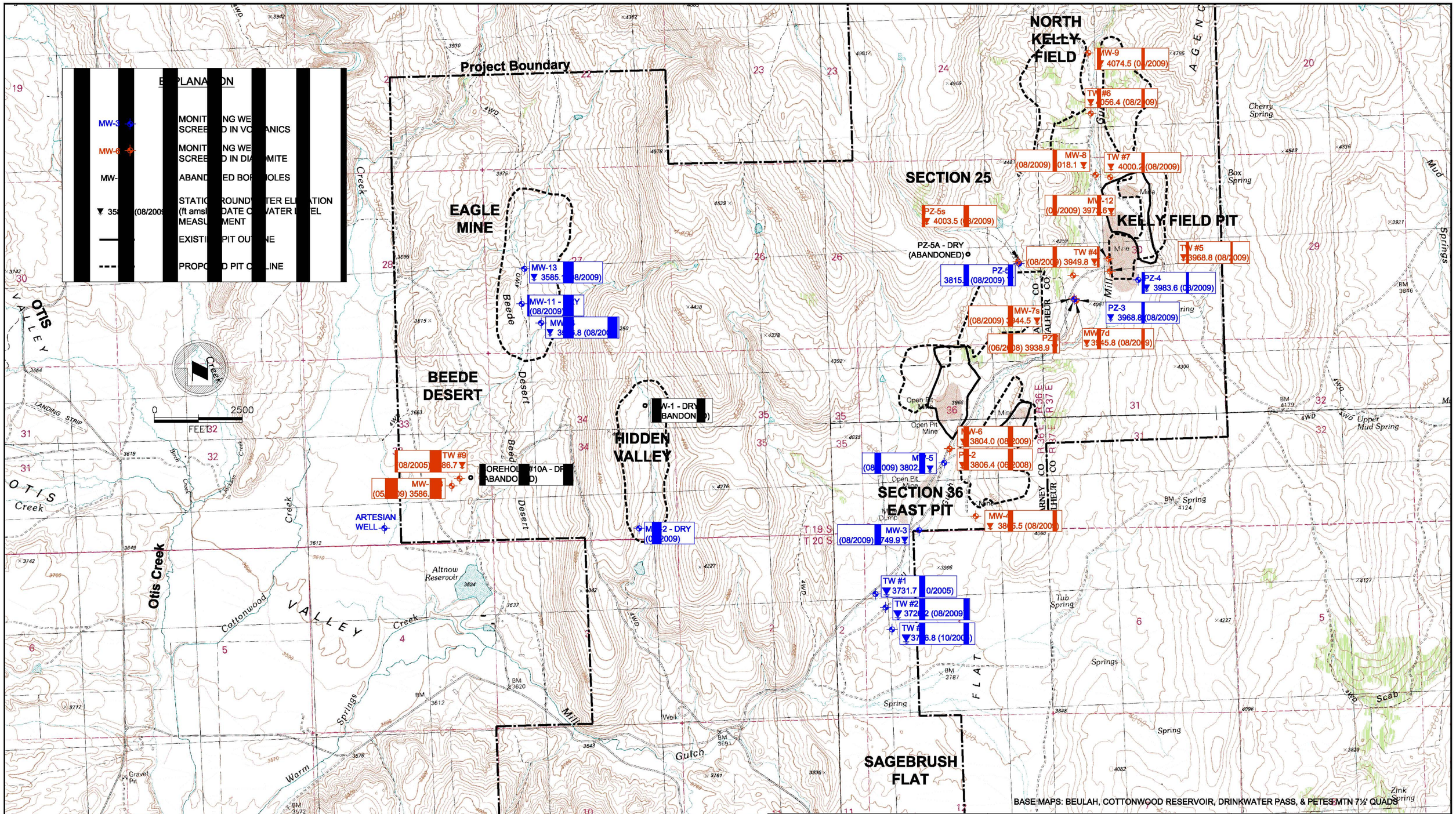
4.2.1 1985 EP Minerals Test Well Program

During 1985, EPM advanced nine water well test holes in the vicinity of the mine. The location of these test wells are shown in Figure 3-4. Two of these wells (TW #6 and #7) are located upgradient of the current Celatom mining operations. Test wells #4 and #5 are located within close proximity to the current Celatom mine site along the Mill Gulch drainage. The remaining three testwells (TW #1, #2 and #3) are located downgradient of the mine site within the Mill Gulch drainage. Test well #9 is located in a separate hydrographic basin 7 miles to the west of the mine site and 1,500 ft north of the Altnow Reservoir in the Beede Desert. Groundwater elevations have been measured at these test wells beginning in November 1986 and monitoring continued on a regular basis through November 2004 and once in October 2005 and again in August 2009. However, no data has been collected from TW #8 since it became inaccessible in July 1997. Hydrographs for the historical groundwater elevations are provided in Appendix J.

Details on the location, construction and conditions encountered in the test wells are summarized in Table 4-1. However, this information was compiled from correspondence from EPM and detailed drill records including field notes, drill logs and well completion logs are not available. Furthermore, test wells were not constructed according to State of Oregon monitoring well construction regulations (OAR 690 Division 240) and generally consist of an open hole with surface casing. All of the test wells, with the exception of TW #8, were sampled by EPM in July 2004 to determine baseline chemistry of groundwater upgradient, onsite, and downgradient of the mine site. Results of the groundwater sampling event (July 2004) are discussed in detail in Section 7.5.2.

Table 4-1: 1985 EP Minerals Test Well Monitoring Well Details

EP Test Wells	Coordinates			Total Depth (est. ft bgs)	Lithology	Well Completion (est. ft bgs)	Static Water Level (ft bgs)
	Lat	Long	Elevation				
TW #1	43.8614711	-118.246704	3741.4059	40	0-12 volcanic waste 12-40 shaley volcanics	10' cemented surface casing 10-40' open hole	9.7
TW #2	43.8604002	-118.245648	3738.1251	40	0-7 soil 7-16 clay and gravel 16-40 shaley volcanics	10' cemented surface casing 10-30' 2" screen w/gravel 30-40' open hole	12.65
TW #3	43.8586672	-118.245009	3810.9589	120	0-85 volcanic ash 85-120 shaley volcanics	6' cemented surface casing 6-120' open hole	84.2
TW #4	43.8858852	-118.22447	3981.8886	120	0-120 diatomite	20' cemented surface casing 20-120'open hole	34.8
TW #5	43.8861232	-118.220479	3987.794	57	0-57 diatomite	5' cemented surface casing 5-57' open hole	22.4
TW #6	43.8984853	-118.222083	4089.4988	60	0-2 alluvium 2-60 diatomite	6' cemented surface casing 6-60' open hole	30.7
TW #7	43.8934707	-118.220181	4056.0347	60	0-12 gravel and clay 12-60 diatomite	15' cemented surface casing 15-60' open hole	52.15
TW #8	Abandoned	--	--	--	--	--	--
TW #9	43.8713348	-118.291204	3607.5493	30	0-24 alluvium/diatomite 24-30 basalt	15' cemented surface casing 15-30' open hole	20.8



SRK Consulting
Engineers and Scientists

PREPARED FOR: EP Minerals™ AN EAGLEPICHER COMPANY

DRAWING TITLE: **MONITORING WELL AND PIEZOMETER LOCATIONS**

DESIGN: AP	DRAWN: ML/JQG	REVIEWED: -	**CELATOM MINE BASELINE CHARACTERIZATION REPORT**	DRAWING NO. FIGURE 3-4	REVISION NO. A
CHECKED: -	APPROVED: AP	DATE: 03/30/2010		SRK JOB NO. 152500.05	
FILE NAME: Bsln_Fig3-4_DrillHole_Well_ML_JQG_20100325.dwg					

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4.2.2 2005 SRK Drilling Program

WDC Exploration and Wells, Inc. (WDC) mobilized a truck-mounted sonic drill rig (model Supersonic II) to the site on September 27, 2005. During the course of the hydrogeologic investigation phase of the baseline data collection project, 12 drill holes were advanced, of which 10 were completed as approved monitoring wells (Figure 3-4). Significant drilling delays resulted from mechanical failures of the drill rig, and adverse weather conditions (i.e., rain and snow). Drilling was terminated on November 18, 2005 and well development activities were completed on November 20, 2005. The drilling and sampling program was directed on the ground by a SRK geologist, who was supervised by a senior SRK geologist registered as a Professional Geologist in Oregon. Daily drill reports, compiled WDC at the end of each shift for the duration of the project, are provided in Appendix D along with the Monitoring Well Report filed with the Oregon State Department of Water Resources by the drilling company. The following sections describe drilling activities, as well as an outline of drill core collection, handling, logging and sampling protocols.

A total of 12 drill holes were drilled during the 2005 field program. The locations of the drill holes were selected based on the following criteria:

- Accessibility of the site and suitability of location for future monitoring (i.e., will not be compromised by expansion of mine facilities);
- Ability to provide representative hydrogeologic data; and
- Likelihood of encountering a productive zone of saturation within the target lithology.

The GPS coordinates were obtained for each drill site using a hand held GPS unit (Trimble) and are provided in Table 4-2. A summary of the data collected during the 2005 drilling program and well installation is provided in Table 4-3.

Two locations (MW-1 and MW-2) were drilled within the Hidden Valley drainage for the purposes of monitoring groundwater upgradient (MW-1) and downgradient (MW-2) of mining operations in Hidden Valley. However, the diatomite in both locations was dry. A monitoring well was installed at MW-2 to intercept possible groundwater in the underlying basalt and a monitoring well was not installed at the upgradient drill site in Hidden Valley (MW-1).

Monitoring wells MW-3, MW-4, MW-5 and MW-6 are located downgradient of the existing Section 36 Pit. MW-4 was installed east of the Section 36 Main Pit and immediately downgradient of the Section 36 East Pit. MW-5 was installed to characterize groundwater in the underlying volcanic basement immediately downgradient of the Section 36 Main Pit. MW-3 is the most downgradient monitoring point in Mill Gulch and is intended to characterize groundwater exiting the mine site. In this location, the diatomite was absent; therefore, the monitoring well was installed in the volcanic basement.

Table 4-2: 2005 Monitoring Well Coordinates

Mine Area	Monitoring Well	Coordinates[1]		Surface Elevation[1]
		Lat	Long	ft amsl
Hidden Valley	MW-1	43.87663	-118.271	3983.42
	MW-2	43.86708	-118.272	3910.59
Section 36	MW-3	43.86636	-118.242	3784.17
	MW-4	43.86733	-118.236	3824.19
	MW-5	43.87155	-118.239	3827.12
	MW-6	43.87263	-118.238	3837.53
Kelly Field	MW-7s	43.88408	-118.224	3968.03
	MW-7d	43.8839	-118.224	3964.07
North Kelly Field	MW-8	43.89369	-118.222	4046.19
	MW-9	43.90322	-118.222	4145.35
Beede Desert	MW-10A	43.87139	-118.29	3621.00
	MW-10B	43.87079	-118.292	3599.78
	MW-11	43.88482	-118.284	3772.35

[1]Latitude, longitude and elevation coordinates based on NAD83.

MW-7 is a well pair (MW-7s and MW-7d) intended to characterize the saturated diatomite and underlying basalt lateral to the Kelly Field Pit area. This location was selected in order to maximize the potential for saturation in both the diatomite and basalt units. However, in this location, the depth of the underlying bedrock exceeded the capacity of the WDC drill rig, and the deep well (MW-7d) was installed in saturated diatomite and provides a measurement of the vertical gradient within the diatomite.

MW-8 is located upgradient of the Kelly Field Pit and downgradient of the proposed disturbance in Section 19 (North Kelly Field Pit) and represents background groundwater conditions in the diatomite. MW-9 is located in Section 19, and is the most upgradient monitoring point in Mill Gulch and is upgradient of the existing operations. MW-9 monitors background groundwater conditions in the diatomite for the proposed disturbance within North Kelly Field area.

MW-10B is located west and downgradient of EP Test Well #9 and monitors the impacts of the disturbance associated with the existing Beede Desert operations. MW-11 is also located within the Beede Desert mine area in the Eagle Mine area that is currently undisturbed. The diatomite in this area is dry; therefore, MW-11 was installed to intercept groundwater in the underlying basalt (if any). This well was screened immediately below the contact between the diatomite and basalt bedrock and has been dry since installation.

4.2.2.1 Well Development

The 2005 monitoring wells were developed by WDC to remove the loose native fine material in the drill hole adjacent to and within the sand pack. Development was conducted to settle the sand pack and to maximize water production by removing fine grained material from the sand pack.

Table 4-3: Summary of 2005 Drilling and Well Installation Data

Drill Hole	Drill Hole Location	Total Depth (ft bgs)	General Lithology			GW Enc. (ft bgs)	Static Water Level (ft bgs)	Screened Interval (ft bgs)	Screened Formation
			Interval (ft bgs)		Lithology				
MW-1	Hidden Valley	161	0 3 111 119	3 111 119 161	Soil Oxidized Diatomite Ash/Tuff Basalt	None	Borehole Abandoned (Dry Conditions)		
MW-2	Hidden Valley	112	0 2 89 90	2 89 90 112	Soil Oxidized Diatomite Tuff/Lahar Basalt	None	Dry	92-112	Basalt
MW-3	Section 36	55	0 2 30	2 30 55	Soil Tuff Basalt	36	27.05	30-50	Basalt
MW-4	Section 36	66.5	0 13 18	13 18 66.5	Soil/Alluvium Oxidized Diatomite Unoxidized Diatomite	26-46	19.69	35-55	Unoxidized Diatomite
MW-5	Section 36	101	0 16 60 76 98	16 60 76 98 101	Soil/Alluvium Opalized Diatomite Volcanic Ash/Tuff Andesite Weathered Andesite	24-52	25.15	81-101	Andesite
MW-6	Section 36	73	0 3 21	3 21 73	Alluvium Oxidized Diatomite Unoxidized Diatomite	60	34.73	52.3-72.3	Unoxidized Diatomite
MW-7s	Section 30 Kelly Field	46	0 7 30	7 30 46	Soil Oxidized Diatomite Unoxidized Diatomite	36	25.20	25.5-45.5	Oxidized and Unoxidized
MW-7d	Section 30 Kelly Field	225.5	0 7 22 145 172.5 204 207	7 22 145 172.5 204 207 225.5	Soil Oxidized Diatomite Unoxidized Diatomite Ash/Tuff Unoxidized Diatomite Ash/Tuff Unoxidized Diatomite	34	20.9	176-216	Unoxidized Diatomite
MW-8	Section 30 Kelly Field	52	0 16 21 46 50	16 21 46 50 52	Soil/Alluvium Oxidized Diatomite Unoxidized Diatomite Ash/Diatomite Ash/Tuff	26	26.12	25-45	Unoxidized Diatomite
MW-9	Section 19 North Kelly Field	102	0 9 20 35 43	9 20 35 43 102	Alluvium Oxidized Diatomite Unoxidized Diatomite Ash Unoxidized Diatomite	92	70.20	82-102	Unoxidized Diatomite
MW-10A	Beede Desert	31	0 16	16 31	Soil/Alluvium Basalt	None	Borehole Abandoned (Dry Conditions)		
MW-10B	Beede Desert	29	0 15 16 20 22	15 16 20 22 29	Soil/Alluvium Oxidized Diatomite Unoxidized Diatomite Oxidized Diatomite Unoxidized Diatomite	10	13.8	9-29	Alluvium, Ox/Unox Diatomite
MW-11	Eagle Mine	126	0 5 43 103	5 43 103 126	No Recovery Oxidized Diatomite Unoxidized Diatomite Basalt	None	NA	106-126	Basalt

4.2.2.2 Drilling Methods and Sample Collection

The drill holes advanced in 2005 were drilled using rotosonic drilling methods that uses oscillatory vibration without circulation of fluids to advance the core barrel. In general, subsurface conditions were compatible with the selected drilling method, as the geologic profile consisted of "soft" rock (i.e., diatomite) that was easily cored by rotosonic drilling techniques. However, hard bedrock was encountered in 5 out of the 12 drill holes and the addition of a fluid (i.e., potable water) was required to advance the core barrel effectively. Recovery of material was typically good (approximately 90-100%) for the softer materials. Drill water was obtained from an unnamed artesian well located on a cattle ranch downgradient of the mine site. A sample of water was collected from this well for analysis and the results of this testing are provided in Section 7.5.

Recovered core was examined onsite during drilling. For each drill location, a detailed drill log was completed that included a description of the geologic profile encountered. These drill logs are provided in Appendix E and include notes on color, lithology, and mineralogical variations and degree of oxidation. Other observations include estimated water content, noticeable odors, and the presence of organic material.

Geologic samples were collected from the recovered core at 5- to 10-foot intervals, or as determined by the occurrence of discrete lithologic contacts. For each sample interval, 5 to 10 pounds (lbs.) of rock material was placed in a large, heavy-duty polyethylene sample bag. From the same sample interval, a small split (a minimum of 200 grams) was also collected, screened to 100 percent passing 4.75 mm (-4.75 mm) when possible, and stored in a clean 8-ounce plastic jar or Ziploc bag for field screening. Field screening techniques are described in Section 8.1.

4.2.2.3 Monitoring Well Installation

Ten out the 12 drill holes advanced in 2005 were completed as monitoring wells in accordance with the regulations specified by Oregon Administrative Rule (OAR) 690 Division 240. All monitoring wells were completed under the supervision of a qualified well installer with a current license from the State of Oregon who was subcontracted directly by WDC. Following completion of each monitoring well, the subcontractor prepared certified well records for submittal to the state of Oregon Department of Water Resources office (ODWR).

Each monitoring well was constructed of either 2" or 4" Schedule-40 PVC casing, depending upon the subsurface conditions encountered. The screened interval was constructed with 0.020" slotted Schedule 40 PVC casing across the desired interval. In most cases, the screened interval was placed across the water table. However, in low-permeability zones, such as diatomite, groundwater recharge into the drill hole is slow and often takes several hours (or days) for the water to recover to static conditions and it was not always possible to allow the water level to equilibrate over a long period of time. For wells MW-4 , MW-6 and MW-9, the depth to the static level had to be estimated for the purpose of selecting the depth of the well screen. Also, three of the wells were installed below the diatomite deposit (MW-2, MW-5 and MW-11). For these wells, the screen interval was placed to capture groundwater within discrete lithologic zones.

The sand pack was placed in a uniform and continuous manner, such that hydraulic segregation and bridging was minimized or eliminated. The well casings extend at least 2

feet above the ground surface and are enclosed in locking steel surface casing with a permanent well identification label (tag) affixed to the outside. Each tag is stamped with a well tag number issued by the State of Oregon.

The well collar elevations were surveyed using a Trimble GPS unit and were measured to within 0.1 foot. The survey data and completion details for each monitoring well are provided in Appendix E along with drill logs and monitoring well construction diagrams.

The wells were developed using a combination of bailing and swabbing until the groundwater was devoid of settleable (very fine sand-sized) material. Following bailing, the wells were pumped until the water was clear or until field parameters (temperature, pH, EC, and oxidation-reduction potential or Eh) stabilized to +/- 10 percent. Field parameters were collected at regular intervals using a Myron ULTRAMETER™ 6P instrument.

4.2.3 2008 SRK Drilling Program

The BLM requested that an additional monitoring well be placed closer to the Kelly Field Pit in the vicinity of the EP Test Well #5. This monitoring well (MW-12) was installed during June 2008 in a location approximately 200 feet north of the EP Test Well #5 and was installed to monitor saturated diatomite immediately downgradient of the Kelly Field Pit.

Drilling and installation methods for MW-12 were the same to those employed during the previous groundwater investigation (2005) which included drilling by rotosonic methods and installing a 2-inch monitoring well. An SRK project-level geologist was present during drilling and monitoring well construction. In addition, a licensed well driller was present during the drilling and installation of MW-12.

Following completion, MW-12 was developed to remove the loose fine material in the borehole adjacent to and within the sand pack. The monitoring wells was developed using a submersible pump to purge the well until the water was clear and devoid of fine material.

During the 2008 drilling event, two piezometers (PZ-1 and PZ-2) were drilled. Piezometer PZ-1 was drilled downgradient of the Kelly Field Pit within about 15 feet of MW-7s. Piezometer PZ-2 was drilled downgradient of the Section 36 Pit and within about 15 feet of an existing monitoring well (MW-6). These piezometers were installed to serve as observation points during subsequent hydraulic testing. Because of the low permeability of the diatomite, the boreholes were specified to be about 4-inch in diameter with standpipe piezometers no larger than necessary (i.e., 1-inch PVC casings).

The GPS coordinates were obtained for each drill site and are summarized in Table 4-4. A summary of the data collected during the 2008 drilling program and well/piezometer installation is provided in Table 4-5.

Table 4-4: 2008 Monitoring Well and Piezometer Coordinates

Monitoring Well	Location	Coordinates		Surface Elevation[1]
		Lat	Long	ft amsl
MW-12	Kelly Field	43.8871	-118.2206	3995.68
PZ-1	Kelly Field	43.8840	-118.2244	3962.33
PZ-2	Section 36	43.8726	-118.2383	3835.29

[1]Latitude, longitude and elevation coordinates are based on NAD83.

Table 4-5: Summary of 2008 Drilling and Well Installation Data

Drill Hole	Drill Hole Location	Total Depth	General Lithology			GW Enc. (ft bgs)	Static Water Level (ft bgs)	Screened Interval (ft bgs)	Screened Formation
			Interval (ft bgs)		Lithology				
MW-12	Kelly Field	107	0	5	Gravel fill/soil	47	16.39	20-70	Unoxidized Diatomite
			5	15	Oxidized Diatomite				
			15	107	Unoxidized Diatomite				
PZ-1	Kelly Field	47	0	9	Soil	37	23.39	25-45	Oxidized/ Unoxidized Diatomite
			9	30	Oxidized Diatomite				
			30	47	Unoxidized Diatomite				
PZ-2	Section 36	77	0	8	Gravel fill/soil	47	28.91	55-75	Unoxidized Diatomite
			8	27	Oxidized Diatomite				
			27	37	Unoxidized Diatomite				
			37	47	Ash/Tuff				
			47	77	Unoxidized Diatomite				

4.2.4 2009 SRK Drilling Program

Additional drilling and well installation was conducted in July and August 2009 in order to address comments made by HCItasca, Inc., a subcontractor to Enviroscientists, in a memorandum received on April 22, 2009. This additional baseline characterization work included:

1. Installation of monitoring wells for the Eagle Mine area to characterize background groundwater conditions in this area; and
2. Installation of additional piezometers in the Mill Gulch area in order to further characterize the hydraulic properties of the volcanic bedrock, and better define the vertical gradients in this area.

During the 2009 drilling program, a total of 10 holes were advanced by Boart Longyear using Reverse Circulation (RC) drilling methods that use water to advance the drill bit and air to recover the injection water. This method was selected due to the efficiency of drilling through hard substrate in comparison to rotosonic drilling. Drill cuttings from the reverse circulation drilling were collected at 5 to 10 foot intervals for ore grade testing. In most cases, the recovery of drill cuttings from the diatomite unit was poor. However, enough material was recovered to provide a complete geologic description of each drill hole. Due to the potential for the air pressure to ‘push’ groundwater away from the drill hole, care was taken during drilling in order to identify water zones. This was accomplished by putting the drill rig on standby for several hours or overnight to make sure that saturated conditions were not encountered; particularly in the diatomite.

Six out the ten drill holes were completed as monitoring wells or piezometers. In the Eagle Mine area, two drill holes were completed as monitoring wells (MW-13 and MW-14) and in the Kelly Field area, four drill holes were completed as piezometers (PZ-3, PZ-4, PZ-5S and PZ-5D). The remaining drill holes were abandoned for reasons described below. GPS coordinates were obtained for each drill site and are summarized in Table 4-6. A summary of the data collected during the 2009 drilling program and well/piezometer installation is provided in Table 4-7.

Table 4-6: 2009 Monitoring Well and Piezometer Coordinates

Location	Monitoring Well	Coordinates		Surface Elevation[1]
		Lat	Long	ft amsl
Kelly Field	PZ-3	43.884	-118.224	3962.07
	PZ-4	43.8854	-118.217	4028.12
Section 25	PZ-5s	43.88706	-118.23	4102.22
	PZ-5d	43.88692	-118.23	4094.53
	PZ-5A	43.88776	-118.236	4297.52
Eagle Mine	MW-13	43.88755	-118.284	3773.26
	MW-14	43.88329	-118.282	3773.61

[1]Latitude, longitude and elevation coordinates are based on NAD83.

Monitoring wells MW-13 and MW-14 were drilled in the northern and southern portion of the Eagle Mine area, respectively. In both locations, groundwater was not encountered in the overlying diatomite, and MW-13 and MW-14 were completed in the basalt unit underlying the diatomite. Due to the dry conditions of the diatomite, shallow wells were not installed in this area. The depth at which groundwater was first encountered was controlled by the depth at which the groundwater bearing fractures were encountered. In MW-13, the depth at which groundwater was encountered was 280 feet, and in MW-14, groundwater was encountered at 240 feet. The static depth to groundwater is similar for MW-13 and 14, at about 188 feet below ground surface (bgs). This indicates that the diatomite deposit in the Eagle Mine area is underlain by greater than 100 feet of unsaturated basalt, and any moisture stored in the diatomite is not connected to the regional groundwater system.

In Kelly Field, piezometer PZ-3 was drilled to bedrock and is located about 25 to 50 feet from existing monitoring wells MW-7s and MW-7d that are screened in diatomite. In this location, artesian groundwater conditions were encountered in the volcanic basement at approximately 490 feet bgs. The first hole drilled in this location (PZ-3A) had to be abandoned due to a poor surface casing seal and was re-drilled. An artesian piezometer was installed in the second hole drilled in this location that is equipped with a pressure gauge in order to determine the hydraulic head of the basement aquifer. The surrounding diatomite wells served as monitoring points for the diatomite during the hydraulic testing described below.

Piezometer PZ-4 was also drilled to bedrock south of the Kelly Field Pit, and south of previous 2008 exploration holes KF-EC-08-07, -08, and -09. Groundwater was not encountered in the overlying diatomite, and PZ-4 was completed in the volcanic basement rocks underlying the diatomite. Due to the dry conditions of the diatomite, a shallow well was not installed in this area.

Table 4-7: Summary of 2009 Drilling and Well Installation Data

Drill Hole	Drill Hole Location	Total Depth (ft bgs)	General Lithology			Static Water Level	Static Water Level	Screened Interval	Screened Formation
			Interval (ft bgs)		Lithology	(ft bgs)	ft amsl	(ft bgs)	
MW-13	Eagle Mine	300	0	64	Oxidized Diatomite	188.12	3585.14	258-298	Basalt
			64	80	Unoxidized Diatomite				
			80	87	Grayish-green Tuff				
			87	300	Basalt				
MW-14	Eagle Mine	250	0	40	Oxidized Diatomite	186.78	3586.83	210-250	Basalt
			40	76	Unoxidized Diatomite				
			76	78	Grayish-green Tuff				
			78	250	Basalt				
PZ-3	Kelly Field	499	0	28	Oxidized Diatomite	6.7 (ft ags)	3968.77	458-498	Tuff/ Black Organics/ Basalt
			28	166	Unoxidized Diatomite				
			166	195	Grey Tuff/Ash				
			195	255	Unoxidized Diatomite				
			255	285	Grey Tuff/Ash				
			285	423	Unoxidized Diatomite				
			423	438	Diatomite/Tuff with Black Organics				
			438	449	Grey Tuff/Ash				
			449	459	Grayish-green Tuff				
			459	488	Tuff with Black Organics				
			488	499	Basalt				
PZ-4	Kelly Field	137	0	40	Oxidized Diatomite	44.5	3983.62	96-136	Tuff/ Black Organics/ Basalt
			40	65	Unoxidized Diatomite				
			65	75	Diatomite with Black Organics				
			75	87	Grey Tuff/Ash				
			87	97	Grayish-green Tuff				
			97	122	Tuff with Black Organics				
			122	137	Basalt				
PZ-5s	Section 25	345	0	26	Basalt Overburden	98.7	4003.52	305-345	Unoxidized Diatomite
			26	55	Oxidized Diatomite				
			55	281	Unoxidized Diatomite				
			281	304	Grey Tuff/Ash				
			304	345	Unoxidized Diatomite				
PZ-5d	Section 25	551	0	13	Basalt Overburden	278.82	3815.70	520-550	Basalt
			13	49	Oxidized Diatomite				
			49	260	Unoxidized Diatomite				
			260	279	Grey Tuff/Ash				
			279	472	Unoxidized Diatomite				
			472	486	Diatomite/Tuff with Black Organics				
			486	506	Grayish-green Tuff				
			506	519	Tuff with Black Organics				
			519	551	Basalt				
PZ-5A	Section 25	205	0	10	Basalt Overburden	dry	dry	--	--
			10	75	Oxidized Diatomite				
			75	159	Unoxidized Diatomite				
			159	165	Grey Tuff/Ash				
			165	180	Brown Clay				
			180	195	Blue-grey Tuff				
			195	205	Basalt				

The first hole drilled in Section 25 (PZ-5A) was located in the same area as the 2008 exploration drill hole S25-EC-08-07. Exploration drilling indicated fairly saturated conditions in the diatomite in this location. However, dry conditions were encountered in both the diatomite and the underlying tuff/basalt sequence. Groundwater was not encountered to a depth of 50 feet below the diatomite, and the hole was abandoned. Piezometer PZ-5 was re-drilled at a lower elevation where groundwater occurred in both the diatomite and basalt (PZ-5S and PZ-5D). Groundwater was encountered in the diatomite at approximately 150 feet bgs, and PZ-5S was screened across the contact of the unoxidized diatomite with a thick ash/tuff layer. Piezometer PZ-5D was screened in the volcanic sequence underlying the diatomite.

4.2.4.1 2009 Well Completion

Six out of the ten holes drilled in 2009 were completed as monitoring wells or piezometers in accordance with the regulations specified by the OAR 690 Division 240. All monitoring wells and piezometers were completed under the supervision of a qualified well installer with a current license from the state of Oregon and certified well records were prepared for submittal to the state of ODWR. Drill logs and well construction diagrams are provided in Appendix E.

Each monitoring well and piezometer was constructed with 2” Schedule-40 PVC casing with a 0.020” slotted Schedule 40 PVC casing across the desired screen interval. The sand pack was placed in a uniform and continuous manner, such that hydraulic segregation and bridging was minimized or eliminated. The well casings extend at least 2 feet above the ground surface and are enclosed in locking steel surface casing with a permanent well identification label (tag) affixed to the outside. Each tag is stamped with a well tag number issued by the State of Oregon.

Piezometer PZ-3 was completed with Schedule 80 PVC, with 20 feet of stainless steel casing at the top of the well. Due to the artesian conditions, a gravel pack was used for the screen interval in this piezometer, followed by a fine sand and brine solution that temporarily slowed the artesian flow enough to allow placement of the bentonite chip seal.

4.2.4.2 Well Development

The 2009 monitoring wells and piezometers were developed by air lifting to remove the loose native fine material in the drill hole adjacent to and within the sand pack. During development, field parameters were collected at regular intervals using a Myron ULTRAMETER™ 6P instrument.

Prior to placement of the bentonite seal during construction of PZ-4, Boart Longyear surged the sand pack with air to settle the sand pack. Further development of PZ-4 was accomplished by airlifting water from the well until field parameters (temperature, pH, EC, and Eh) stabilized to +/- 10 percent.

Due to the artesian conditions at PZ-3, well development was accomplished during the hydraulic testing during which the shut-in valve was opened for 24-hours and water was allowed to flow at the surface. The initial flow rate from the well was about 40 gallons per minute (gpm). After about 5 hours, the flow rate stabilized to 30 gpm. Therefore, more than 40,000 gallons of groundwater was removed from this well prior to collecting the sample. Field parameters were measured during the test and stabilized before the water quality sample was collected.

Because PZ-5D is greater than 500 feet deep, Boart Longyear was retained to assist in the development of this piezometer to ensure proper development. Development was accomplished by running tremie pipe to the bottom of the well and airlifting water until field parameters stabilized to +/- 10 percent variability.

For MW-14, the column of water in the well is only about 65 feet, which limited the submergence of the airlift head and continuous 'pumping' of the groundwater by air lifting was not possible. Therefore, development was accomplished by submerging the airlift to the bottom of the well and air lifting the entire well volume and then allowing the column of water to completely recover before re-applying air. This process was repeated until field parameters stabilized to +/- 10 percent variability.

4.3 Hydraulic Testing

Several phases of hydraulic testing have been completed for the Celatom Mine. The first hydraulic testing program was completed immediately following the 2005 sampling event. This testing included single-well pumping and slug tests to determine hydraulic conductivity (*K*) values of the diatomite and underlying volcanic rocks. However, single-well tests cannot be used to determine storage (i.e., specific yield) coefficients for aquifers. Consequently, an additional field investigation was conducted specifically to determine storage values for the diatomite and supplement the existing hydrologic database. The 2008 investigation included installation of two small-diameter standpipe piezometers (PZ-1 and PZ-2), and conducting two short-term pumping tests in nearby monitoring wells. Additional hydraulic testing was performed in 2009 immediately following completion of monitoring wells and piezometers in the Kelly Field and Eagle Mine areas. Results of the tests, along with re-interpreted data from earlier tests, were used to make preliminary estimates of groundwater flow. The hydraulic testing programs completed for the Celatom Mine are described in the following sections.

4.3.1 2005 Hydraulic Test Program

Hydraulic conductivity (*K*) values in diatomite and underlying volcanic rocks were estimated in 2005 from six, single-well, composite pumping/slug tests conducted in newly-constructed monitoring wells. Hydraulic testing of each well was conducted by increasing the pumping rate until the water level in the well was at the pump intake in order to maximize drawdown. The pump was then removed from the well and a pressure transducer with data logger was immediately inserted to record water level recovery. Specific details of the purging, sampling, and hydraulic testing for each monitoring well location are summarized in Table 4-8.

The water level recovery data were analyzed with AQTESOLV Ver. 3.0 software to estimate hydraulic conductivity of the subsurface material. The output of the modeling program is provided in Appendix F, and the interpretation of the results is presented in Section 7.2.

Table 4-8: 2005 Hydraulic Test and Recovery Data

Well ID	Static Water Level	Estimated Purge Volume		Approx. Flow	Allowed Recovery Time	Final Recovered Water Level	Percent Recovery
	feet bgs	# well vol.	gallons	gpm	hours	feet bgs	(% of SWL)
MW-2	Dry	--	--	--	--	--	--
Test Well #2	15.26	-- [a]	-- [a]	-- [a]	-- [a]	-- [a]	-- [a]
MW-3	27.05	4	68	1	23	29.05	10%
MW-4	19.69	3	66	-- [b]	23	22.1	10%
MW-5	25.15	3	160	0.5	20	28.07	90%
MW-6	34.73	3	69	0.6	17	37.48	90%
MW-7s	25.2	3	36	-- [b]	22	27.4	100%
MS-7d	20.9	1.1	150	-- [b]	41	24	97%
MW-8	26.12	1.4	15	-- [b]	20	28.74	100%
MW-9	70.2	1	19	-- [b]	45	76.96	94%
MW-10B	13.8	3	24	1.2	-- [c]	-- [c]	-- [c]
MW-11	Dry	-- [d]	-- [d]	-- [d]	-- [d]	-- [d]	-- [d]

[a] The completion details of this well are unknown and as a result hydraulic testing was not done on this well.
[b] The rate of recharge was slower than the minimum pumping rate and a flow rate could not be established. In this case, the water level was pulled to the pump intake and the well was allowed to recover for 1-2 hours prior to collecting a sample.
[c] Drawdown conditions did not develop during purging and the well could not be tested by measuring recovery with a transducer. Instead, the well was pumped at 1.2 gpm for 100 minutes for a constant discharge test.
[d] Only 0.05 gallons of water were recovered from the well using a disposable bailer. The water level did not recover after the well was bailed dry.

4.3.2 2008 Low Volume Pump Tests

In order to determine storage values for the diatomite, two additional hydraulic tests were conducted that required drilling and installation of two additional piezometers within about 15 feet of an existing 2-inch monitoring wells. The purpose of these piezometers was to serve as observation points during the hydraulic testing, as groundwater is pumped from the 2-inch monitoring wells. Because of the low *K* values involved, the boreholes drilled were about 4-inch in diameter and the standpipe piezometers installed were no larger than necessary (i.e., 1-inch PVC casings). The small diameters are necessary in order to minimize wellbore storage and accompanying time lags during drawdown tests.

Monitoring well locations that were selected for the hydraulic testing include MW-6 and MW-7s. The diatomite deposits in both of these locations are typical of those observed in the Mill Gulch mine areas. Monitoring well MW-7s is located downgradient of the Kelly Field Pit and monitoring well MW-6 is located downgradient of the Section 36 Pit.

For both piezometers, a 1-inch standpipe was installed in the drill hole and was screened in diatomite across the water table to match the interval screened in the nearby 2-inch monitoring well. Following construction, a short-term (3 to 12 hour), low volume (0.5 to 5 gpm) pumping test was conducted at each site, and included pumping from the 2-inch monitoring well while monitoring water-level drawdown and recovery in the nearby piezometers. In addition, a single-well slug test was conducted in the newly installed MW-12. The results of these additional hydraulic tests are discussed in Section 7.2.

4.3.3 2009 Hydraulic Test Program

Following well construction, hydraulic tests were conducted in each of the new Kelly Field piezometers, and in the monitoring wells installed in the Eagle Mine area. Tests were designed to estimate *K* values of the bedrock and lower diatomite, and to investigate possible hydraulic connection between the two. The hydraulic testing included airlift 'pumping' while monitoring aquifer drawdown and recovery at each location. Water was evacuated from the screen interval by injecting air at about 150 standard cubic feet per minute (scfm) down an airline placed at the base of the water column in the well. The rising air lifted water out and through a discharge port attached to the well. The rate and volume of water was measured by directing the air/water discharge into an open-top container (5-gallon bucket) while recording the time it took to fill the container. Pressure transducers were placed in both the pumping well and an observation well to measure changes in the water levels during pumping, and after the air pressure was turned off and the wells recovered. During the pumping, water levels were also measured by hand in nearby wells to determine if there were any observable changes. For the Eagle Mine area wells, the overlying diatomite was dry, so the tests were limited to determining the hydraulic conductivity of the basalt formation (i.e., no observations wells were monitored during the testing).

Depending upon the groundwater conditions encountered, the hydraulic test data were analyzed as either data derived from constant-rate pumping (aquifer drawdown) and subsequent recovery data or as rising or falling head recovery data (i.e., slug analysis). For wells where withdrawal of groundwater by airlift pumping created a cone of depression, the recovery data were analyzed graphically using the Theis straight-line method (Kruseman and DeRidder, 1970) to determine the hydraulic conductivity. According to this method, residual drawdown was plotted against the logarithm of the ratio of total time to recovery time (T/t'). In most instances, typical recovery curves show a steep portion representing well-bore storage affects, followed in time by a flatter portion where the slope, along with pumping rate, can be used to estimate transmissivity and hydraulic conductivity of the test interval. Wells for which this method of data analysis was applicable included MW-13D, PZ-4 and PZ-5S. Graphs showing the recovery data and resulting analysis are shown in Appendix F.

The static water level in MW-14 was excessively low relative to the total well depth, and as a result, there was not enough submergence of the airline to sustain a constant pumping rate capable of creating any measureable aquifer drawdown. A sustained pumping rate was also difficult to maintain in PZ-5D due to limitations in the length of the airline (480 feet) that resulted in less than 40% submergence. For these wells, a single volume (slug) of water was displaced during the initial evacuation of air/water which was followed by a pause in the pumping as water displaced in the well was allowed to recover to its static level. The Theis straight-line method of data analysis is not the preferred method for determining hydraulic conductivity under these conditions. As an alternative, the Hvorslev's method (1951) for analyzing rising and falling-head (slug test) data was used to determine hydraulic conductivity. According to this method, the logarithm of the ratio of residual drawdown to total drawdown, (H-h)/(H-H0) is plotted versus time (t) on an arithmetic scale. Hydraulic conductivity is then derived using a value of t_0 when recovery has reached 37 percent of the initial, maximum drawdown. Alternatively, the same analysis can be conducted by plotting

the same relationship over time using data collected from the rate of a falling head of water throughout the test interval (i.e., falling-head slug test).

During the hydraulic testing at PZ-5D, a transducer was placed in PZ-5S to monitoring changes in water levels. Piezometer PZ-5S is located about 50 feet upgradient of PZ-5D and is screened across the bottom contact of a thick ash/tuff layer and diatomite. Data from the transducer indicate that water levels in PZ-5S did not appreciably change as a result of pumping water from PZ-5D. However, as described above, a cone of depression could not be created in PZ-5D during airlifting due to limited submergence of the airline, thus a response in PZ-5S would not be expected under these pumping conditions.

In addition to the testing and analysis described above, a shut-in test was conducted to define the hydraulic conditions in the artesian piezometer PZ-3. During this test, the discharge valve of the piezometer was opened allowing water to flow at the surface for a 24 hour period. Discharge measurements of the artesian flow were periodically measured during the 24 hour period. At the beginning of the test, the rate of artesian flow was about 40 gpm. This flow rate decreased over the 24 hour test period to around 28 gpm. The average discharge rate was about 30 gpm. After 24 hours, the discharge valve was shut, and a pressure transducer attached to the pressure gauge port was used to record the rate of pressure change that occurred after stopping the free flow of water to the surface. A hydrograph was generated from the transducer data and hydraulic conductivity was determined using the Theis straight-line method as described above. During the course of the test, nearby wells PZ-1 and MW-7D were monitored for changes in water level. In addition, water levels in wells installed in the basement unit located at a greater distance from PZ-3 were also measured (i.e., PZ-4 and PZ-5D). In all cases, the response of surrounding basement wells to the shut-in test was minimal and no notable changes in water levels were observed in PZ-4 (measured by transducer) or PZ-5D (measured with water level indicator). Monitoring well MW-7D, which is screened within the deep diatomite, is located about 50 feet away from PZ-3 and slightly downhill. Initially, the water from PZ-3 was allowed to flow to this low point and collect in the area around MW-7D. As a result, the water levels in MW-7D actually increased until water was diverted around this area. After the water was diverted, the water level in MW-7D showed only a slight decrease from 19.75 feet bgs (static) to 19.8 feet bgs despite the close proximity of this well to PZ-3 (i.e., less than 50 feet). Piezometer PZ-1 is located about 25 feet uphill from PZ-3 and is screened within the diatomite across the water table (i.e., shallow diatomite well). Water level measurements taken at this well during the test showed no response to the ongoing shut-in test.

4.4 Groundwater Sample Collection and Testing

4.4.1 2005/2006 Groundwater Sampling

Following well installation and development, groundwater samples were collected for analytical testing to determine groundwater quality. Following sample collection, water level recovery data were recorded in order to characterize the hydraulic properties of the aquifers.

Monitoring well sampling took place approximately 20 days after the monitoring wells were developed, and water levels reported during the sampling and testing activities are considered representative of static conditions.

During the 2005 monitoring event, groundwater samples were collected from MW-3, MW-4, MW-5, MW-6, MW-7s, MW-7d, MW-8, MW-9 and MW-10B. Monitoring wells MW-2, and MW-11 have both been dry since installation, and samples could not be collected. Additionally, a sample was collected from EP Test Well #2 and the artesian well that was used for water supply during drilling.

During this first sample event, a Grundfos Redi-Flo 2 pump and controller were used to purge the wells and collect groundwater samples for laboratory testing. Between each well, the sample equipment was decontaminated with Liquinox and de-ionized water. Dedicated or decontaminated tubing was used in order to eliminate the potential for cross contamination between wells. The following steps were followed for each monitoring well during groundwater sample collection:

- Static groundwater level reading was taken using an electronic water level indicator and the well volume was calculated;
- The pump intake was placed in the middle of the screen interval and approximately three well volumes were purged to ensure that samples were representative of the formation water;
- Field parameters of the purge water, including pH, temperature, EC, and Eh, were measured using a Myron ULTRAMETER™6P for each well volume that was purged;
- Groundwater samples were collected in individual, pre-preserved sample bottles provided by the laboratory for the requested analysis; and
- The sample bottles were placed in an insulated cooler and sealed with a signed custody/security seal and shipped via overnight courier to ACZ Laboratory in Steamboat, Colorado. All coolers were accompanied with Chain-of-Custody documentation.

The static water levels and purge volumes for each monitoring well are summarized in Table 4-9 along with field parameters measured prior to sample collection.

In addition to the groundwater samples, a total of four quality control (QC) samples were collected as described below:

- One randomly selected field duplicate was collected from MW-4 using identical sample techniques within a 24-hour period in order to demonstrate that all samples were collected in an identical manner and that sample results are reproducible and are representative of field conditions. The duplicate results also provide a means to evaluate analytical precision;
- One field blank was collected to assess whether contamination was introduced during the handling or transportation of the samples. The field blank was prepared by decanting de-ionized water into the appropriate sample containers in place of an actual sample. One equipment rinsate blank was collected during the sampling program to assess sample contamination resulting from the sampling equipment. This blank was collected following sample collection and equipment decontamination by pumping de-ionized water through the pump and collecting the “rinsate”. This water was pumped directly into the appropriate sample containers. The results of the field rinsate blank provide an indication of the effectiveness of equipment decontamination procedures in preventing cross-contamination between sampling locations.

- One sample from the drill supply well (i.e., artesian well) located in Otis Valley, east of Cottonwood Creek and north of the Altnow Reservoir. This sample was collected to confirm the quality of the water used during drilling and monitoring well completion. Water was issuing from the well casing at about 15 to 20 gpm, and the sample and field parameters were collected from the discharge point. Photographs of this well are provided in Appendix B.

Field sheets summarizing the data collected during purging and sampling activities during each sample event are summarized in Appendix G and the results of the groundwater analyses are provided in Section 7.5. A tabulation of the water quality results is provided in Appendix H. Laboratory reports associated with Appendix H are provided electronically on the enclosed CD only.

Table 4-9: 2005/2006 Monitoring Well Purge Data and Field Test Results

Well ID	Monitoring Well Purge Data								Field Parameters[c]			
	Surface Elevation (ft amsl)	Static Water Level (ft bgs)	GW Elevation (ft amsl)	Total Depth (ft bgs)	Well Diameter (inches)	Static Water Column (ft)	Well Volume (gallons)	Estimated Purge Volume (gallons)	pH (s.u.)	Temp. (°C)	EC (μmhos)	ORP (mV)
MW-2	3910.59	(dry)	(dry)	112	2	(dry)	(dry)	(dry)	--	--	--	--
Test Well #2	3745.62	15.26	3730.36	23	unknown	7.74	1.3	1.3 [a]	7.69	11.6	381.2	41
MW-3	3784.17	27.05	3757.1	55	4	25.95	17	51 [b]	7.43	12.6	318.4	-147
MW-4	3824.19	19.69	3804.5	55	4	32.9	22	66	7.39	15.3	424.9	-147
MW-5	3827.12	25.15	3802.0	101	4	73.37	53	160	7.19	12.5	329.1	-127
MW-6	3837.53	34.73	3802.8	72.3	4	35.07	25	69	6.92	11.2	330.8	-118
MW-7s	3968.03	25.20	3942.8	45.5	4	18.1	11.8	35.5	6.4	11.8	437.4	134
MS-7d	3964.07	20.90	3943.2	226	4	202.7	132	396	6.39	14.8	397.8	-88
MW-8	4046.19	26.12	4020.1	45	4	16.26	10.6	31.8	6.81	10.7	216.7	-44
MW-9	4145.35	70.20	4075.2	102	4	29.4	19	57	6.61	13.5	382.1	-76
MW-10B	3599.78	13.80	3586.0	29	4	12.6	8.2	24.6	6.75	13.9	304.7	27
MW-11	3772.35	(dry)	(dry)	126	2	(dry)	(dry)	(dry)	--	--	--	--
Drill Supply Well [d]	3555.22	(artesian)	--	--	--	--	--	--	7.20	17.8	133.1	--

[a] One pore volume was purged using a bailer before the well went dry. The well was allowed to recharge for 24 hours before the sample was collected with a new disposable bailer.
[b] Approximately 4 well volumes were purged before parameters stabilized and a sample was collected.
[c] Reported field parameters (pH, Temp., EC and ORP) are the final measurements recorded before sample collection.
[d] Well completion details for the artesian well located in Otis Valley are unknown. This well was the source of potable water for the drilling program.

4.4.2 2007 Groundwater Sampling

Groundwater samples were collected from nine monitoring wells (MW-3 through MW-10B) by SRK during June 2008 as part of an ongoing monitoring program to provide additional information on the groundwater conditions within the vicinity of the mine site. Monitoring wells installed in the Hidden Valley (MW-2) and Eagle Mine (MW-11) areas have been dry since they were installed in 2005, and no samples could be obtained from these wells during the 2007 sampling event. In addition to the groundwater samples, a total of three quality control samples were collected including: one field duplicate, one field blank, and one equipment rinsate blank.

During this sample event, groundwater samples were collected using low flow sampling techniques as described by Puls and Barcelona in USEPA's Ground Water Issue Paper Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures (April 1996). This method minimizes the impact that purging can have on groundwater chemistry during sample collection (such as sediment leaching, oxidation and element desorption) and ensures that the samples collected are representative of groundwater conditions.

Low-flow sampling is accomplished by lowering the pump intake to the screen interval and pumping at a rate that approximates the hydraulic conductivity of the aquifer and minimizes the amount of drawdown. Pumping at this rate is continued until field parameters stabilize and then samples are collected. The pump intake was positioned above the bottom of the screen interval to avoid disturbing any sediment that may have settled at the bottom of the well. Exceptions to this include approach included MW-6 and MW-9, where the pump was positioned about 5 feet above the bottom of the well, which resulted in disturbance of the bottom sediments.

An adjustable rate MegaMonsoon pump with a Low Flow Power Booster III Controller was used to purge the monitoring wells and collect groundwater samples for laboratory testing. This pump is constructed of inert materials (i.e., stainless steel and PVC) in order to minimize possible contamination. Dedicated polyethylene tubing was used and disposed of after each use to prevent cross-contamination between each well. The power source for the pump was a truck battery that was connected using power cables. The power cable for the pump was measured with a measuring tape and marked for accurate placement of the pump intake within the well. During set-up at each location, the water level indicator probe and tape were decontaminated by unraveling approximately 10 feet of the tape into a bucket containing phosphate free detergent (i.e., Liquinox), agitating the tape in the water by hand and rinsing with distilled water.

Groundwater was pumped directly into a closed flow through cell equipped with a multi-parameter meter. The water quality parameters that were monitored during purging include pH, dissolved oxygen (DO), turbidity (visual), EC, and temperature. This meter was calibrated every day prior to initiating sampling activities. An in-line disposable filter was used for preparation of the dissolved metal sample aliquot. An electronic water level indicator was used to measure the depth to water during purging and sample collection.

Due to low permeability conditions of the diatomite aquifer, stabilization of drawdown could not always be achieved. Under these conditions, there is a potential to create unrepresentative conditions during sampling and obtain false positives for unfiltered metals due to the disturbance of sediment during purging. If the drawdown could not be maintained and the water level was constantly decreasing during purging, the samples were collected

before the depth to water fell below the top of the well screen, with the exception of MW-8. For this well, the static water level is initially below the top of the screen. Monitoring wells that demonstrated low permeability conditions during this sample event included MW-4, MW-5, MW-6, MW-7d, MW-8 and MW-9. For these wells, drawdown and recovery were a problem during low-flow purging. Despite the low flow conditions encountered in these wells, complete dewatering of the well screen did not occur for any of the wells. The data collected during sample collection activities are summarized in Table 4-10. A monitoring report that summarizes the methods and results of the October 2007 groundwater monitoring event in detail is provided in the *Monitoring Report - October 2007 Groundwater and Surface Water Sampling Event for the EaglePicher Celatom Mine, Drewsey, Oregon* (SRK, 2008). Field sheets summarizing the data collected during purging and sampling activities are summarized in Appendix G and the results of the groundwater analysis are provided in Section 7.5. A tabulation of the water quality results is provided in Appendix H. Laboratory reports associated with Appendix H are provided electronically on the enclosed CD only.

Table 4-10: October 2007 Monitoring Well Purge Data and Field Data

Monitor Well	Initial Depth to Water (static)	Ending Depth to Water After Pumping	Top of Screen Interval	Dissolved Oxygen	pH	EC	Temp
	ft bgs	ft bgs	ft bgs	%	s.u.	µS	°C
MW-3	27.8	28	30	0.29	7.41	414	13.79
MW-4	17.86	25.8	35	0.38	7.36	364	14.63
MW-5	23.01	27.38	81	0.1	7.42	NM	15.41
MW-6	30.3	33.4	52.3	0.66	7.02	NM	13.49
MW-7d	18.3	22.7	25.5	1.9	6.63	955	11.35
MW-7s	24.06	24.4	176	2.14	6.73	1560	10.8
MW-8	26.02	27.3	25	0.18	6.32	405	12.13
MW-9	66.53	73.75	82	0.18	6.31	915	14.53
MW-10B	13.27	13.27	9	4.83	6.9	219	13.76

NM = no measurement

4.4.3 2008 Groundwater Sampling

Groundwater samples were collected from 10 monitoring wells by SRK during June 2008. Samples were collected from the same monitoring wells as the previous groundwater monitoring event (October 2007). In addition, a sample was collected from the newly installed well adjacent to Kelly Field Pit (MW-12). Monitoring wells MW-2 and MW-11 were again dry, and therefore not sampled. In addition to the groundwater samples, a total of three quality control samples were collected including: one field duplicate, one field blank and one equipment rinsate blank.

Sample methods applied during this sample event are the same as the low-flow techniques used during the October 2007 groundwater monitoring event.

Monitoring wells that demonstrated low permeability conditions during this sample event included MW-4, MW-5, MW-6, MW-7d, MW-8, MW-9 and MW-12. For these wells, drawdown and recovery were a problem during low flow purging. Despite the low flow conditions encountered in these wells, complete dewatering of the well screens did not occur for any of the wells. The data collected during sample collection activities are summarized in Table 4-11.

Field sheets summarizing the data collected during purging and sampling activities are summarized in Appendix G and the results of the groundwater analysis are provided in Section 7.5. A tabulation of the water quality results is provided in Appendix H. Laboratory reports associated with Appendix H are provided electronically on the enclosed CD only.

Table 4-11: June 2008 Monitoring Well Purge Data and Field Data

Monitor Well	Initial Depth to Water (static)	Ending Depth to Water After Pumping	Top of Screen Interval	Dissolved Oxygen	pH	EC	Temp
	ft bgs	ft bgs	ft bgs	%	s.u.	µS	°C
MW-3	32.10	32.65	30	0.3	7.6	0.4	14.2
MW-4	18.16	21.79	35	1.8	7.3	0.4	22.7
MW-5	22.71	27.62	81	0.4	7.1	0.3	18.7
MW-6	28.55	30.86	52	2.6	6.6	0.4	15.6
MW-7s	23.20	23.55	26	5.5	6.9	0.5	11.5
MW-7d	17.72	28.92	176	0.6	6.4	0.3	18.8
MW-8	21.60	27.15	25	4.1	6.0	0.1	13.4
MW-9	67.42	78.60	82	0.7	6.2	0.4	19.3
MW-10B	13.15	13.15	9	5.3	6.8	0.2	15.2
MW-12	16.39	21.75	20	2.7	5.8	0.5	18.0

4.4.4 2009 Groundwater Sampling

In May 2009, groundwater samples were collected from 11 monitoring wells by SRK. Samples were collected from the same monitoring wells as the previous groundwater monitoring event (June 2008). Monitoring wells MW-2 and MW-11 were dry, and therefore not sampled. In addition to the groundwater samples, a total of three quality control samples were collected including: one field duplicate, one field blank and one equipment rinsate blank.

Sample methods applied during this sample event are the same as the low-flow techniques used during the October 2007 and June 2008 groundwater monitoring events. As with the previous sampling events, monitoring wells that demonstrated low permeability conditions included MW-4, MW-5, MW-6, MW-7d, MW-8, MW-9 and MW-12. For these wells, drawdown and recovery were a problem during low flow purging. Despite the low flow conditions encountered in these wells, complete dewatering of the well screen did not occur for any of the wells. The data collected during sample collection activities are summarized in Table 4-12. Field sheets summarizing the data collected during purging and sampling activities are provided in Appendix G.

In addition to the groundwater samples collected in May 2009, samples were collected from the newly installed piezometers in Kelly Field (PZ-3, PZ-4, PZ-5D, PZ-5S) and the Eagle Mine area monitoring wells (MW-13 and MW-14) following completion and development in August 2009. These samples were collected by airlift pumping during or after the hydraulic testing activities as described above. The data collected during sample collection activities are summarized in Table 4-13.

The groundwater chemistry results for the May 2009 and August 2009 sampling events are discussed in Section 7.5, and a tabulation of the water quality results is provided in Appendix H. Laboratory reports associated with Appendix H are provided electronically on the enclosed CD only.

Table 4-12: May 2009 Monitoring Well Purge Data and Field Data

Monitor Well	Initial Depth to Water (static)	Ending Depth to Water After Pumping	Top of Screen Interval	Dissolved Oxygen[a]	pH	EC	Temp
	ft bgs	ft bgs	ft bgs	mg/L	s.u.	µS	°C
MW-3	26.05	26.15	30	23.5	7.54	432	15.16
MW-4	20.85	23.05	35	13	7.28	423	17.28
MW-5	25.95	27.22	81	9.5	7.19	362	14.11
MW-6	34.71	35.59	52	24.6	7.03	483	15.57
MW-7s	25.25	25.25	26	47.7	6.27	563	10.66
MW-7d	20.41	49.95	176	3.6	5.94	338	10.98
MW-8	27.07	29.02	25	12.0	5.49	134	8.20
MW-9	72.45	75.75	82	4.1	5.96	305	12.98
MW-10B	15.62	15.77	9	80.6	6.43	190	14.77
MW-12	18.91	22.93	20	80.5	5.7	449	9.03

[a] The dissolved oxygen concentrations for several of the wells exceed the solubility of oxygen in water at the reported temperatures and estimated pressures and are probably inaccurate. The error, however, was consistent during purging and dissolved oxygen concentrations stabilized prior to collecting the samples.

Table 4-13: August 2009 Monitoring Well Purge Data and Field Data

Monitor Well	Depth to Water (static)	Volume of Water Purged	pH	EC	Temp	ORP
	ft bgs	gallons	s.u.	µS	°C	mg/L
PZ-3	6.7 [a]	40,000	7.53	383.5	20.4	-74
PZ-4	44.5	50	8.00	271.2	18.8	20
PZ-5S	98.7	40	7.90	96.22	16.7	212
PZ-5D	278.82	100	8.07	473.8	21.6	-62
MW-13	188.12	50	8.10	187.7	32.3	187
MW-14	186.78	40	8.16	210.1	22.8	199

[a] Water level measurement reported in feet above ground surface based on reading from the pressure gauge of 10 psi and a water column that weighs one pound per 2.31 feet.

4.5 Material Characterization Sample Collection and Testing

The material characterization program was designed to address mineralogy and bulk geochemical characteristics of mine materials associated with the Celatom Mine. Characterization data from this program supplements data collected previously by SRK from the Kelly Field and Section 36 pit areas, and provides additional baseline geochemical data for the proposed expansion areas including Hidden Valley, Eagle Mine, and North Kelly Field (Section 19 and 24). The material characterization program also includes by-products produced from mining and processing of diatomite ore. The following sources of sample material were included in the characterization program:

1. Drill core samples from active and proposed mine areas;
2. Samples of in-situ waste backfilled in the Kelly Field Pit and Beede Desert Pit;
3. Mineral process materials from the Vale Plant that are returned to the mine site; and
4. Sediment from sediment basin in Mill Gulch.

Sample collection and testing activities completed for these sources are briefly described in the following sections. Samples selected for geochemical characterization were submitted for the following tests:

- Bulk geochemical analysis using the CHEMEX MEMS-61 four acid digestion to determine total metal, metalloid and cation chemistry for 27 elements on each sample;
- Net Acid Generating (NAG) test reporting final NAG pH and final NAG value after a two-stage hydrogen peroxide digest;
- Acid Base Accounting (ABA) using the British Columbia Acid Mine Drainage Task Force (BCAMDTF) modified Sobek with Leco sulfur speciation analysis; and
- Meteoric Water Mobility Procedure (MWMP - ASTM E2242-02) and analysis of leachate.

The number of samples selected for each test summarized in the sample matrix provided in Table 4-14.

Table 4-14: Geochemical Characterization Sample Matrix

Sample Source	Sample Type	Contact Testing	Multi-Element	ABA	NAG	MWMP
2004 Samples	Pit Wall	31	31	7	7	7
	Drill Core	--	--	3	3	3
2006 Core Samples	Hidden Valley Drill Holes	31	9	9	9	9
	Beede Desert Drill Holes	18	8	8	8	8
	North Kelly Field Drill Holes	12	3	3	3	3
	Kelly Field Drill Holes	36	5	5	5	5
	Section 36 Drill Holes	20	9	9	9	9
2007 Pit Backfill Samples	Kelly Field Backfill	--	15	15	15	15
	Beede Desert Backfill	--	9	9	9	9
2006 Vale Plant Samples	Blended Ore	--	4	4	4	4
	Process Waste	--	2	2	2	2
2007 Vale Plant Samples	Process Waste	--	3	3	3	3
2007 Sed Pond Samples	Pond Sediment	--	2	2		2
	Total	**148**	**100**	**79**	**77**	**79**

Samples were submitted to McClelland Laboratories (MLI) in Sparks, Nevada for sample preparation, including compositing and MWMP extraction. The MWMP extracts were submitted to ACZ Laboratories, Inc. (ACZ) in Steamboat, Colorado for analysis, along with a split of each composite sample for Total Inorganic Carbon (TIC) and NAG testing. A separate split of each composite sample was sent to SVL Analytical in Kellogg, Idaho for ABA testwork. The material characterization program results are presented and discussed in Section 8, along with a comparison to the data collected during the 2004 ARD study.

4.5.1 Drill Core Sample Collection

For each drill hole that was advanced during the 2005 drilling program, small core samples were collected at approximately 5 to 10 foot intervals, screened to 100 percent passing 4.75 mm (when possible), and stored in a clean 8 oz plastic jar or Ziploc bag for field contact testing. Bulk samples consisting of 10 to 20 pounds of core material were also collected at 5 to 10 foot intervals.

These samples were collected for the material characterization program designed to address mineralogy and bulk geochemical characteristics of mine materials from existing and proposed expansion areas within the project area. This characterization program used a phased approach in which each phase was predicated on the results of the previous phases. For instance, the results of the initial field contact tests and observations were used to validate the material type delineations prior to selecting larger core samples for static testing.

Contact pH and EC were determined on a total of 117 samples collected from discrete lithologic intervals that are representative of the main rock types encountered during drilling. The procedure used to determine the potential field reactivity of the selected core samples was the same as that applied during the 2004 ARD study.

The results of the contact test results were used to select the sample intervals for compositing and additional geochemical testing and characterization in order to fully characterize the range of acid generation/neutralization and constituent leaching capacity for each rock type.

A total of 34 bulk samples were obtained by compositing discrete lithologic intervals from the drill holes in order to obtain a representative sample for static testing. Only samples of identical lithology and similar reactivity as indicated by contact tests (i.e., similar pH and EC values) were composited. The composite intervals selected for geochemical testwork are summarized in Table 4-15 below. Detailed descriptions of the selected sample intervals are provided in the drill logs in Appendix E.

From the site investigations, seven distinct geologic material types have been identified for the Celatom Mine including:

1. Alluvium/soil;
2. Oxidized diatomite;
3. Transitional diatomite;
4. Unoxidized diatomite;
5. Opalized diatomite;
6. Volcanic ash and tuff layers interbedded with diatomite deposit; and
7. Basement volcanic rocks including basalt and andesite.

The rationale used to determine the number of samples needed for characterization of each of these material types was based on several factors, including the relative abundance and geochemical significance of the material and the variability in the geochemical behavior as determined by the initial field screening testing and the previous ARD study.

Of these seven rock types, diatomite is the most abundant and represents the main material that will be exposed in pit walls. Of the three types of diatomite, unoxidized diatomite is the most significant in terms of geochemistry because of the potential for acid generation from this rock type, as demonstrated by the contact test results. However, because of the consistent nature and relatively simplistic composition (i.e., SiO_2) of the diatomite deposit, significant variability in the geochemical behavior of the diatomite is not anticipated, and an exhaustive sampling program was not warranted. This conclusion was supported by the results of the 2004 ARD study that showed variability between results from samples of the same material type is extremely limited. For instance, MWMP results from samples of unoxidized diatomite are very similar, and all show a potential for acid generation and metals leaching. Because of the internal consistency of the previous results and the type of deposit, testing of the diatomite deposit focused on the variability that exists between the different mine areas.

Geochemical characterization also included testing of the various volcanic rock types associated with the diatomite deposit, including interbedded ash and tuff, as well as volcanic basement rocks (basalt and andesite). Characterization of basalt and andesite is limited to the four (out of 12) drill locations where basement rock was encountered. Characterization of the interbedded ash and tuff is limited to locations where the interbedded material was of sufficient thickness to allow for collection of a representative sample. In general, fewer samples of ash and tuff were collected because these rock types do not account for a significant portion of rock types that will be encountered during mining. Furthermore, none of the pits will intersect the underlying volcanic sequence.

Table 4-15: Drill Core Sampling Frequency and Contact Test Inventory

Mine Area / Rock Types	Contact pH (s.u.)			Contact EC (µS)			# Contact Samples	# Composite Samples	Sample Intervals
	Min	Max	Mean	Min	Max	Mean			
Hidden Valley (MW-1, MW-2)									
Oxidized Diatomite	6.07	7.52	6.72	24.7	293	71.7	17	5	MW-1 (14-34) MW-1 (68-88) MW-1 (88-108) MW-2 (32-54) MW-2 (54-89)
Ash/Tuff	6.58	7.13	6.84	12.85	61.07	29.13	5	2	MW-1 (112.5-119) MW-2 (89-90)
Basalt Bedrock	6.34	7.33	7.06	9.16	36.8	20.6	9	2	MW-1 (122-156) MW-2 (90-112)
Beede Desert (MW-10B, MW-11)									
Alluvium	6.83	7.35	7.09	47.66	880.4	441.3	3	1	MW-10B (5-15)
Oxidized Diatomite	6.53	7.28	6.87	555.5	1164	808.2	3	1	MW-11 (5-25)
Transitional Diatomite	3.85	5.85	4.85	892.1	61.2	476.7	2	2	MW-10B (22-25) MW-11 (38-42)
Unoxidized Diatomite	3.7	6.45	5.20	681.6	933.5	830.9	5	2	MW-11 (48-65) MW-11 (70-100)
Ash/Tuff	6.72	6.72	6.72	311.7	607.5	459.6	2	1	MW-11 (27-30)
Basalt Bedrock	5.53	5.99	5.74	41.88	87.99	70.72	3	1	MW-11 (107-124)
Section 36 and Kelly Field Mine Areas in Mill Gulch (MW-3, MW-4, MW-5, MW-6, MW-7s, MW-7d, MW-8)									
Oxidized Diatomite	5.07	7.2	6.04	82.57	816.8	281.4	6	2	MW-6 (3-20) MW-7d (11-21)
Transitional Diatomite	5.82	6.8	6.27	32.46	435.7	190.7	5	1	MW-6 (20-25)
Unoxidized Diatomite	2.78	6.32	3.71	326	2618	1428	29	4	MW-6 (36-60) MW-7d (47-67) MW-7d (172.5-187) MW-8 (21-44)
Opalized Diatomite	5.07	6	5.41	262.5	816.8	550.2	3	2	MW-5 (26-41) MW-5 (41-60)
Ash/Tuff	4.78	6.9	5.8	95.9	583	319	8	3	MW-3 (5-30) MW-6 (34-36) MW-7d (145-154.5)
Basalt Bedrock	6.41	6.87	6.6	257	272	266	3	1	MW-3 (37-55)
Andesite Bedrock	3.73	6.6	5.165	191.2	1508	849.6	2	1	MW-5 (76-86)
North Kelly Field - Sections 19 and 24 in Mill Gulch (MW-9)									
Transitional	3.82	4.48	4.157	310.4	713	521.9	3	1	MW-9 (14-20)
Unoxidized Diatomite	2.87	6.32	3.76	633.9	2134	1456	7	1	MW-9 (43-68)
Ash/Tuff	4.87	4.91	4.89	426.1	644.3	535.2	2	1	MW-9 (35-43)
						Total	***117***	***34***	

4.5.2 Backfill Waste Sample Collection

Two types of waste are used as pit backfill material during concurrent reclamation activities at the site. These include: 1) waste that is a by-product generated during processing of diatomite ore at EPM's processing plant in Vale, Oregon; and 2) onsite mining waste that has been selectively removed from the mined ore and stockpiled during mining activities.

The mineral process waste consists of a mixture of impure diatomite, clay, volcanic ash, and soda ash that are removed from the ore grade diatomite during processing. The soda ash that is added as a fluxing agent during ore processing creates a mineral process waste that is highly acid neutralizing. The onsite mining waste consists of alluvial overburden as well as impure diatomite and volcanic ash and clay units that are interbedded with the diatomite deposit. During pit backfilling, the waste materials are mixed as they are pushed into the pit.

Two areas have thus far been backfilled with waste during mining activities, including the Kelly Field Pit and the Beede Desert Pit. The portion of the Kelly Field Pit that has been backfilled with mine waste and processing waste is approximately 3 acres and extends 75 feet bgs. It is estimated that waste backfilled in this area consists of 60% mineral process waste and 40% waste generated onsite during mining. The majority of the material used to backfill the Beede Desert Pit consisted of mineral process waste. In this area, the backfill covers an area of approximately 1 acre and extends to an estimated depth of 60 feet bgs.

In 2007, a truck mounted auger was used to collect auger samples from three locations within the Beede Desert backfill area (Figure 3-5) and seven locations within the Kelly Field backfill area (Figure 3-6). At each location, samples were collected at 3-foot intervals throughout the backfilled waste profile. These samples were then composited into 15 to 20-foot composites. The drill hole location information and sample intervals are summarized in Table 4-16.

Table 4-16: Backfill Waste Drill Holes and Sample Intervals

Location	Drill Hole	Lat	Long	Elev (ft amsl)	Depth (ft bgs)	Interval		# sub-samples
						From	To	
Beede Desert Backfill	BD-01	43.8754	-118.2843	3774.56	53	0	15	5
						15	30	5
						30	51	7
	BD-02	43.8758	-118.2836	3776.85	50	0	15	5
						15	30	5
						30	48	6
	BD-03	43.8760	-118.2831	3781.05	53	0	15	5
						15	30	5
						30	48	6
Kelly Field Backfill	KF-01	43.8897	-118.2188	4048.87	35	0	18	6
						18	36	6
	KF-02	43.8903	-118.2190	4048.49	41	0	18	6
						18	39	7
	KF-03	43.8912	-118.2193	4050.80	44	0	18	6
						18	39	7
	KF-04	43.8894	-118.2177	4056.00	11	No sample (hit refusal)		
	KF-05	43.8895	-118.2177	4054.88	53	0	15	5
						15	30	5
						30	51	7
	KF-06	43.8901	-118.2177	4057.48	32	0	15	5
						15	30	5
	KF-07	43.8914	-118.2176	4066.27	53	0	15	5
						15	30	5
						30	51	7

As shown in Table 4-16, a total of 9 composite samples were generated to represent the Beede Desert backfill and 14 samples were generated to represent the Kelly Field backfill. The recovered backfill material varied in both particle size and moisture and consisted of a mixture of off-spec diatomaceous earth, ash, clay, and rocks that ranges in particle size from clay to boulders. The samples were placed in air-tight sealed bags for transportation to the laboratory.

4.5.3 Mineral Process Waste Sample Collection

Samples of process materials were collected from the Vale processing plant during August 2006. These samples consisted of crude ore and waste stream material (i.e., mineral process waste) generated during the processing of diatomite ore. The crude ore samples consisted of a blend of oxidized and unoxidized ore grade diatomite collected prior to being placed in the kiln for processing. The mineral process waste stream samples consisted of the by-products produced from processing the blended ore and represented the material that is backhauled to the site. These materials are selectively removed from the diatomite ore during processing and include a mixture of impure diatomite, clay, volcanic ash, and soda ash. The latter is added to the diatomite as a fluxing agent during ore processing.

Small samples (~500 grams) of the process and waste materials were collected during the morning, afternoon and evening shifts over a two week period. These samples were composited to produce four samples representative of crude ore processed for the two active mine areas (Section 36 and Kelly Field) over the duration of a week for two weeks and two samples representative of the coeval waste stream that was generated during the same two week period. A total of 6 composites were produced for testing as summarized in Table 4-17.

Table 4-17: 2006 Vale Plant Composites

Sample	Composite Name	Sample Dates	Description	# Subsamples
1	C-KF-11-17	8/11/2006 - 8/17/2006	Kelly Field Blended Ore	21
2	C-KF-18-25	8/18/2006 - 8/25/2006		20
3	C-SEC36-11-17	8/11/2006 - 8/17/2006	Section 36 Blended Ore	21
4	C-SEC36-18-25	8/18/2006 - 8/25/2006		19
5	W-11-17	8/11/2006 - 8/17/2006	Waste Stream	31
6	W-18-25	8/18/2006 - 8/25/2006		27

Three additional waste stream composites were collected during 2007 from the processing plant in Vale, Oregon over a 3 month period (February, March, and April), as summarized in Table 4-18. Each composite sample consisted of sub-samples collected every day over the course of the month. Each subsample consisted of approximately 0.25 kg. The resulting composite consisted of approximately 7 kg of material that represents the mineral process waste that will be backhauled to the site during that month.

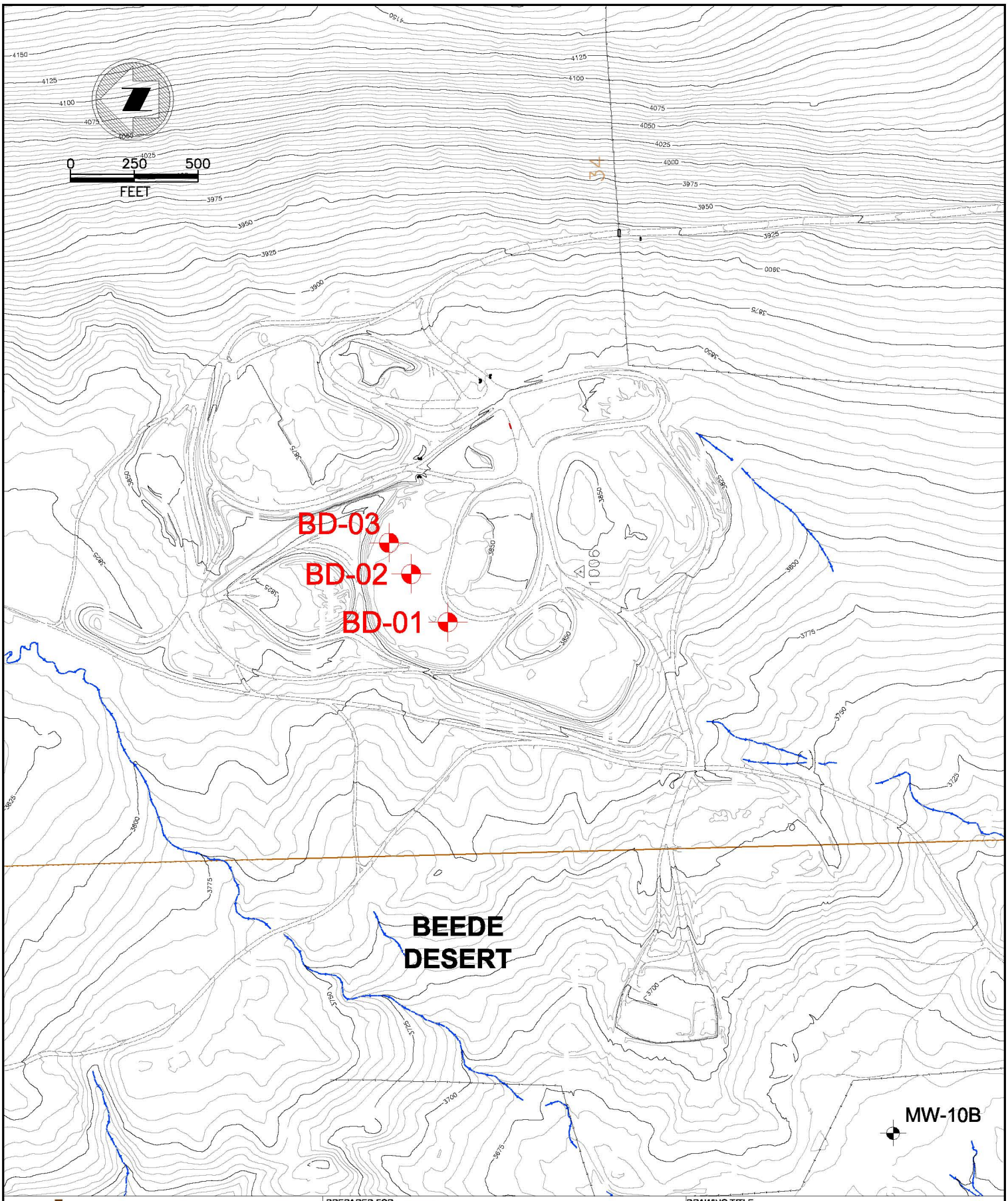
It should be noted that the by-products produced from processing of diatomite ore are controlled by numerous factors, and can vary with time. The samples of waste collected for this characterization program are not intended to be fully representative of waste generated during processing over the life of the mine, but rather, provide an indication of the potential buffering capacity of this material type.

Table 4-18: 2007 Vale Plant Composites

Sample	Composite Name	Sample Dates	Description	# subsamples
1	February Composite	2/1/2007 - 2/28/2007	Waste Stream	28
2	March Composite	3/1/2007 - 3/31/2007	Waste Stream	31
3	April Composite	4/1/2007 - 4/30/2007	Waste Stream	30

4.5.4 Sediment Pond Sample Collection

Sediment basins have been installed throughout the active mine areas in Mill Gulch to prevent stormwater from reaching the Mill Gulch drainage. The sediment basins are also used to evaporate water that accumulates in the base of the pits during an unusually wet year. At the request of the BLM, samples have been collected from the sediment basin downgradient of the Section 36 Pit for material characterization purposes. The sample material collected consists of a mixture of topsoil, clay and diatomite.



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EP Minerals™
AN EAGLEPICHER COMPANY

DRAWING TITLE:
BEEDE DESERT BACKFILL SAMPLE LOCATIONS

DESIGN: AP	DRAWN: ML	REVIEWED: -	
CHECKED: -	APPROVED: AP	DATE: 01/04/2010	
FILE NAME: Bsln_Fig3-6_KellyFld_ML_JQG_20100104.dwg			

CELATOM MINE BASELINE CHARACTERIZATION REPORT

DRAWING NO. **FIGURE 3-5**

SRK JOB NO. **152500.05**

REVISION NO. **A**

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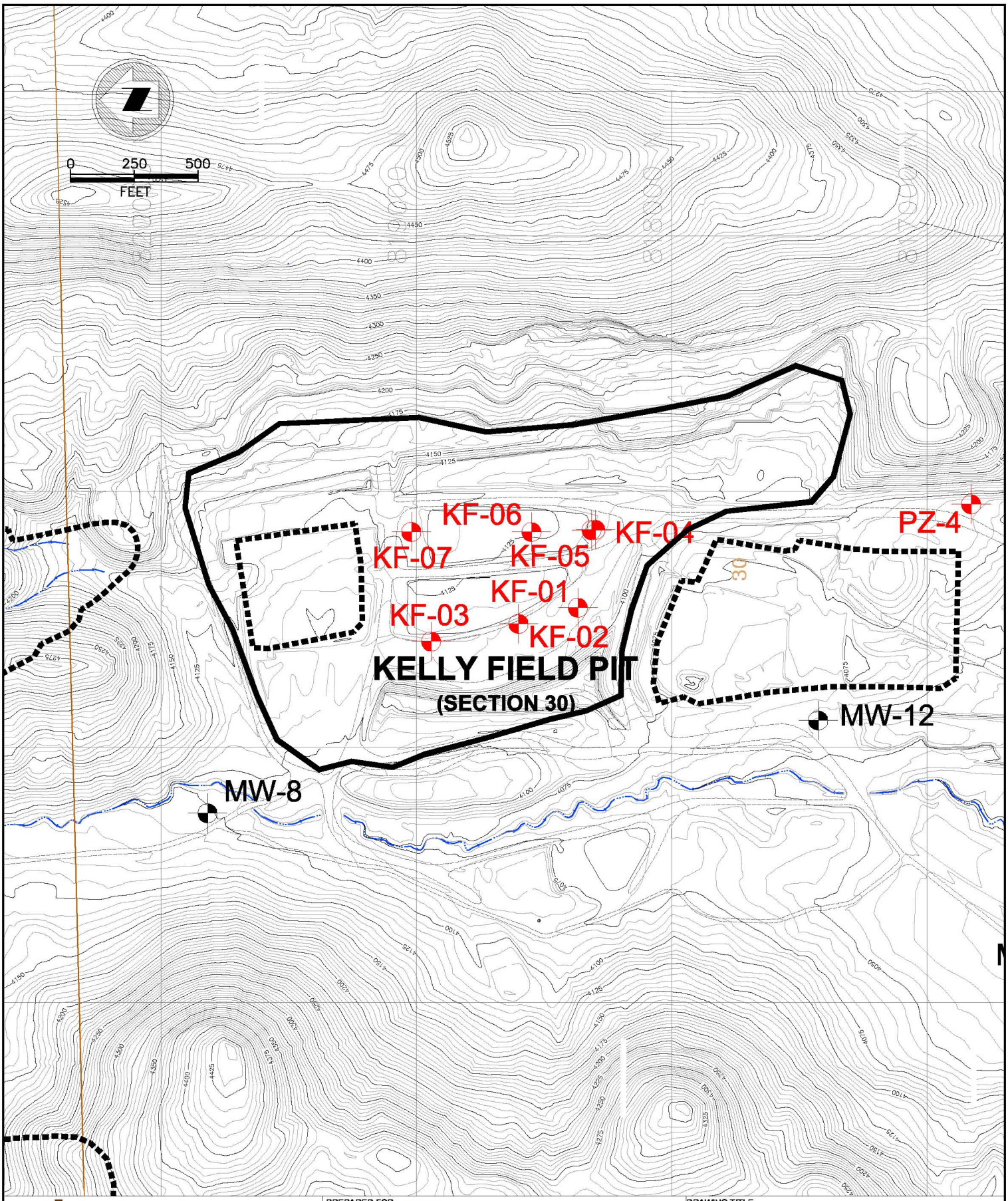

SRK Consulting Engineers and Scientists	PREPARED FOR: EP Minerals™ AN EAGLEPICHER COMPANY	DRAWING TITLE: KELLY FIELD BACKFILL SAMPLE LOCATIONS	
DESIGN: AP / DRAWN: ML / REVIEWED: -	CELATOM MINE BASELINE CHARACTERIZATION REPORT	DRAWING NO. FIGURE 3-6	REVISION NO. A
CHECKED: - / APPROVED: AP / DATE: 01/04/2010		SRK JOB NO. 152500.05	
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5. SITE GEOLOGY

5.1 Subsurface Geology

Subsurface conditions encountered during drilling were generally consistent with the geologic information available for the site, and indicate the geologic profile across the site is limited to the occurrence of a few major rock types. The main rock unit encountered during the drilling program was diatomite and, to a lesser extent, volcanic ash and tuff layers interbedded and underlying the diatomite deposit. Volcanic basement rocks consisting of andesite and basalt were also encountered during the various drilling activities.

The thickness of the diatomite deposit varies across the project area and is controlled by the configuration of the erosional surface of the underlying volcanic rocks. The diatomite deposit can be divided into an upper and lower diatomite unit based on differences in color and mineral content. The lower diatomite unit is unoxidized, as indicated by a distinct grey to green color on surface exposures. This portion of the diatomite deposit contains diffuse, amorphous sulfide blebs that are distributed uniformly throughout the unit. The unoxidized diatomite typically has higher sulfur content, as demonstrated by a noticeable sulfur odor, and the precipitation of sulfur crystals that develop on surface exposures in the summer as a result of high evaporation rates. Additionally, a strong iron oxide staining or coating is common on surfaces and fractures in the pit.

The upper oxidized diatomite unit is light tan to buff on surface exposures and turns very white when dry. The oxidized diatomite does not contain any visible sulfides and is occasionally interbedded with thin layers of gypsum. Also common in this unit is an iron oxide staining or coating on fractures.

Light to medium grey ash and tuff layers of variable thickness are interbedded with both the unoxidized and oxidized diatomite units, although they are more common at depth within the unoxidized diatomite. These layers of pyroclastic material are generally thin (1-2 centimeters) but can be as much as 30 feet and are very consistent in composition. Ash layers are composed of fine to very fine grained glass shards and pumice. The units described as tuff are coarser-grained equivalents of the ash layers and consist of pumice and glass fragments with some rounded quartz particles. The size of the pyroclastic particles within the tuff units range in size from fine ash to fine lapilli sized fragments. No mineralization was observed within either the ash or tuff units.

The frequency of the ash and tuff layers increases with depth toward the contact with the underlying volcanic basement. Immediately above the basement, lies a sequence of tuff and ash occasionally interbedded with organic-rich sediment representing the early stages of basin filling. The volcanic basement was encountered in several of the drill holes and generally consists of a black to dark grey aphanitic basalt that is commonly vesicular and locally weathered. Near the contact with the overlying sediments, the vesicles are occasionally filled with pyrite or an unidentified clay mineral. A detailed description of geologic profile encountered during the drilling program is provided for each general mine area in the following sections.

5.1.1 Mill Gulch Area

In the upper Mill Gulch (Kelly Field area), the thickness of the diatomite unit varies from about 400 feet in PZ-3 to less than 65 feet in PZ-4. Based on observations from drill holes PZ-5S, PZ-5D, PZ-3 and MW-7D, a relatively thick ash/tuff layer (30 feet) occurs within the middle of the diatomite sequence and, although missing in PZ-4, is fairly uniform over the area. The basement contact is similar in appearance across the Kelly Field area as observed in PZ-3, PZ-4 and PZ-5D. In this area, the diatomite deposit is underlain by approximately 50 feet of interbedded volcanic tuff and dark brown to black organic-rich sediments that represent the early filling of the basin. Immediately below this unit, lies vesicular aphanitic basalt with coarse pyrite grains filling the vesicles. At PZ-4, the diatomite deposit is thinner and the basement contact is similar, but occurs at a significantly higher elevation. These observations support the occurrence of a fault running along the trace of Mill Gulch as tentatively mapped by Greene (1972). However, Greene (1972) shows the fault movement with the down thrown fault block to the east. However, the subsurface information indicates PZ-4 is located on the upthrown block, as evidenced by the significant upward displacement of the tuff/organic sediment unit and the absence of the thick interbedded ash/tuff layer. The drill holes within the North Kelly Field (MW-8 and MW-9) were terminated within the diatomite and, as a result, the thickness of the deposit cannot be defined in these locations by this investigation.

To the south, in the lower Mill Gulch (Section 36), the diatomite deposit thins to the east, west and south with the thickest sequence observed in or near the Section 36 Main Pit. Weathered basalt was encountered at the most downgradient point in Mill Gulch (i.e., MW-3). This basalt belongs to the volcanic complex that regionally underlies the diatomite deposits. In this location, approximately 30 feet of a fine-grained weathered volcanic tuff overlies the basalt and the diatomite deposit is not present. The base of the diatomite unit was also encountered in Section 36 immediately to the north of MW-3 and south of the Section 36 Main Pit in MW-5. In this location, about 15 feet of fine-grained grey tuff/ash layer overlies a competent, greenish grey, andesitic tuff. A similar green tuff unit was encountered in PZ-3, PZ-4 and PZ-5D, above the basalt basement, and is possibly correlative.

In MW-5, the overlying diatomite unit is approximately 45 feet thick and has undergone various degrees of silicification (i.e., opalized diatomite) and mineralization (euhedral pyrite crystals). The occurrence of opalized diatomite in MW-5 suggests the drill hole is located at a point of gradual thinning of the diatomite deposit due to diatomite dissolution. Where this occurs silica is redeposited as opal (this is a hydrated poorly crystalline to amorphous version of silica) which partially cements the diatomite. The diatomite deposit thins to the south and is replaced by opalized diatomite as it approaches MW-3. Further south near MW-3, both the opalized diatomite and the diatomite deposit are missing entirely.

A possible northeast-southwest trending structure may offset basement rocks in lower Mill Gulch, accounting for thicker diatomite in Section 36 Main Pit, northwest of the gulch, in comparison to thinner diatomite over a shallow basement (e.g., MW-3, MW-5) roughly on the southeast side of the gulch and in the Section 36 East Pit.

The contact between the oxidized and unoxidized diatomite was encountered in all of the drill holes, except MW-3, where the diatomite is absent, and MW-5, where the diatomite has been opalized. The depth of this contact is fairly consistent and occurs between 18 and 30

feet bgs. The alluvial cover within Mill Gulch ranges from 3 feet at MW-6 to as much as 10 feet in the location of MW-8. The thickness of the alluvium is dependent upon where the drill hole location falls within the current erosional landscape. The depth of soil development is fairly consistent and extends to as much as 7 feet below the surface.

5.1.2 Hidden Valley Area

Both drill holes advanced in the Hidden Valley area encountered basalt below the diatomite deposit. Thin layers of ash and tuff separate the basal basalt unit from the overlying diatomite deposit. In Hidden Valley, the basalt is fine-grained, dark grey with fine to large vesicles occasionally filled with a fine-grained yellow clay. The upper 1 to 3 feet of the basalt showed signs of weathering (i.e., oxidized with some clay development). The underlying basalt was fresh (i.e., unweathered) and very competent, making drilling difficult using rotosonic drilling methods. The density of the basalt required water to be added during drilling, the implications of this in the identification of groundwater are discussed further in Section 7.

The thickness of the diatomite deposit in Hidden Valley ranges from 73 feet in MW-1 (northern portion of the valley) to 87 feet in MW-2 (southern portion of the valley). Based on the results of EPM's exploration program, the thickest section of diatomite occurs within the middle portion of the valley and thins towards the north (MW-1) and south (MW-2) and thins toward the east and west. The diatomite deposit in Hidden Valley differs from the diatomite deposit in Mill Gulch, in that the lower unoxidized diatomite unit is absent. The deposit consists of a thick sequence of high-grade oxidized diatomite ore containing very few impurities (based on assay by EPM). A few ash layers were observed throughout the diatomite deposit, however, the occurrence and thickness of the ash layers is significantly less than that observed to the east in Mill Gulch. Additionally, the diatomite in this location is generally dry near the surface with only a slight increase in moisture with depth. Even though the moisture content increases with depth, the diatomite was never fully saturated.

A thin veneer of soil ranging from 2 to 3 feet thick occurs at the surface in both Hidden Valley locations. This diatomaceous soil consists of silt and fine-grained sand with basalt gravel and cobbles near the surface.

5.1.3 Beede Desert

The geologic profile in the Beede Desert is defined by three drill holes (MW-10A, MW-10B, and MW-11).

In MW-10B, a 15-foot thick sequence of alluvium sits unconformably above the diatomite deposit. The alluvium consists of diatomite debris with some fine to medium rounded basalt gravel and minor cobbles. Desiccation cracks filled with a darker diatomite derived soil indicates a desiccation surface once existed in this area. The upper oxidized diatomite is generally absent in this location. Below the alluvium is seven feet of partially oxidized (i.e., transitional) diatomite. For the remaining length of the drill hole, the diatomite is a dark green color consistent with the lower unoxidized diatomite seen in Mill Gulch and the Eagle Mine area.

In the location of MW-10A, basalt, rather than diatomite, lies below an alluvial deposit composed of diatomite debris and rounded basalt clasts. The basalt was difficult to drill, and groundwater was not encountered within the upper 15 feet. As a result, the drill hole was

abandoned, and the observation point was moved approximately 500 feet downgradient to MW-10B.

5.1.4 Eagle Mine Area

The geologic profile in the Eagle Mine area consists of a relatively uniform diatomite deposit about 100 feet thick. Thin layers of ash and tuff separate the basal basalt unit from the overlying diatomite deposit. The basalt is competent and vesicular with a weathered zone extending about 5 feet below the basalt surface and is similar in character to that observed in Hidden Valley. However, the basalt in this location appears fractured and contains euhedral pyrite crystals within vugs and along fractures.

The diatomite deposit in the Eagle Mine area can be divided into an upper oxidized zone and lower unoxidized zone. In this location the contact between the oxidized and unoxidized diatomite occurs about 40 to 60 feet bgs. Within the upper 60 feet, the diatomite was dry and crumbly. The moisture content increased with depth and at approximately 70 feet bgs, the diatomite is fairly saturated. However, no water developed in the open boreholes.

5.2 Generalized Geologic Model

A simplified geologic model that includes generalized lithology and the oxidized/unoxidized boundary was developed by Mine Development Associates (MDA, 2009) for the Mill Gulch mine area using the existing drill hole database. The three-dimensional geologic block model was constructed by wire-frame triangulation modeling techniques using SURPAC mine planning software. Two generalized lithologic units were modeled by MDA; the diatomite and the underlying volcanic units. No geologic structures were included in the model. The MDA model does not capture faults, structures or interbedded ash or sand lenses in the diatomite. Even though these features exist in the Mill Gulch area, their frequency, distribution, and characteristics are poorly understood. Consequently, in this regard, the model is simplified.

A surface marking the boundary between the oxidized diatomite and the unoxidized diatomite was interpreted and modeled using detailed information from the drill hole database. The contact is easily distinguishable and was encountered in most of the drill holes. Therefore, the oxidized/unoxidized boundary can be confidently modeled. However, the drill data available for the depth of the diatomite/bedrock contacts are not very well populated, so in many areas, the occurrence of the basement unit was extrapolated from these limited data. Additional subsurface information was obtained during the 2009 drilling program following completion of the geologic model by MDA. Several of the drill holes (PZ-3, PZ-4, PZ-5A and PZ-5D) intercepted the diatomite/basement contact. Based on this newer information, the location of the basement contact was modified from the original MDA geologic model in those areas where new information was obtained. Additional data collected from PZ-5A, PZ-5S and PZ-5D were used to extrapolate the geologic conditions for Section 25.

The geologic model for Mill Gulch is provided in Appendix I as a series of cross-sections that show the current topography, the estimated future pit boundaries, the oxidized/unoxidized diatomite boundary, the bedrock basement contact, and the monitor well locations. A map showing the location of the cross-sections in relation to the proposed mine areas is also provided in Appendix I. At the time the MDA geologic model and cross-

sections were developed limited exploration data was available for the Section 25 and this area was not included in the geologic model.

As discussed in Section 7, a groundwater surface was also modeled using static groundwater elevation data collected within the Mill Gulch area during the 2009 field programs. The approximate water table that was estimated from this surface is shown in the cross-sections provided. Due to the limited number of wells completed in the underlying basement rock, the location of the deeper water table was not modeled or included in the cross-sections. A more detailed interpretation of the geology and groundwater conditions within Mill Gulch is discussed in Section 7.

5.2.1 Pit Geology

As shown in the cross-sections, the geologic units that will be exposed in the final Mill Gulch pits (Section 36, Kelly Field and North Kelly Field) include both oxidized and unoxidized diatomite. The bottoms of the pits will also be comprised of diatomite which will form a barrier of variable thickness above the volcanic basement rocks. As shown in the cross-sections, the majority of the proposed mining will take place above the water table in unsaturated diatomite. The pit boundaries shown in the cross-sections are approximated and the actual depth of the future pits will depend upon the depletion of ore grade diatomite and the depth to the basement rock.

Cross-sections containing simplified geologic information were developed for the Hidden Valley, Beede Desert, and Eagle Mine areas based on EPM mine plans developed from the exploration database. These cross-sections are provided in Appendix I. As shown in the cross-section in Appendix I, oxidized diatomite with insignificant interbeds of volcanic ash and tuff will be the only rock type exposed in the final Hidden Valley Pit. The diatomite in the Hidden Valley area is unsaturated and the proposed pit is located above the local water table.

The ore in Beede Desert is mainly oxidized diatomite with only a small amount of uneconomic, unoxidized diatomite below. Contour mining techniques have been used for the Beede Desert deposit, and all of the pit excavations have been backfilled with a combination of mine waste and plant process waste to an elevation approximating the original topography. The deposit is located above the water table and groundwater was never encountered during mining of the Beede Desert Pit.

The geologic units that will be exposed in the final Eagle Mine Pit will include both oxidized and unoxidized diatomite. The diatomite deposit in this location is shallow and, based on past exploration drilling, appears to be relatively uniform in thickness (~100 feet). Groundwater in the Eagle Mine area occurs within fractures in the basalt at a depth of about 188 feet bgs. Therefore, the Eagle Mine Pit excavation will only encounter unsaturated conditions and will be underlain by about 100 feet of unsaturated basalt.

6. SURFACE WATER HYDROLOGY

Baseline surface water inventories resulted in the identification of several surface water features within the hydrologic study area as described below according to surface water type. The surface water locations are shown in Figure 6-1.

6.1 Surface Water Features

6.1.1 Seeps and Springs

A total of 32 potential seeps and springs were identified within the hydrologic study area. However, all but five of the seep and spring locations were dry during the 2009 field program. The Tub Spring and Box Spring are the most prominent springs in the area and were included in preliminary surface water investigations conducted between 2005 and 2008. A description of the seep and spring sites that were sampled during the 2009 field survey are described below. A complete inventory and description of potential seeps and springs identified during the 2009 field program is provided in Appendix C. The results of the laboratory tests are discussed in Section 6.2.

Mill Gulch Seep (Site SE-C11)

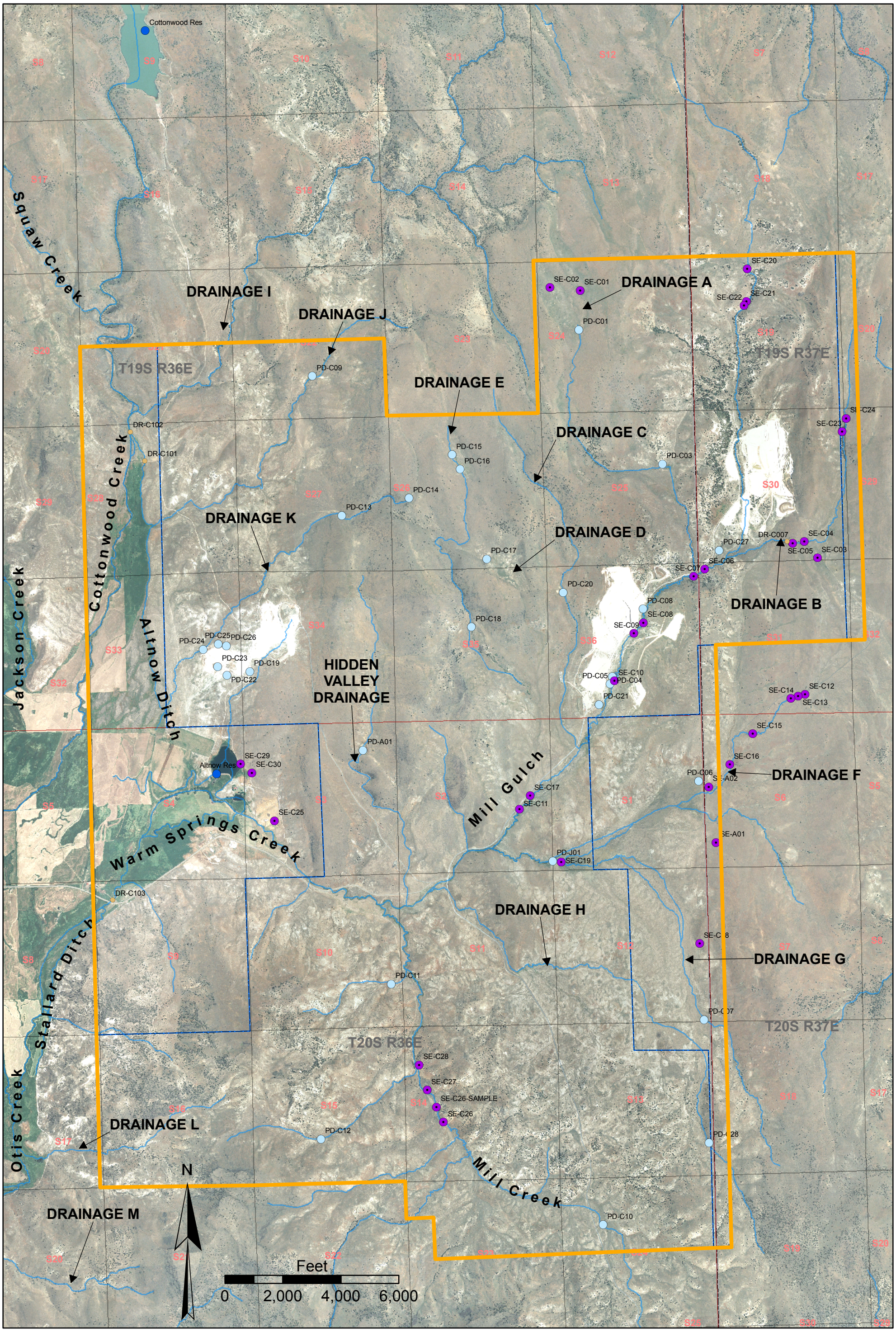
One seep area was identified within the Mill Gulch drainage that contained water suitable for sampling. This site is likely only visible as a separate water source when Mill Gulch is not flowing. Cattails were present at this point in the stream, indicating a higher water table. A pool of standing water beneath the cattails was present at the time of the 2009 field program, although no flow was observed. This sample site is located downgradient of mine facilities and therefore cannot be used to define background conditions.

Mill Creek Seeps (Sites SE-C26 and SE-C27)

Sites SE-C26 and SE-C27 are located within the Mill Creek drainage. These locations support wetland vegetation and shallow standing water within the Mill Creek drainage; however, there was no evidence of flow at either location, and both sites had been impacted by cattle. Although flow was not observed at either sample location, a flow measurement was obtained downgradient at site DR-C85. At this location, the flow rate was measured at 3.35 gpm using a cutthroat flume. However, some water escaped the flume through the heavily vegetated drainage bottom, so this measurement should be considered a minimum estimate of flow. These sample sites are located in an area that has not been disturbed by mining activities and represent background conditions for the Mill Creek area.

Mill Gulch Tributary Seep (Site DR-C007)

Site DR-C007 is located within a small tributary to Mill Gulch (Drainage B). During the 2009 field program, meteoric water, and water from the seeps above the site, had converged in the drainage for an observable flow. A surface water sample was taken using a flow pipe placed in the stream at a narrow point and the water was allowed to run through the pipe for approximately 10 minutes before the sample and a flow measurement were taken. The flow rate at that location was measured at 0.92 gpm. This sample site is located in an area not previously disturbed by mining and upgradient of existing mine activities and represents background conditions for surface water within the Mill Gulch area.



EXPLANATION

- Pond
- Resevoir
- Seep/Spring
- Project Area
- Drainage
- Hydrologic Study Area

SRK Consulting
Engineers and Scientists

DESIGN: CAS	DRAWN: JQG	REVIEWED: -
CHECKED: -	APPROVED: AP	DATE: 01/04/2010
FILE NAME: BsIn_Fig6-1_Sp_Spr_Res_JQG_20100125		

EP Minerals™
AN EAGLEPICHER COMPANY

CELETOM MINE
BASELINE CHARACTERIZATION REPORT

DRAWING TITLE:
SEEPS, SPRINGS, RESERVOIRS, STREAMS, & PONDS

DRAWING NO. FIGURE 6-1
SRK JOB NO. 152500.050
REVISION NO. A

Path: H:\EP Minerals\152500.05_Celatom_Additional_Baseline_Characterization\040_Drafting\BsIn_Fig6-1_Sp_Spr_Res_JQG_20100125.mxd

Tub Spring

The Tub Spring site is a developed spring within the Sage Flat basin located at the southern extension of a low-lying north-south ridge. Water issuing from this spring discharges to Sage Flat at a point northeast of the confluence with the Mill Gulch drainage. Spring water is captured with metal pipes and fed into a half-buried stock tank outfitted with overflow pipes that discharge to a low lying area where it collects within two ponds separated by a barbed wire fence. This water source supports a wide variety of birds and vegetation, in addition to cattle from the nearby ranches. A thick stand of cattails is located immediately upgradient of the stock tank.

During the initial field investigation (2005), the sample and flow measurement were collected at the inlet to the pond approximately 20 feet south and downgradient of the stock tank. The measured flow rate was 2 gpm in 2005. During the October 2007 sample event, the sample was collected at the outlet to the fenced wetland area located immediately upgradient of the stock tank using a peristaltic pump that was lowered into the stream of water issuing from the wetland area. Due to the low flow conditions in 2007, no flow measurement could be obtained. During the June 2008 sample event, the Tub Spring area was dry with the exception of stagnant water that pooled in small depressions created by cattle. Therefore, a representative sample could not be collected. During the 2009 sample event and field program, the sample and flow measurements were collected from the inlet pipe to the stock tank. At this time, the flow rate was 0.5 gpm.

Because Tub Spring has been developed and water is piped through a metal pipe, chemistry from this spring cannot be used to define background conditions for the project.

Box Spring

Box Spring is also a developed spring located in an unnamed drainage immediately east of the Kelly Field Pit operations. This area is separated from the pit by the Agency Ridge. From the USGS topographic map, surface water from Box Spring flows south for approximately 200 feet, where it turns westward and flows toward Mill Gulch through a gap in the ridge line.

Water flow from Box Spring is captured and fed into a half-buried stock tank via a metal pipe. Overflow from this stock tank drains to a second stock tank located immediately downgradient via PVC piping. From this stock tank, overflow is discharged to a small surface drainage that carries the water away from the stock tank area. Box Spring is shaded by a relatively thick stand of cedar and white juniper, and it is evident that this spring is a popular site for range cattle and wildlife, and appears to receive heavy use during the hot, dry season. As a result, the area immediately surrounding the stock tanks is devoid of any significant vegetation, other than a few sparse grasses and large, well-established trees.

During all sampling events, flow measurements and water quality samples were collected from the metal pipe feeding the first (i.e., upgradient) stock tank. Flow rates for the Box Spring have decreased from 2 gpm in 2005 to 1.3 gpm in 2008, to 1 gpm in 2009.

Because Box Spring has been developed and water is piped through a metal pipe, chemistry from this spring cannot be used to define background conditions for the project.

6.1.2 Ponds

A total of 29 ponds were identified within the hydrologic study area. Most of the ponds were stock ponds, and some of the ponds were sediment ponds associated with mining activities. All of these ponds were dry during the 2009 field program, including the Hidden Valley Pond, which contained water during the preliminary surface water investigations conducted between 2005 and 2008. A description of the Hidden Valley Pond site is provided below, and a complete inventory and description of pond areas identified during the 2009 field survey is provided in Appendix C.

The Hidden Valley Pond is a small man-made BLM stock grazing pond located at the lower end of Hidden Valley. This pond is an ephemeral water feature that is fed by intercepted surface water (stormwater) from the Hidden Valley watershed. This pond is located in an area that has not been disturbed by mining activities and represents background conditions.

The pond is elongate and oriented in line with the valley topography. Water is stored behind a berm constructed across the drainage on the downgradient margin of the pond. The pond has shallow sloping margins that gently deepen toward the downgradient end. It is likely this pond undergoes significant seasonal fluctuation, as evidenced by high water marks and a broad shoreline of mud with signs of desiccation. This water source supports the local livestock and wildlife and the water column is generally devoid of vegetation or algae. This area is most likely impacted by urea associated with the livestock manure in and around the pond recharge area.

During the initial 2005 field investigation, the pond was covered with ice and snow, and an area of ice was removed in order to collect the sample. During the 2007 and 2008 sampling events, the pond level was very low. The pond level has continued to decrease, and by May 2009, only a small area adjacent to the berm contained standing water. During the 2009 field program in August, there was no standing water remaining. Photographs of the Hidden Valley Pond taken during each 2009 sampling event are provided in Appendix B and C.

6.1.3 Drainages

The major drainages within the hydrologic study area include: Mill Gulch, Mill Creek, Warm Springs Creek, Cottonwood Creek, the Altnow Ditch, and the Stallard Ditch. During the 2009 field program, 12 tributaries to these larger drainages were also identified. Multiple observations were taken along the length of these tributaries and documented. Many of the drainages appeared to have seen seasonal flows in the past, although flowing water was only observed in portions of Mill Creek, the lower reaches of Warm Springs Creek, Cottonwood Creek, and in the Altnow Ditch and Stallard Ditch downgradient of the Altnow Reservoir.

SRK also conducted a preliminary Waters of the United States (WoUS) jurisdictional determination survey within the study area boundary to assess the location and extent of potential jurisdictional resources as regulated by the USACE. Waters from the hydrologic study area flow west toward Cottonwood Canyon and south toward Malheur Lake. From Malheur Lake, the water flows east into the Malheur River which joins the Snake River near the Oregon-Idaho border. The Snake River flows north into the Columbia River. The Columbia and Snake rivers are navigable water ways, thus are jurisdictional under the USACE. The waters within the hydrologic study area could be jurisdictional, as tributaries to a navigable waterway or as wetlands adjacent to jurisdictional waters.

The field investigation indicated that WoUS are potentially located within the project area as indicated by the stream geomorphology and vegetation characteristics. However, further investigations would be required for a full and conclusive delineation. Potential wetland areas were located within Mill Gulch, Mill Creek, Warm Springs Creek, and the Altnow Ditch agricultural area. Potential wetland areas were also located in Drainage B, Drainage F, Drainage G, Drainage H, in some pond bottoms, and around isolated seeps upgradient of Drainage A.

6.1.4 Perennial Reservoirs and Streams

The only permanent water body located within the hydrologic study area, is the Altnow Reservoir. The Altnow Reservoir is located downgradient and southwest of the Beede Desert operations, and is reportedly fed by an artesian water source. During the 2009 field program, a sample was taken from the edge of the reservoir, just in front of an earthen dam. The reservoir appeared full at the time of observation (i.e., no visible high water marks). The Altnow Reservoir feds the Altnow Ditch, which is located upgradient from the Stallard Ditch that connects Warm Springs Creek and Otis Creek. During the 2009 field program, flow measurements taken with a digital meter indicated a flow rate of 2,420 gpm in the Altnow Ditch.

The Cottonwood Reservoir site is located north and upgradient of the proposed mining operation. Even though this water body is not located within hydrologic study area, a sample was taken at the edge of the reservoir during the 2009 field program to define background conditions. At that time, the reservoir appeared to have a low water level as indicated by the exposed high water line. The Cottonwood Reservoir feds the Cottonwood Creek that flows south toward the Altnow Ditch and irrigation system. Flow measurements taken with a digital meter indicated a flow rate of 11 gpm in the Cottonwood Creek.

6.2 Surface Water Quality

Water quality samples were only collected from the three most prominent surface water features (i.e., Tub Spring, Box Spring and Hidden Valley Pond) during the 2005/2006, 2007, and 2008 sampling events. A total of 11 water quality samples were collected during the 2009 field program. Locations with waters suitable for sampling included:

- Two improved springs (Tub Spring and Box Spring);
- Two seep locations within Mill Creek;
- One seep location within Mill Gulch;
- One seep location within Drainage B (a tributary to Mill Gulch);
- Three perennial stream locations, including the Cottonwood Creek, the Altnow Ditch and where the Cottonwood Creek is diverted into the Altnow irrigation ditch; and
- Two perennial reservoirs, including the Cottonwood Reservoir and Altnow Reservoir.

In addition, surface water samples were collected by EP Minerals in April 1995 from water that collected within the Sections 36 Pit and Kelly Field Pit after the spring freshet. Water quality results from these samples were compared to Oregon MCLs. Samples from the perennial surface water features were also compared to Oregon Aquatic Life Criterion.

6.2.1 Spring and Seep Water Quality

The water quality data for the seep and spring water samples are summarized in Table 6-1 for select parameters. A complete tabulation of the data are provided in Appendix H. Laboratory reports associated with Appendix H are provided electronically on the enclosed CD only. Similar to previous sample events conducted by EPM for Tub Spring and Box Spring, manganese and iron (total and dissolved) were elevated above the Oregon MCLs in Tub Spring and none of the parameters were above Oregon MCLs in Box Spring. Manganese (total and dissolved), total iron and total aluminum were also elevated in the Mill Gulch seep and the tributary to Mill Gulch (Drainage B). Total and dissolved arsenic values are also slightly elevated above the Oregon MCL in the tributary to Mill Gulch. All constituents are below the respective MCLs in the two Mill Creek seep samples, with the exception of total and dissolved manganese values that are elevated in the most downgradient location (i.e., SE-C27).

Based on results from sites located upgradient of existing mine areas or in areas not previously disturbed by mining (i.e., background conditions) constituents that may be naturally elevated include aluminum, arsenic, iron and manganese. In the Mill Creek drainage, only manganese is elevated for background conditions.

Table 6-1: Spring and Seep Chemistry

PARAMETER	Oregon MCLs (333-061-0030)	Tub Spring	Box Spring	Mill Gulch Seep	Tributary to Mill Gulch	Mill Creek Seep	Mill Creek Seep
		SP-A02	SE-C23	SE-C17	DR-C07	SE-C26	SE-C27
Aluminum, dissolved	0.2	<0.03	<0.03	<0.03	<0.03	<0.03	0.04
Aluminum, total	0.2	<0.03	<0.03	1.19	0.76	0.06	0.04
Arsenic, dissolved	0.01	0.0023	0.0045	0.0059	0.0146	0.0012	0.001
Arsenic, total	0.01	0.0019	0.0041	0.0059	0.015	0.001	0.001
Iron, dissolved	0.3	0.37	<0.02	0.27	0.31	0.02	0.02
Iron, total	0.3	0.89	<0.02	1.54	1.49	0.06	0.04
Manganese, dissolved	0.05	0.846	<0.005	2	1.4	0.015	0.059
Manganese, total	0.05	0.884	<0.005	2.04	1.47	0.015	0.066
Nitrate/Nitrite as N	10	<0.02	0.09	0.03	0.16	<0.02	<0.02
pH (s.u.)	6.5-8.5	8.2	8.2	7.8	8.3	8.2	8.6
Total Dissolved Solids	--	300	250	420	520	280	270
Sulfate	250	40	20	80	70	33	46
Total Alkalinity	--	176	193	219	268	165	155

All values reported in mg/L unless otherwise noted.
Shaded values exceed the respective Oregon Maximum Contaminant Levels (MCLs) as regulated by 333-061-0030.
< Denotes less than the specified laboratory method detection limit (MDL).

6.2.2 Pond Water Quality

During the 2009 field program, none of the surface water ponds within the hydrologic study area, including the Hidden Valley Pond, contained water suitable for sampling. However, water samples have been collected from the Hidden Valley pond during previous sampling events.

The chemistry for the Hidden Valley Pond from the three earlier sampling events is summarized in Table 6-2 for select parameters. A complete tabulation of the data are

provided in Appendix H. Laboratory reports associated with Appendix H are provided electronically on the enclosed CD only.

As shown in Table 6-2, aluminum, iron and manganese are consistently elevated above the respective MCLs, and the total metals concentrations are several orders of magnitude greater than the dissolved metals for all three samples. These constituents are naturally elevated in the Hidden Valley Pond and are likely to be elevated during future monitoring events.

Despite the similarities, the TDS and sulfate results for the 2005 sampling event are considerably higher than the other two sampling events, even though samples were collected from the same location using the same sample collection methods. For the October 2007 and June 2008 sampling events, TDS and sulfate concentrations were below the respective MCLs. In addition, total metals concentrations are greater for the October 2007 and June 2008 samples. This might be due to the occurrence of a surface water runoff event prior to sample collection. The introduction of surface water runoff to the pond could potentially reduce sulfate and TDS loads (by dilution) and increase suspended solids in the water column, resulting in an increase in total metals concentrations.

The watershed upgradient of Hidden Valley Pond, is undisturbed and mining activities have not yet been expanded to this area. The elevated metals and sulfate concentrations in the Hidden Valley Pond can be attributed to colloidal suspensions and the natural process of concentration by evaporation (i.e., evapoconcentration) of constituents in surface water runoff that is collected and stored in the pond.

Table 6-2: Hidden Valley Pond Chemistry

Parameter	Fraction	Hidden Valley Pond				Oregon MCLs (333-061-0030)
		Nov-09	Oct-09	Jun-09	May-09	
pH (s.u.)	--	7.7	8.1	7.9	7.3	6.5-8.5
TDS	--	**1520**	360	210	380	500
Sulfate	--	**510**	20	10	25	250
Alkalinity	--	44	202	81	33	--
Aluminum	dissolved	**5.19**	**1.92**	**6.6**	**0.23**	0.05-0.2
	total	**111**	**371**	**183**	**155**	
Arsenic	dissolved	0.0026	0.0049	<0.003	0.0011	0.01
	total	0.01	**0.039**	0.006	0.009	
Iron	dissolved	**1.94**	**4.22**	**2.68**	0.16	0.3
	total	**108**	**374**	**159**	**123**	
Manganese	dissolved	0.04	**0.909**	**0.672**	**0.063**	0.05
	total	**0.891**	**9.46**	**3.25**	**1.27**	

All values reported in mg/L except pH, which is reported as s.u.
< denotes less than the specified laboratory method detection limit.
Shaded values exceed the respective Oregon MCLs (333-061-0030)

6.2.3 Perennial Stream and Reservoir Water Quality

Four aquatic life samples were collected from perennial surface water features including the Cottonwood Reservoir, Cottonwood Creek, Altnow Reservoir and the Altnow Ditch. The water quality data for the surface water samples are summarized in Table 6-3 for select parameters along with Oregon Aquatic Life Criterion and Oregon MCLs. A complete

tabulation of the data is provided in Appendix C. Laboratory reports associated with Appendix C are provided electronically on the enclosed CD only.

This comparison indicates dissolved aluminum concentrations in both the Cottonwood Reservoir and Cottonwood Creek were above the Oregon Aquatic Life Criterion of 0.087 mg/L. Total aluminum and total iron concentrations were elevated in all samples, except the Altnow Reservoir sample. Both total and dissolved manganese values were greater than the Oregon MCLs, but less than the Oregon Aquatic Life Criterion in the Altnow Ditch and Cottonwood Reservoir. In addition, the pH values observed in both reservoirs was greater than the Oregon MCL of 8.5 s.u. All other parameters were below the respective Oregon Aquatic Life Criterion and Oregon MCLs. For the sample collected at the Altnow irrigation ditch diversion within the Cottonwood Creek drainage, the only parameter that is elevated above Oregon MCLs is aluminum. Dissolved aluminum concentrations at this location are comparable to aluminum concentrations observed in the aquatic life samples collected from Cottonwood Creek and the Cottonwood Reservoir.

Based on results from sites located upgradient of existing mine areas (Cottonwood Reservoir and Cottonwood Creek), constituents that have the potential to be elevated in background conditions include aluminum, iron and manganese.

Table 6-3: Perennial Stream and Reservoir Water Quality

Parameter	Oregon MCLs (333-061-0030)	Aquatic Life Criteria		DR-C103 (Altnow Ditch)	Cottonwood Reservoir	DR-C102 (Cottonwood Creek)	Altnow Reservoir
		Acute (CMC)	Chronic (CCC)				
Aluminum, dissolved	0.2	0.75	0.087	<0.03	0.19	0.12	<0.03
Aluminum, total	0.2	0.75	0.087	0.51	4.66	0.5	0.04
Arsenic, dissolved	0.01	0.85	0.048	0.0014	<0.0005	<0.0005	0.0008
Arsenic, total	0.01	0.85	0.048	0.0015	0.0005	<0.0005	0.0009
Iron, dissolved	0.3	--	--	0.09	0.27	0.15	<0.02
Iron, total	0.3	--	--	0.68	3.25	0.3	0.04
Manganese, dissolved	0.05	--	--	0.055	0.054	0.02	<0.005
Manganese, total	0.05	--	--	0.196	0.087	0.013	<0.005
Mercury, dissolved	0.002	0.0024	0.000012	0.0000006	0.000004	0.0000008	0.0000003
Mercury, total	0.002	0.0024	0.000012	0.0000006	0.0000028	0.0000009	0.0000003
Nitrate/Nitrite as N	10	--	--	0.1	<0.02	<0.02	<0.02
pH (s.u.)	6.5-8.5	--	--	8.2	8.5	7.8	9.4
Total Dissolved Solids	500	--	--	140	120	100	120
Sulfate	250	--	--	<1	<1	<1	<1
Sulfide as S	--	--	0.002	<0.02	0.02	<0.02	<0.02
Total Alkalinity	--	--	20[a]	80	45	50	70

All values reported in mg/L unless otherwise noted.

Shaded values exceed the respective Maximum Contaminant Levels (MCLs) or aquatic life criteria.

< Denotes less than the specified laboratory method detection limit (MDL).

[a] Oregon Aquatic Life Criterion of 20 mg/L for alkalinity is derived from the EPA Aquatic Life Criterion, which is a minimum value (EPA, 1986).

6.2.4 Pit Surface Water

The water quality data for the April 1995 and February 2010 samples are summarized in Table 6-4 for select parameters. A complete tabulation of the data is provided in Appendix H. Laboratory reports associated with Appendix H are provided electronically on the enclosed CD only. Results from the April 1995 and February 2010 pit surface water are considered comparable to any water that may collect in the existing and proposed pits that intercept unoxidized diatomite. In Table 6-4, this chemistry has been compared to Oregon MCLs and background surface water chemistry for Mill Gulch as defined by DR-C07 (Tributary to Mill Gulch). In addition, two samples were collected from water in the sediment ponds within Mill Gulch. Background surface water chemistry for the Eagle Mine is not available and has therefore not been included in this comparison. The Hidden Valley pit will only expose oxidized diatomite and therefore the results below do not apply to surface water that may collect in the Hidden Valley pit.

Table 6-4: Pit Surface and Sediment Pond Water Quality

Parameter	Oregon MCLs (333-061-0030)	DR-C07 Tributary to Mill Gulch	1995 Pit Water		2010 Surface Water Samples			
			S-36 Pit Water Sample	Kelly Field	KELLY FIELD PIT	S36 PIT	SED BASIN 1	SED BASIN 2
Total Alkalinity	--	268	0	0	<2	<2	47	5
Acidity as $CaCO_3$	**--**	<10	--	--	100	20	<10	<10
Chloride	250	33	2	2	1	<1	13	2
Fluoride	2	0.3	0.59	0.36	0.5	<0.1	0.3	0.1
Nitrate/Nitrite as N	10	0.16	<0.1	<0.1	0.17	0.09	0.72	0.18
pH (s.u.)	6.5-8.5	8.3	**3.2**	**3.1**	**3.3**	**4.2**	7.6	7
Sulfate	250	70	**441**	**316**	**440**	19	**260**	65
Total Dissolved Solids	500	**520**	**670**	**506**	**650**	30	460	120
Aluminum, dissolved	0.2	<0.03	--	--	**8.41**	**1.19**	<0.2	0.06
Aluminum, total	0.2	**0.76**	**3.8**	**5.3**	**8.69**	**2.02**	**2.25**	**8.29**
Arsenic, dissolved	0.01	**0.0146**	--	--	0.0017	<0.0005	0.0057	0.0021
Arsenic, total	0.01	**0.015**	0.006	<0.005	0.0022	0.0009	0.0059	0.0061
Iron, dissolved	0.3	**0.31**	--	--	**3.87**	**0.32**	0.1	0.03
Iron, total	0.3	**1.49**	**2.05**	**3.56**	**4.49**	**1.54**	**2.4**	**7.85**
Manganese, dissolved	0.05	**1.4**	--	--	**1.12**	**0.299**	**0.19**	0.029
Manganese, total	0.05	**1.47**	**1.18**	**0.56**	**1.09**	**0.538**	**0.267**	**0.099**

All values reported in mg/L except pH, which is reported as s.u.
< denotes less than the specified laboratory method detection limit.
Shaded values exceed the respective Oregon MCLs (333-061-0030)
Parameters not reported in this table were below the respective Oregon MCLs.

As shown in Table 6-4, the pit surface water samples from 1995 and 2010 are comparable with acidic pH values ranging from 3 s.u to 4 s.u. and concentrations of aluminum, iron, manganese, sulfate and TDS elevated above Oregon MCLs. However, these concentrations are comparable to background conditions observed for sample DR-C07, with the exception of sulfate which is lower in the background sample. The sediment pond chemistry is comparable to the pit waste and also has elevated aluminum, iron, manganese and sulfate

concentrations, although concentrations are lower than those observed in the pit water and pH values are 7 s.u.

6.2.5 Categorization of Surface Water Types Based on Chemistry

In Figure 6-2, the major ion concentration of water samples collected in 2009 are plotted on a trilinear diagram. A trilinear diagram provides a method to compare water types based on the ionic composition of different water samples. Cation and anion concentrations for each sample are converted from milligrams per liter (mg/L) to milliequivalents per liter (meq/L) and plotted as percentages of their respective totals in two triangles. The cation and anion relative percentages in each triangle are then projected into a quadrilateral polygon that describes the water type.

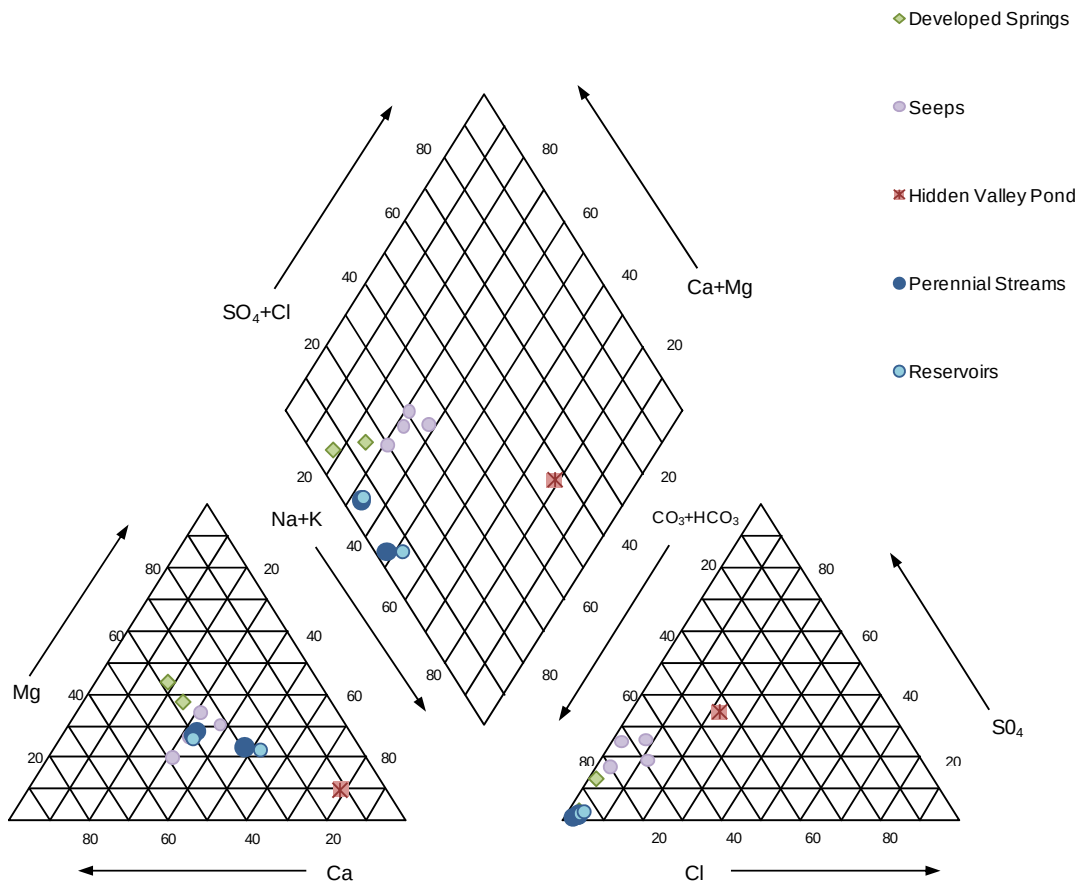
From Figure 6-2, the major ion chemistry for the Altnow and Cottonwood Creek perennial streams and associated reservoirs are all similar and show a strong enrichment in bicarbonate in comparison to the other samples. Although, the Altnow reservoir and Altnow ditch are slightly enriched in sodium+potassium in comparison to the Cottonwood Creek and Cottonwood Creek reservoir.

Samples collected from seeps within the Mill Gulch and Mill Creek drainages also plot in a similar area, and are classified as mixed cation-bicarbonate-type waters but show a slight increase in sulfate concentrations in comparison to the perennial streams and associated reservoirs.

The ionic composition of the two developed springs in the area (Tub Spring and Box Spring) is similar and can be classified as mixed cation-bicarbonate-type waters. These springs show a slight enrichment in magnesium ions in comparison to the other surface water samples, suggesting a more evolved groundwater source for the spring water.

The sample from the Hidden Valley pond collected during 2008 is enriched in sodium+potassium and chloride in comparison to the other surface water samples suggesting the pond chemistry is influenced by evapoconcentration.

Figure 6-2: Trilinear Plot – Surface Water



7. GROUNDWATER HYDROGEOLOGY

Geologic and hydrologic data collected from the site were incorporated into a conceptual hydrogeological model for the Mill Gulch, Hidden Valley and Beede Desert areas. The Mill Gulch area is the only proposed mine area where a shallow groundwater system was encountered within the diatomite deposit. A shallow groundwater system does not occur in the Hidden Valley area and the moisture content of the diatomite there is significantly lower than that observed in the other mining areas. Furthermore, groundwater has not been encountered in the Beede Desert area during past mining operations and a shallow groundwater system does not occur in the Eagle Mine area.

A discussion of the hydrogeologic data collected for the separate mine areas is provided in the following sections and the hydrogeologic conditions are illustrated in a series of cross-sections developed for the different mine areas. These cross-sections are provided in Appendix I and show the estimated water table surface in relation to geologic units and the anticipated pit boundaries.

7.1 Groundwater Levels

7.1.1 Mill Gulch Area

Water levels measured in the diatomite along the axis of Mill Gulch range from approximately 70 feet bgs in MW-9, the upgradient well in North Kelly Field, to 15 feet bgs in Test Well #2, downgradient from the mine. On average, the static groundwater levels within the diatomite stand at about 35 feet bgs in the Mill Gulch valley. The water level data collected during this investigation (along with water level data collected from the EP test wells) define a potentiometric surface within the diatomite in Mill Gulch (Figure 7-1) with flow from northeast to southwest along a horizontal hydraulic gradient of 0.023 ft/ft. Verification of the groundwater gradient in Mill Gulch is provided by data collected during past exploration drilling activities. Many of the original exploration rotary drill holes were terminated when diatomite moisture reached sufficient saturation to inhibit drill cutting returns. The total depths reported for numerous exploration drill holes throughout Mill Gulch roughly correspond with the estimated potentiometric surface as shown in Figure 7-1.

7.1.1.1 Diatomite Groundwater Levels

Although the potentiometric surface along the axis of Mill Gulch is well defined, measured diatomite water levels along sections across the valley are sparse. A relatively deep water level in PZ-5S, and undetected groundwater further to the west at the abandoned PZ-5A, suggest that the potentiometric surface, though generally rising with topography, is relatively subdued in cross section, at least beneath the lower slopes of Mill Gulch where mining is to occur.

7.1.1.2 Basement Groundwater Levels

Groundwater levels in the basement rocks beneath Mill Gulch were measured in PZ-3, PZ-4, and PZ-5D in upper Mill Gulch, and in MW-5 and MW-3, to the southwest in lower Mill Gulch. At PZ-4 and PZ-5D, on the east and west slopes of upper Mill Gulch, respectively, groundwater levels differ by nearly 165 feet. At PZ-5D, water levels in the basement are lower than groundwater levels in the diatomite, resulting in a downward gradient. The diatomite deposit near PZ-4 is thin and unsaturated; therefore, diatomite groundwater

elevation data in this location are not available. MW-12 is the nearest surveyed monitoring well to PZ-4 that is installed in diatomite, but this well is 1,200 ft away and about 33 ft lower in elevation. Therefore, a direct relationship between the diatomite and basement water levels cannot be made in this area. However, estimated contours of groundwater levels in the diatomite suggest that the water level in the basement is very near to the level in the diatomite.

In lower Mill Gulch, basement piezometer MW-5 is paired with diatomite piezometer MW-6, and also shows a slight downward gradient. The groundwater level measured in shallow basalt in MW-3, further down Mill Gulch, appears to be slightly deeper than the corresponding, projected potentiometric contours in the diatomite. These observations indicate there is a hydraulic connection between the diatomite unit and the underlying basement and in general the vertical groundwater gradients are downward through the diatomite into the basement.

Only at PZ-3 are basement groundwater levels higher than groundwater levels in the diatomite. At PZ-3, located between PZ-4 and PZ-5D where the straight, N-S oriented trace of upper Mill Gulch turns abruptly southwest, groundwater levels in the basement result in a flowing artesian well. PZ-3 is located along what is interpreted from aerial photos, and based on structural trends from Greene (1972) to be a north-south-oriented fault zone.

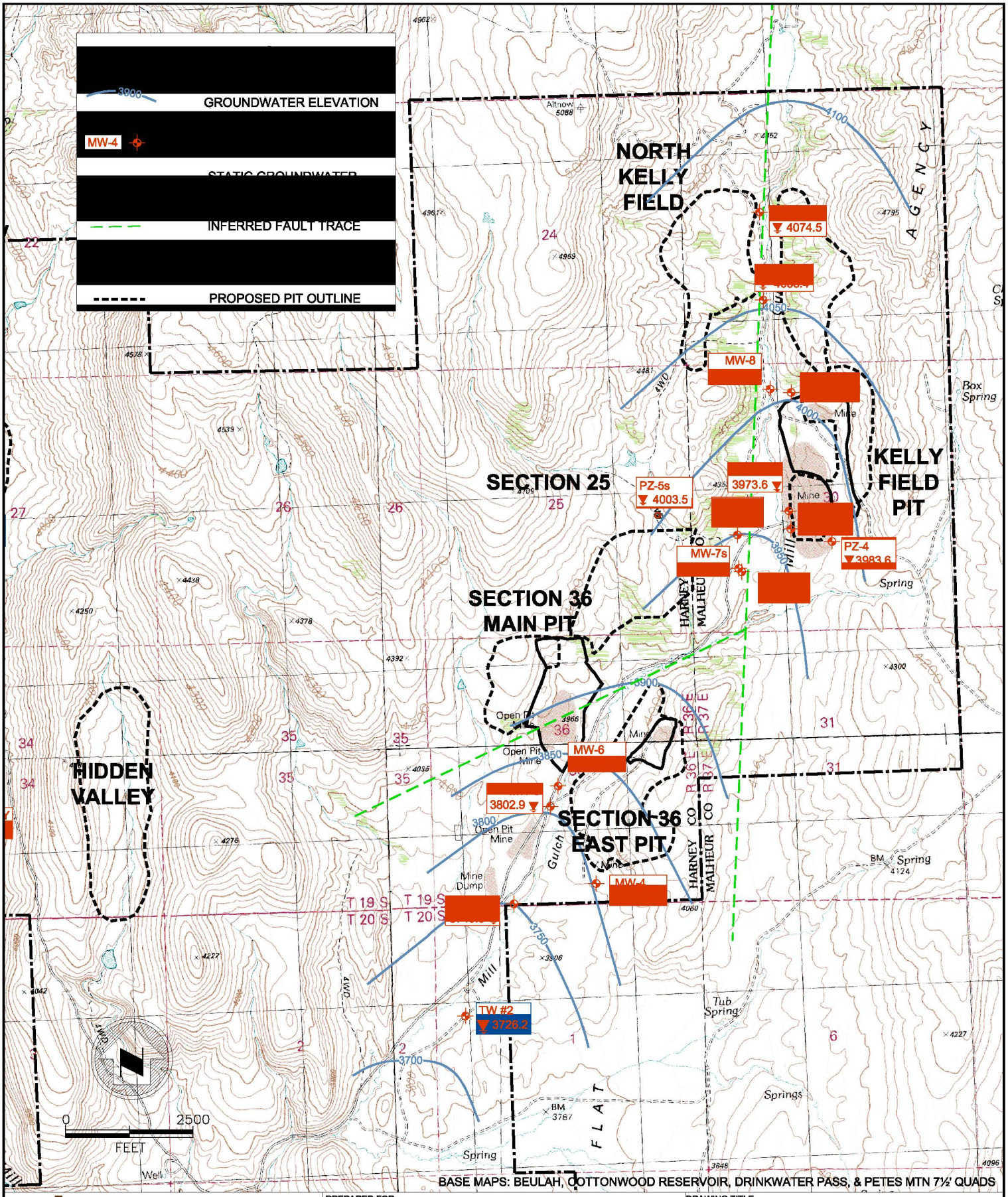
7.1.1.3 Seasonal Variations

Based on historic groundwater elevation data from the EP test wells, groundwater levels in both the basement and the diatomite fluctuate seasonally. In the various basement wells, dry season (November) water levels are about 1 to 5 feet lower than spring water levels; in the diatomite wells the range is about 0.25 to 4 feet (Appendix J). The hydrographs in Appendix J also indicate that groundwater levels have responded to at least two moderate droughts in the last 20 years, the most recent causing a general, more or less steady decline since 1998.

7.1.2 Hidden Valley Area

A shallow groundwater system does not occur in the Hidden Valley area and the moisture content of the diatomite in this location is significantly less than that observed in the other mining areas. Monitoring well MW-2 was installed as a downgradient well for Hidden Valley (Figure 3-4). Water was not encountered while drilling through the diatomite. A considerable amount of water was added while drilling the underlying basalt, making it difficult to confirm the presence of groundwater. The well MW-2 was completed in basalt at a depth of 112 feet. The well remained dry after the drill water was removed during development.

Another drill hole was completed on the north end of Hidden Valley (MW-1); however, water was not encountered in the diatomite at this location either. Based on the results at MW-2 (i.e., dry conditions), the decision was made to abandon the drill hole at the MW-1 location. Both MW-1 and MW-2 are therefore located above the regional groundwater surface.



BASE MAPS: BEULAH, COTTONWOOD RESERVOIR, DRINKWATER PASS, & PETES MTN 7½' QUADS

SRK Consulting Engineers and Scientists	PREPARED FOR: Ep Minerals™ AN EAGLEPICHER COMPANY	DRAWING TITLE: AUGUST 2009 POTENTIOMETRIC SURFACE MAP FOR MILL GULCH	
DESIGN: AP / DRAWN: ML / REVIEWED: -	CELATOM MINE BASELINE CHARACTERIZATION REPORT	DRAWING NO. FIGURE 7-1	REVISION NO. A
CHECKED: - / APPROVED: AP / DATE: 03/25/2010		SRK JOB NO. 152500.05	
FILE NAME: Bsln_Fig7-1_Potentiometric_ML_JQG_20100325.dwg			

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7.1.3 Beede Desert Area

Beede Desert is located west of Mill Gulch and Hidden Valley, and at a lower surface elevation. Within the Beede Desert mine no water has been encountered during past mining operations. Groundwater in this area occurs in the shallow alluvial system in the Otis Valley, located west of the mine.

Monitoring well MW-10 serves as a downgradient monitoring well for the Beede Desert area. As described in Section 4.2.1, basalt was encountered below the alluvium at the initial location for MW-10. The location was moved about 500 feet to the west, and MW-10B was installed to a depth of 29 feet and screened across the alluvium and diatomite contact. The well produces about 1.2 gpm while drawing down about 1ft. The groundwater at Test Well #9, approximately 200 feet northwest of MW-10B, is at about the same elevation as that of MW-10B. Artesian conditions occur in a well used for drill-water supply (Section 4.2.1), approximately 2,500 feet southeast of MW-10B, and about 40 feet lower in elevation.

7.1.4 Eagle Mine Area

As in the Hidden Valley area, a shallow groundwater system does not occur in the Eagle Mine area, located about one mile north of the Beede Desert wells. During drilling of MW-13 and MW-14, groundwater was not encountered in the diatomite that is relatively thin in this location (i.e., approximately 100 feet). Groundwater in the Eagle Mine area occurs within fractures in the basalt unit underlying the diatomite deposit. The depth at which groundwater was first encountered was controlled by the depth at which the groundwater bearing fractures were encountered. In MW-13, the depth at which groundwater was encountered was 280 feet and in MW-14 groundwater was encountered at 240 feet. The static depth to groundwater is similar for MW-13 and 14 at about 188 feet bgs. MW-11is located topographically higher than the other two wells and is screened to a depth of just 126 feet in basalt and is dry. The diatomite deposit in the Eagle Mine area is underlain by greater than 100 feet of unsaturated basalt and any moisture stored in the diatomite is not connected to the regional groundwater system.

7.2 Hydraulic Parameters

7.2.1 Hydraulic Parameters of Diatomite

An initial estimate of the hydraulic conductivity (*K*) values in diatomite is based upon single-well, slug and pumping tests conducted in 2006 and 2008 in newly-constructed monitoring wells. The 2006 test results showed a range in *K* of nearly three orders of magnitude, from 4.0×10^{-3} ft/day to 2.6×10^{-0} ft/day. Pumping tests in 2008 for MW-6 and MW-7S were done for periods of 2 and 4 hours, at discharge rates of just 0.4 and 1.3 gpm, respectively, while monitoring nearby piezometers. The 2008 results, and results of a single pumping test in 2009 for PZ-5S, included *K* values near the high end of the 2006 range of values (Table 7-1).

Table 7-1 also shows the depth to the top of the well screen for each of the tests conducted in diatomite. The data suggest there is a general decrease in the *K* values as screen depth increases; or more accurately, a strong break in *K* values occurs at about 50 feet bgs (Figure 7-2). Shallower screens yield a broad range of *K* values, but all are greater than 10^{-1} ft/day. Deeper screens yield *K* values in a narrower range, but less than 10^{-2} ft/day. This depth (50 feet) approximately coincides with the maximum depth of the root zone of phreatophyte

plants such as sagebrush and greasewood (see for instance Nichols, 1993). Consequently, the low *K* values in deep diatomite likely represent true values for undisturbed diatomite, and the higher *K* values nearer to the ground surface reflect increased permeability from varying degrees of biological disturbance of the aquifer materials. The test results from PZ-5S do not fit this general pattern (the value of 0.33 ft/day is higher than expected for a section of very deep diatomite). However, the geological log of PZ-5S shows that the well is partially screened across a thick tuff unit interbedded within the diatomite that may explain the higher *K* value obtained from this well.

Table 7-1: Summary of Hydraulic Tests for Mill Gulch Wells

Formation	Well	Method	*K* (ft/day)	Mean *K* (ft/day)	Top of Screen (ft bgs)
Diatomite Deposit	MW-4	pump/slug 2006	0.37	3.7E-01	35
	MW-6 [a]	pump/slug 2006	1.547	6.0E-01	47
		slug 2008	0.016		
		pump test 2008	0.24		
	MW-7s	pump/slug 2006	0.142	1.4E+00	25
		pump test 2008	2.56		
	MW-7d	pump/slug 2006	0.004	4.0E-03	175
	MW-8	pump/slug 2006	0.1	1.0E-01	25
	MW-9	pump/slug 2006	0.009	8.5E-03	82
	MW-12	pump/slug 2006	0.12	1.2E-01	15
		slug 2008	0.12		
	PZ-5S [b]	Pump test 2009	0.33	3.30E-01	305
Basement Volcanics	MW-3	pump/slug 2006	0.83	8.3E-01	30
	MW-5	pump/slug 2006	0.41	4.1E-01	81
	MW-13	airlift rec. 2009	6.1	6.1E-00	260
	MW-14	airlift rec. 2009	1.5	1.5E-00	210
	PZ-3	flow/shut-in	17.3	17.3E-00	468
	PZ-4	airlift rec. 2009	0.76	7.6E-01	96
	PZ-5D	slug 2009	1.3	1.3E-00	520

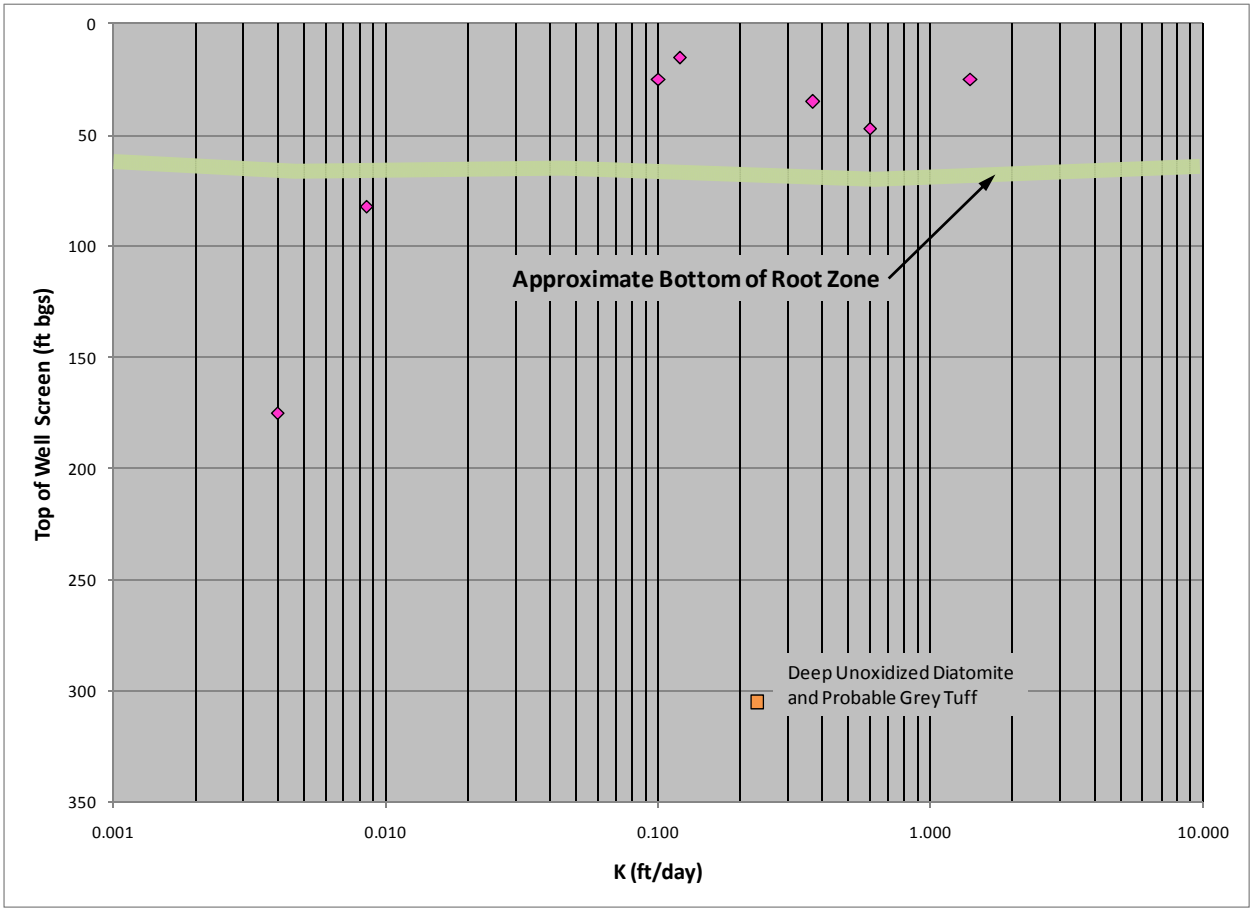
[a] Five feet was subtracted from the depth of the top of the well screen for MW-6 because it is located on a built-up road bed.
[b] this well was screened across a contact between a thick tuff layer and diatomite.

The arithmetic mean value of *K* from the deeper tests (excluding PZ-5S) is 7×10^{-3} ft/day, which is still near the upper end of the range of literature-reported values for diatomite. In the shallow root zone, (excluding a questionable pumping test in MW-12) the arithmetic mean value of *K* is 7×10^{-1} ft/day.

Storativity values in the diatomite were obtained from two multi-well pumping tests, in MW-6 and MW-7s, in the upper diatomite. Storativity is a dimensionless value and refers to the volume of water released from storage per unit decline in hydraulic head, per unit area of the aquifer. In the case of unconfined aquifers, the storativity is approximately equivalent to the effective porosity, which is the amount of interconnected pore space available for fluid flow. In diatomite, effective porosity is approximately equivalent to the external (between

the grains) porosity, rather than internal porosity (voids within individual tests). The storativity value obtained from the short-term test in MW-7s is 0.06, which is a reasonable estimate of the external porosity of diatomite (Inglethorpe, 1993). A much smaller value, 0.005, was estimated from the test results from MW-6, however, SRK believes that the larger value is more representative of the diatomite within Mill Gulch.

Figure 7-2: Hydraulic Conductivity of Diatomite vs. Depth of Well Screen



7.2.2 Hydraulic Parameters of Volcanic Basement Rocks

Tests of hydraulic conductivity in the basement rocks include slug tests in basalt and andesite conducted in 2006, and airlift pumping tests in basalt and in tuffaceous rocks interbedded with sediments in the upper basement contact conducted in 2009. The test results show a broad range of *K* values, from a single very low value of 4.1×10^{-4} ft/day in MW-5 to multiple values in the range of about 1×10^{-0} (Table 7-1). The arithmetic mean of basement *K* values, excluding the highest value, in PZ-3, is about 1.7×10^{-0} ft/day. The *K* value measured in PZ-3 is an order of magnitude higher, at $1.7\times10^{+1}$, and corresponds to a probable fracture zone along the axis of Mill Gulch.

7.3 Conceptual Hydrogeology

7.3.1 Current Groundwater Regime

Groundwater beneath Mill Gulch occurs in a shallow, water-table aquifer within the diatomite, and in a deeper aquifer in fractured volcanic basement rocks. The basement aquifer is locally confined by the overlying diatomite. The thickness of the diatomite aquifer in Mill Gulch appears to be controlled by a structure trending approximately N-S beneath the axis of upper Mill Gulch (referred to informally as the Upper Mill Gulch fault in this report). East of this structure the diatomite is about 75 feet thick, and lies over tuff, organic sediments, and basalt. West of the structure the diatomite also lies upon the sequence of tuff, organic sediments, and basalt, but is as much as 500 feet thick. A second, NE-SW trending structure may offset basement rocks in lower Mill Gulch, accounting for thicker diatomite in Section 36 Main Pit, northwest of the gulch, in comparison to thinner diatomite over a shallow basement (e.g., MW-3, MW-5) roughly on the southeast side of the gulch and in the Section 36 East Pit.

The majority of the diatomite aquifer is of very low permeability, whereas the uppermost 50 feet or so of the diatomite is of higher permeability (not withstanding a 20 to 30 feet thick bed of tuff in the lower diatomite, which is of higher permeability than the diatomite). The transition between high and low permeability within the diatomite is defined by the long-term position of the water table (i.e., high permeability above, low permeability below). In the same way, the long-term position of the water table generally coincides with the transition between oxidized and unoxidized diatomite. As a consequence, lateral groundwater flow in the diatomite occurs primarily in the low permeability, generally unoxidized lower aquifer, with only occasional flow in the upper, higher permeability, generally oxidized zone. Groundwater levels in the diatomite define a fairly regular potentiometric surface sloping down from the hill sides to the valley axis and down the valley, roughly corresponding with the stream gradient (Figure 7-1). The horizontal hydraulic gradient in upper Mill Gulch is 0.023 ft/ft. In view of the enhanced permeability of the upper diatomite, and the seasonal fluctuations in groundwater level, the majority of recharge to the diatomite aquifer is believed to be via direct precipitation. The diatomite may also be recharged, at least locally, from abutting and underlying basement rocks.

Lateral groundwater flow in the basement rocks very generally parallels the flow of groundwater in the overlying aquifer, following the slope of the valley. However, ground water levels in deep drill holes beneath Mill Gulch demonstrate a significant degree of compartmentalization in the basement aquifer. Very different groundwater levels are seen in PZ-5D, on the west side of the inferred Upper Mill Gulch fault versus groundwater levels in PZ-4, east of the fault. It is possible that hydraulic heads are elevated in the basement east of the inferred fault because groundwater flow in the volcanic rocks is impeded by low-permeability diatomite against which the volcanics abut. Groundwater in PZ-3 is at a level consistent with the level in PZ-4, although it is screened in basement rocks on the west side of the fault. However, PZ-3 is drilled very near to the trace of the inferred fault, and flowing artesian conditions in this location are believed to be the result of a direct hydraulic connection with higher heads in the volcanics to the east, and in recharge areas of upper Mill Gulch.

Vertical groundwater gradients are downward through the diatomite into the basement on the west side of the Upper Mill Gulch fault. Data points are sparse on the east side of the

fault; however, at PZ-4, drilling results suggest that the vertical gradient could be slightly upward. The gradient is obviously upward along the axis of the valley, as demonstrated at PZ-3. Recharge to the basement aquifer is via lateral inflow from basement rocks exposed at higher elevations, and locally via vertical flow (conceptually a much smaller component) from the overlying diatomite.

A shallow groundwater system was not encountered in the diatomite in the Hidden Valley and Eagle Mine areas. Groundwater in these areas lies within the volcanic basement, significantly below the base of proposed mining. A potentiometric map was not constructed for the basement groundwater aquifer in the Hidden Valley and Eagle Mine Areas due to the broad spacing of wells. Groundwater in this area likely mimics topography, flowing generally from the highlands in the northeast toward Cottonwood Creek in the southwest. In the lowland areas of Beede Desert the basement groundwater may be confined by the overlying diatomite, as suggested by local artesian conditions.

7.3.2 Rates of Groundwater Inflow

Groundwater will flow into the proposed pit excavations as soon as they are deepened to below the water table. However, the rates of inflow will depend on numerous factors, and will change through time. A very general estimate of initial (maximum) inflow rates can be made using the principle of superposition, where inflows though upper and lower diatomite in the pit walls, and inflows through the pit bottom are analyzed separately. It should be noted that the method, used below, is conservative and will most likely over-estimate the total combined inflow to the open pits.

Figure 7-3 shows parameters and assumptions for a very general analytical calculation of groundwater inflow to a conceptual pit dug into laterally-continuous diatomite. Inflow rates though upper and lower diatomite in the pit walls were analyzed as lateral flow to separate, fully-penetrating large diameter wells in an unconfined aquifer, using an analytical equation derived from the Theim-Dupuit equation and presented in Krusseman and De Ridder (1979):

$$Q = \frac{\pi \cdot K \cdot \left(H^2 - h^2\right)}{Ln\left(\frac{R}{r_p}\right)} \tag{1}$$

Where:

Q = groundwater inflow (L^3/t),
K = hydraulic conductivity of wallrock (L/t),
H = saturated thickness of aquifer (L),
h = head in floor of pit (L),
r_p = equivalent radius of pit (L),
R = radius of influence (L), $= 1.5 \cdot \sqrt{\frac{K \cdot H \cdot t}{S}}$
S = storativity ( ), and
t = life of mine (t).

Inflow rates through the floor of a pit are commonly modeled using an analytical equation presented in Marinelli and Niccoli (2000). However, their equation assumes that the

properties of the materials at the bottom of and underlying the pit are uniform over a significant thickness. Although this may be the case for pits dug in the very thick diatomite on the west and northwest sides of Mill Gulch, on the east and southeast side it is assumed that high-*K* basement rocks will be isolated from the bottom of the pit by a relatively thin barrier of low-*K* diatomite.

For this more conservative scenario, flow through the floor can be estimated using an analytical equation derived directly from the Darcy equation:

$$Q = K_v \cdot A \cdot \left(\frac{H - h}{b} \right) \tag{2}$$

Where:

A = area of pit floor (L^2)

b = thickness of barrier between pit bottom and high-*K* unit (L),

K_v = vertical hydraulic conductivity of barrier (L/t),

and other parameters are as above.

Equation 2 will generally be valid where the low-*K* diatomite floor of the pit remains intact. However, if the floor barrier is left too thin, failure of the floor barrier could result in significantly increased groundwater inflows.

Table 7-2 shows results of calculations using Equations 1 and 2 for an idealized steep-sided pit, with a pit-bottom area of 30-acres, excavated into a laterally-continuous diatomite layer. For these calculations it is assumed that the volcanic rocks underlie the diatomite at a depth of 105 feet below a seepage face developed in the upper diatomite (i.e., the volcanic contact is about 150 feet bgs), and heads in the basement are equivalent to heads in the lower diatomite. In the idealized pit, it is also assumed that no significant ash/tuff layers or other discontinuities mar the diatomite. Table 7-2 shows that for all scenarios, groundwater inflow through the diatomite walls of the pit would be very small. The initial rates of inflow through the pit bottom would be of greater significance. Based on a K_h to K_v anisotropy of 10:1, the inflow rates would range from 8 gpm with a floor barrier of 40 feet, to as much as 97 gpm with a floor barrier of just 5 feet.

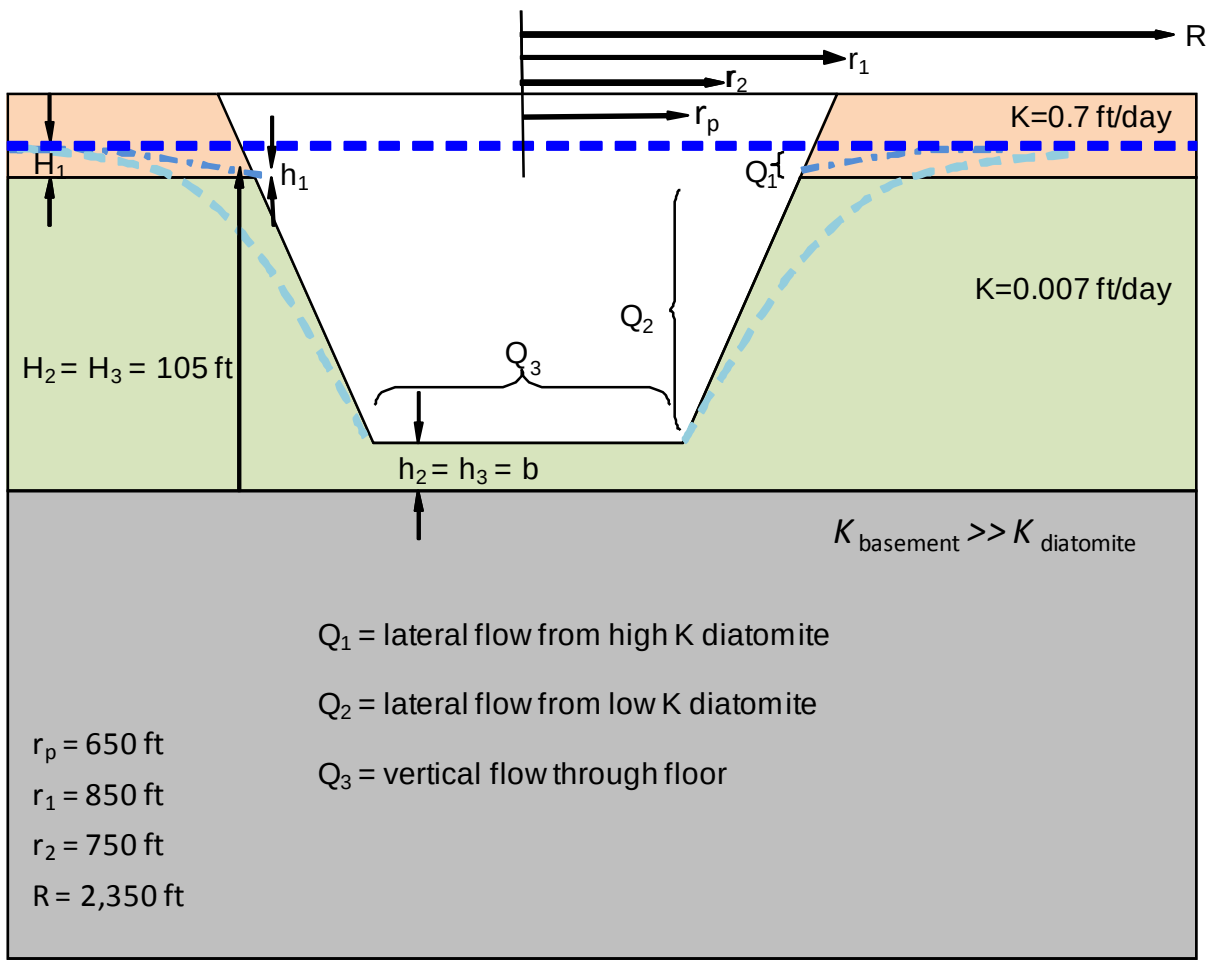
The inflows shown in Table 7-2 are initial rates, and would decrease in time as heads in the formations are lowered. More importantly, they are valid only for an idealized diatomite aquifer with a saturated thickness of 115 feet. Where the saturated diatomite is thinner (e.g., on the east side of Mill Gulch), pits will be shallower relative to the water levels in the basement, and inflow rates therefore will be much lower.

Table 7-2: Analytical Estimates of Initial Rates of Groundwater Inflow to an Ideal, 30-Acre Pit with 115 feet of Saturated Diatomite

Basement Assumption	Floor-Barrier Assumption ($K_h : K_v$ = 10:1)	Initial Inflow (gpm)		
		Upper Diatomite Wall[a]	Lower Diatomite Wall[a]	Pit Floor [b]
K of Volcanics Significantly Greater than ***K*** of Lower Diatomite	Diatomite Floor 40 ft thick	2.3	2.3	8
	Diatomite Floor 20 ft thick	2.3	2.8	21
	Diatomite Floor 10 ft thick	2.3	2.9	46
	Diatomite Floor 5 ft thick	2.3	3.0	97

[a] Equation 2
[b] Equation 3; assume K_v = 0.5 x K_h when unfractured

Figure 7-3: Parameters for Analytical Estimates of Groundwater Inflow to Pit



7.3.3 Hydrogeology Discussion

7.3.3.1 Groundwater Conditions During Mining

The principle criterion by which to assess the potential for dissolved constituents generated in the open pits to migrate into and impact the groundwater system is whether the deepened pits will constitute groundwater sinks or develop into flow-through pit lakes.

The results of the preliminary calculations, above and summarized in Table 7-2, show that if 10 feet of diatomite is left in the bottom of a pit excavated to 105 ft below the water table (and assuming that 10 feet is a sufficient thickness to prevent floor failure) then steady-state inflow rates through the walls and floor of an idealized 30-acre pit could be just a little more than 50 gpm. Yearly net evaporation from the 30-acre pit floor, though, would average about 82 gpm. Consequently, the open pit would remain dry from year to year (although some seasonal accumulation of water could occur). Where floor barriers are thicker and/or where excavations extend to shallower depths below the water table, inflow rates would be lower and the exceedance of the inflow rate by evaporation would be even greater.

Conversely, if the excavation extends significantly below the water table, and the floor barrier is left too thin, then long-term groundwater inflow rates could possibly exceed evaporation rates, and shallow perennial pit lakes might develop. The depth of the hypothetical pit lake would depend first on inflow rates, which would decrease as the lake deepens (due to decreasing head differential), and to a lesser extent on the shape of the pit, which would define an increasing evaporative surface as the lake deepens. Ultimately, evaporation would balance inflow; and the final lake level, which could take many years to establish, would be at some depth below the current static water level in the basement aquifer (i.e., pit lake levels would never reach the current groundwater level due to the effects of evaporation).

Although, in the above case, a pit lake theoretically could form, groundwater flow out of and away from the pit still would not occur if the static lake level remained below the groundwater level in the diatomite. In a very simplified (i.e., isotropic) system all groundwater flow would be toward the lake, and the lake would constitute a long-term sink resulting in a net extraction of groundwater from both the volcanic and diatomite aquifers, with no potential for contaminants to migrate away from the pit.

Only if the current static groundwater level in the volcanic basement is significantly higher than the current groundwater level in the upper diatomite, and the floor barrier were left sufficiently thin that inflow rates would exceed evaporation even as the lake level approaches the water table, could pit-lake water enter the groundwater system and possibly constitute a migrating plume. The current conceptual model shows that this would only be possible in the proposed pits east of the Upper Mill Gulch fault.

The proposed Mill Gulch pits that lie in the western block of the Upper Mill Gulch fault and north of the inferred NE-SW fault in lower Mill Gulch (see Figure 7-1) will develop a thick diatomite unit that lies over deep volcanic rocks. The pit highwalls will be comprised entirely of diatomite, as will the floors of the pits. Current mine plans show that the diatomite floor of the pits on the west side of the valley will remain at least 100 feet above the volcanic contact. Consequently, the low-permeability diatomite will limit groundwater inflow to the pits during and after mining, resulting in year-to-year dry conditions.

Proposed pits that will be initiated or expanded on the east or southeast sides of the inferred faults in Mill Gulch will develop a diatomite deposit that is thinner; therefore the depth of mining will be limited by the approach of the basement contact. In order to minimize groundwater inflow and the potential development of a pit lake, the final depth of each pit should be kept above the water level in the volcanic rocks at that location, or a barrier of diatomite should be left in the floor with a thickness sufficient to limit upward groundwater flow. The thickness required to limit upward flow will be different at each site, and will depend primarily on the final depth of excavation below the water level in the underlying volcanic rocks.

Proposed mining in the Eagle Mine and Hidden Valley areas will not extend below the water table, and therefore, pits will remain dry except for seasonal meteoric accumulations. Low-*K* diatomite pit walls and floors will minimize seepage of the waters until they evaporate in the dry-season.

7.3.3.2 Groundwater Conditions During Closure

As described above, some of the proposed open pits may be excavated to elevations below the water table, potentially resulting in nominal groundwater flow into those particular pits. Although no pit lake is anticipated to form in these pits due to the low groundwater inflow rates and high evaporation rates, there is the potential for accumulation of transient water (influent groundwater + meteoric runoff). The amount of water that may accumulate seasonally will vary depending upon the meteoric and groundwater inputs. There are several closure alternatives available for the pits that intersect groundwater that could have varying impacts on local and regional groundwater and the ultimate closure objectives. A brief synopsis of each alternative is presented below.

No Backfilling

If the pits that intersect groundwater are left open after mine closure (i.e., no backfill), groundwater is likely to continue to flow toward and into each pit due to the draw from evaporation, resulting in a localized groundwater sink. Based on the hydrogeological assessment, a perennial pit lake is not likely to develop, and any accumulation of water would be transient. The SLERA indicates that the metal concentrations in this transient pit water are sufficiently low and would not pose a credible risk to wildlife or livestock when, and if, present (SRK, 2010). However, the pH levels of the seasonal pit water could be low (3 to 4 s.u.) for pits with unoxidized diatomite exposed in the final pit walls.

Complete Backfill

Backfilling of the open pits that intersect groundwater to well above the post-closure water table with waste materials would eliminate the potential for groundwater to accumulate in the pit. However, if pits were backfilled to above the water table, groundwater levels could recover within the backfill to pre-mining levels, resulting once again in a flow-through groundwater system. Under this closure scenario, there is a potential for oxidation products and readily leachable constituents in the backfill material and in the final pit walls to enter the groundwater system and migrate away from the pits, potentially degrading downgradient water resources.

Partial Backfilling

The surface expression of groundwater (albeit transient) could possibly be mitigated through the partial backfilling of the open pits that intersect groundwater. The intent of this

alternative closure strategy would be to maintain the pit as an evaporative sink for groundwater (i.e., no flow-through), while reducing the potential for free-standing water with low pH. This is generally achieved by backfilling the pit to an elevation where evapo-transpiration losses through the uppermost portions of the backfill would equal the rate of groundwater inflow.

Under this partial-backfill scenario, evaporation would occur mostly by capillary action (i.e., soil-moisture flux) so that a free water surface is less likely to occur, but evaporation (and possibly transpiration through vegetation) would continue, and a localized groundwater sink could be maintained. This approach would require balancing the:

- Rate of groundwater inflow, which depends on the head difference between the water table and the evaporative surface;
- Evaporation rate, which depends on the surface area (in turn dependent on the height above the pit floor), and soil-specific parameters; and
- Seasonal variations in precipitation, heat, wind, and vegetative transpiration.

The appropriate backfill level within each pit would need to be calculated for each pit area and would depend upon the shape of the pit, aquifer water levels and pit floor elevations, and evaporation rates due to capillary action within the backfill material.

7.4 Groundwater Chemistry

Groundwater samples have been collected from monitoring wells and piezometers by SRK during the November 2005, October 2007, June 2008, and May/August 2009 sampling events in order to characterize groundwater conditions for the Celatom Mine. Thirteen of these wells are located within the Mill Gulch mine area, four of which (MW-8, MW-9, PZ-5S and PZ-5D) are located upgradient of the current mining operations in Kelly Field. The remaining wells are either located within the active mine area or downgradient of the mine area. The most downgradient point within Mill Gulch is represented by MW-3.

One of the monitoring wells included in the groundwater sampling events is located downgradient of the Beede Desert mine area (MW-10B). Two new monitoring wells in the Eagle Mine area were sampled for the first time during August 2009. In addition, a water quality sample was collected from the artesian well in Otis Valley during November 2005 and provides baseline chemistry for artesian water sources within this area. Groundwater chemistry conditions beneath the Hidden Valley area are not included in this evaluation because the monitoring well in that area (i.e., MW-2) has been dry since installation in 2005.

The average groundwater results are summarized in Table 7-3 for select parameters. A complete tabulation of the data is provided in Appendix H. Laboratory reports associated with Appendix H are provided electronically on the enclosed CD only.

Water quality standards (Oregon MCLs per 333-061-0030) are based on total concentrations; however due to the potential for contamination from suspended fine particles (i.e., clay) in groundwater, samples were submitted for both total (i.e., unfiltered) and dissolved metals (i.e., filtered) analysis. As shown in Table 7-3, total metals are generally greater than dissolved metals in the groundwater samples. This can be attributed to suspended diatomite and clay particles in the samples due to the fine-grained nature of the sedimentary deposits within the area. Furthermore, total silica concentrations are elevated in all samples and dissolved silica concentrations are similar to total concentrations (Appendix

H). Because of this potential for contamination from suspended fine particles, total metals results are considered biased and the dissolved metals results are used in the following evaluation of water chemistry.

Table 7-3: Average Groundwater Results for Select Parameters

Sample Location	Location Relative to Mine Areas	Well	n	pH	SO_4	TDS	Total Alk.	Aluminum		Arsenic		Iron		Manganese	
								diss.	total	diss.	total	diss.	total	diss.	total
Mill Gulch	Upgradient	MW-8	4	7.6	18	135	52	0.03	0.22	0.010	0.011	2.12	3.54	0.1215	0.129
		MW-9	4	7.5	63	260	70	0.03	0.43	0.002	0.014	3.67	34.35	0.36175	0.408
		PZ-5S	1	8.0	13	150	53	<0.03	3.91	0.002	0.004	<0.02	5.69	0.101	0.164
		PZ-5D	1	8.5	45	270	123	<0.03	0.28	0.003	0.004	<0.02	0.51	0.484	0.52
	Onsite	PZ-3	1	8.1	54	280	134	<0.03	0.03	0.002	0.002	0.17	0.78	0.678	0.632
		PZ-4	1	8.5	40	190	115	<0.03	0.11	0.003	0.004	<0.02	0.32	0.403	0.383
		MW-4	4	8.3	31	245	141	<0.03	0.10	0.002	0.002	0.02	0.39	0.2825	0.355
		MW-5	4	8.2	23	205	140	<0.03	1.97	0.001	0.003	0.84	7.04	0.16425	0.336
		MW-6	4	7.9	50	245	126	0.03	0.04	0.003	0.005	0.76	1.83	0.40925	0.446
		MW-7s	4	7.9	133	355	73	0.04	0.14	0.010	0.010	0.03	0.14	0.008	0.008
		MW-7d	4	7.6	51	255	85	0.04	0.04	0.001	0.001	10.54	11.14	0.75575	0.775
		MW-12	2	7.1	170	370	31	<0.03	0.04	0.002	0.002	5.11	6.33	1.04	1.084
	Downgradient	MW-3	4	8.3	25	230	149	0.03	0.07	0.004	0.004	0.10	0.30	0.108	0.127
Beede Desert	Downgradient	MW-10B	4	8.0	24	178	67	0.06	0.19	0.013	0.013	0.03	0.18	0.0065	0.008
		Artesian Well	1	8.2	20	80	49	<0.03	<0.06	0.001	0.001	<0.02	<0.02	<0.005	<0.005
Eagle Mine	Onsite	MW-13	1	8.3	7	140	74	0.07	3.93	0.002	0.002	0.04	3.03	<0.005	0.057
		MW-14	1	8.3	11	150	78	<0.03	7.31	0.002	0.003	0.02	12.6	<0.005	0.243
Oregon MCLs (333-061-0030)				**6.5-8.5**	**250**	**500**	**--**	**0.2**	**0.2**	**0.01**	**0.01**	**0.3**	**0.3**	**0.05**	**0.05**

All values reported in mg/L except pH, which is reported as s.u.
< denotes less than the specified laboratory method detection limit.
Shaded values exceed the respective Oregon MCLs as regulated by 333-061-0030.

As can be seen from the groundwater monitoring data provided in Table 7-3, pH values for all groundwater samples are within the Oregon MCLs (i.e., between 6.5 and 8.5 s.u.). Sulfate and TDS concentrations are generally low, and are below the respective MCLs for all groundwater samples.

As shown in Appendix H, all dissolved groundwater constituent concentrations are below the Oregon MCLs, with the exception of arsenic, iron and manganese. Arsenic is slightly elevated above the MCL in the three shallowest wells; MW-7s, MW-8 and MW-10B. Iron and manganese are elevated above the MCLs in all of the Mill Gulch monitoring wells except MW-7s. The highest manganese values were obtained from MW-7D and MW-12 located adjacent to the Kelly Field Pit. Monitoring well MW-7D also has the highest iron concentrations. Iron and manganese are also elevated above the MCLs in the upgradient monitoring wells MW-9 and MW-8 that are representative of background conditions for the site. As a result, the observed concentrations of iron and manganese in groundwater beneath the site are considered naturally occurring. The only dissolved constituent elevated above the MCLs in the Section 25 (PZ-5s and PZ-5d) area is manganese. All other constituents are below the respective MCLs. The quality of groundwater downgradient of Mill Gulch (MW-3) is considered good, with pH values around 8 s.u. and constituent concentrations below the respective MCLs, with the exception of manganese. The elevated manganese and iron concentrations measured in the upgradient and onsite monitoring wells can be attributed to

mobilization of these constituents from the unoxidized (sulfide bearing) horizons within the localized groundwater system. This is demonstrated by Figure 7-4 where pH is plotted versus manganese. As shown in Figure 7-4, the highest manganese concentrations are obtained from wells screened in unoxidized diatomite. Manganese concentrations are also elevated in the underlying volcanic bedrock as represented by MW-5 and MW-3, but at slightly lower concentrations than observed for the well screened in unoxidized diatomite. Manganese for the one well screened in oxidized diatomite (MW-7s) is significantly lower and is below the laboratory detection limit. A similar trend is observed for iron concentrations in Figure 7-5.

A comparison of groundwater chemistry with depth of the screened interval indicates there is a linear relationship between analyte concentration and depth for a few important constituents. In Figure 7-6, arsenic, iron and manganese concentrations were plotted versus depth of the screened interval. As shown in Figure 7-6, both iron and manganese concentrations generally increase with depth. This trend indicates reducing conditions exist that can affect the chemistry (i.e., mobility) of some constituents, particularly redox-sensitive species (Hem, 1985; Stumm and Morgan, 1996; Drever, 1997). Both iron and manganese are highly sensitive to redox conditions, and both are more soluble in reducing conditions (Hem, 1985). Conversely, arsenic concentrations show a decrease with depth and are greatest in the shallow wells screened across the oxidized and unoxidized diatomite zone (MW-8, MW-7s and MW-10B). The trends in arsenic concentrations with depth can be related to the control of pH on arsenic conditions and the presence of insoluble Fe-Mn hydroxides that act as adsorption surfaces.

For the Beede Desert monitoring well (MW-10B), water quality is good with pH values around 8.0, low TDS and sulfate, and iron and manganese are below the MCLs. Average arsenic concentration for MW-10B is slightly elevated above the MCL at 0.013 mg/L. As expected, the water quality of the artesian well in Otis Basin is good with all parameters below the respective MCLs, pH greater than 8 s.u, and very low total dissolved solids (i.e., 80 mg/L). Arsenic is detected in this sample, but the concentrations in both the total and dissolved fraction are below the respective MCL. Water quality for the two basalt bedrock wells in the Eagle Mine area (MW-13 and MW-14) is similar where none of the dissolved constituents are elevated above Oregon MCLs. However, total aluminum, iron and manganese are elevated above Oregon MCLs in both wells.

Figure 7-4: Groundwater pH versus Dissolved Manganese

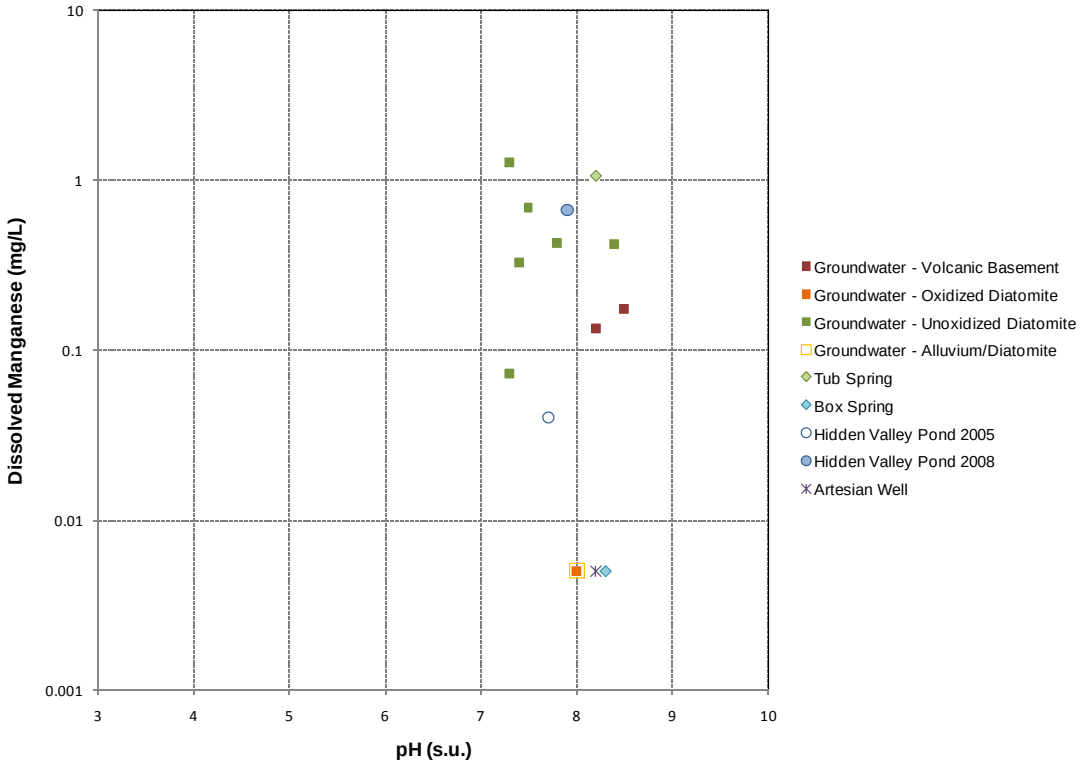


Figure 7-5: Groundwater pH versus Dissolved Iron

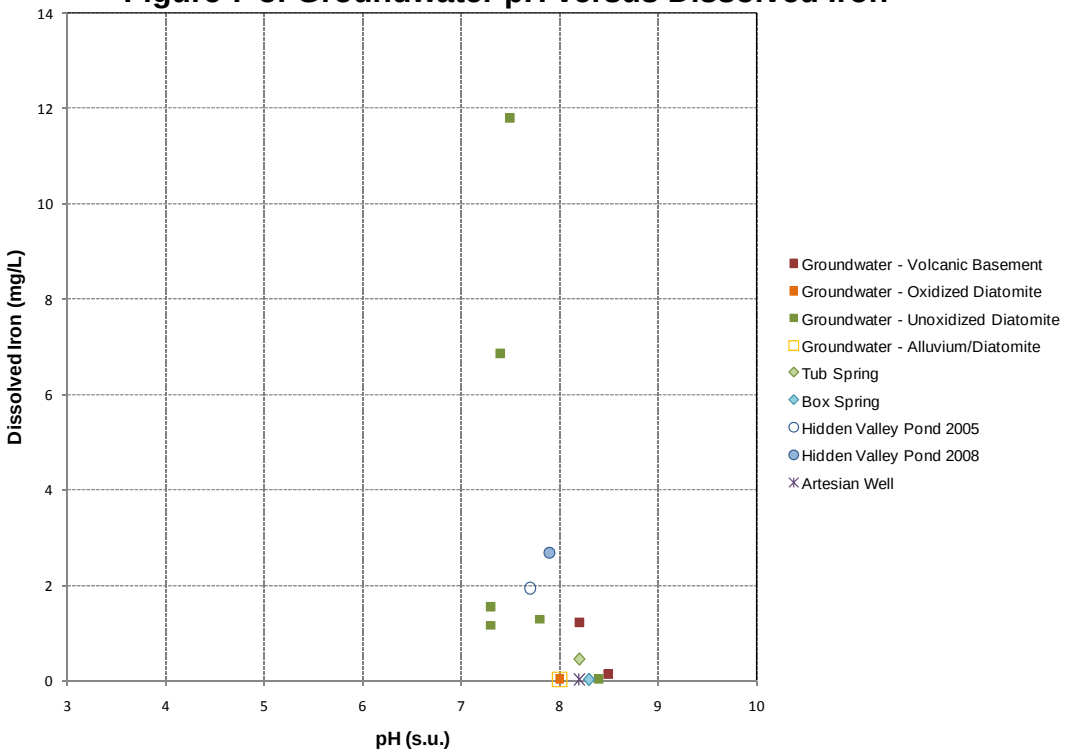
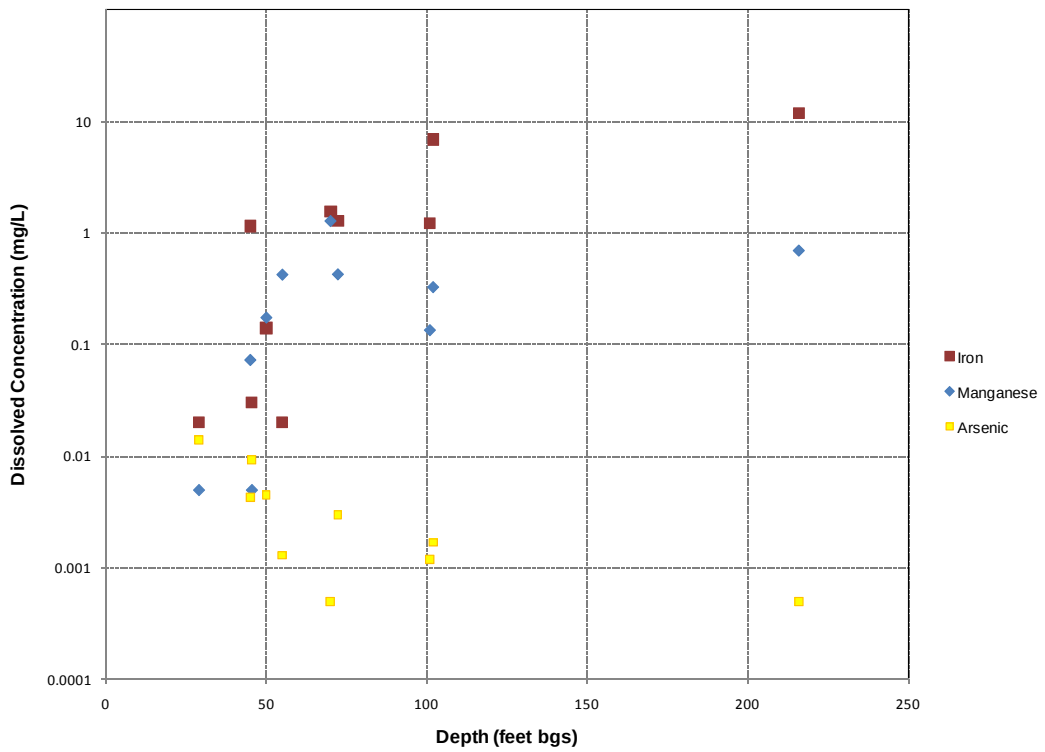


Figure 7-6: Dissolved Iron, Manganese and Arsenic versus Depth



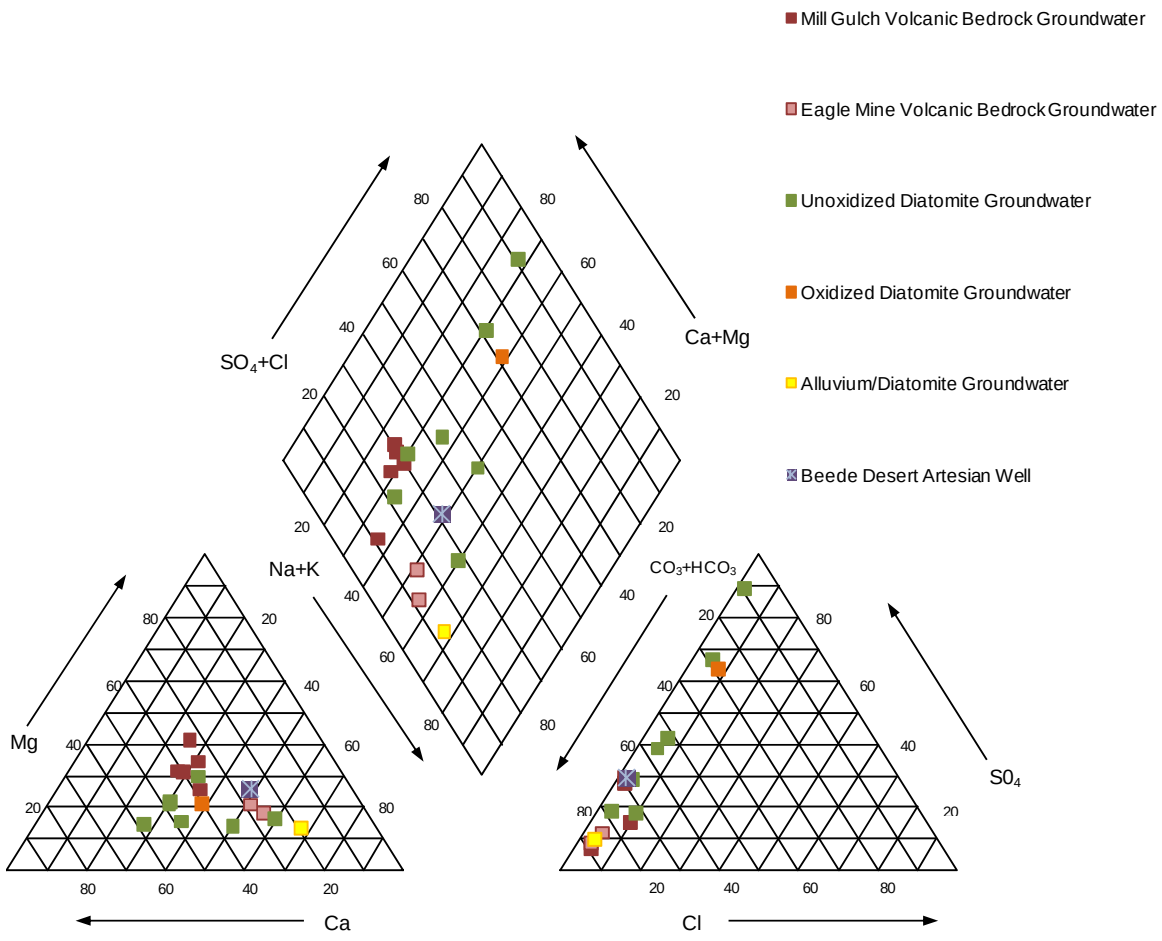
7.4.1 Categorization of Water Types Based on Chemistry

In Figure 7-7, the major ion concentration of water samples collected in 2009 are plotted on a trilinear diagram, indicating a wide range in major ion chemistry for the groundwater samples. Most of the groundwater samples have the same cation composition (i.e., mixed with no dominate cation) but the dominant anion varies between bicarbonate and sulfate. The majority of the groundwater samples can be classified as mixed cation-sulfate-type and mixed cation-bicarbonate-type waters.

Samples representing the groundwater in the Mill Gulch volcanic bedrock (MW-3, MW-5, PZ-4 and PZ-5D) are all similar and have a mixed cation composition with bicarbonate as the dominant anion. The one sample representative of the oxidized diatomite aquifer (MW-7s) is classified as mixed cation-sulfate water. Sample from wells screened in unoxidized diatomite show a wide range in anion composition, ranging from bicarbonate to sulfate dominated. Monitoring well MW-12 is more enriched in calcium and sulfate in comparison to the other groundwater samples and is classified as calcium-sulfate-type water.

The sample from MW-10B that is screened across the alluvium/diatomite contact in Beede Desert is slightly enriched in sodium and potassium in comparison to the other groundwater samples and is classified as sodium + potassium-bicarbonate type water. The samples from the two Eagle Mine wells screened in the basalt bedrock are similar in ionic composition to MW-10B and are also classified as sodium+potassium-bicarbonate-type waters. The artesian well in Beede Desert plots in a similar area with a slight enrichment in calcium and bicarbonate as the dominant anion.

Figure 7-7: Trilinear Plot - Groundwater



7.4.2 EP Test Wells

Groundwater samples were collected from the EP test wells during 2004 by site personnel, and are provided in Table 7-4 for completeness and comparison. Originally, the intent was to augment the data from this early sampling event with the results of the current investigations. However, upon comparison of the two data sets, it became clear that some significant differences existed, despite being developed within the same aquifers. For instance, metals concentrations in the EP test wells are several orders of magnitude greater than those observed in the recently installed monitoring wells (Table 7-4). In addition, lower pH values were reported for the EP test wells.

Table 7-4: 2004 Groundwater Chemistry for the EP Test Wells (Superseded)

Location Relative to Mining Areas	Well ID	pH	TDS	Sulfate	Total Alk.	Dissolved Metals			
						Al	As	Fe	Mn
Downgradient	WELL#1	7.98	327	53	236	<0.02	**0.013**	<0.02	**0.177**
	WELL#2	7.82	270	39.5	154	<0.02	**0.016**	<0.02	<0.02
	WELL#2	8.1	250	40	145	<0.03	0.0051	<0.02	<0.005
	WELL#3	8	308	68.8	187	<0.02	<0.01	<0.02	0.0486
Onsite	WELL#4	6.68	157	32.3	32	<0.02	**0.015**	**1.42**	**0.138**
	WELL#5	**4.37**	**547**	**326**	--	**0.357**	**0.01**	**13.9**	**0.914**
	WELL#6	**6.43**	276	91.7	37.4	<0.02	**0.012**	**2.32**	**0.154**
Upgradient	WELL#7	**6.05**	**670**	**378**	32	<0.02	<0.01	**20.2**	**1.06**
Downgradient (Beede Desert)	WELL#9	7.86	147	3.14	74.3	<0.020	<0.01	<0.02	<0.02
Oregon MCLs (333-061-0030)		**6.5-8.5**	**500**	**250**	**--**	**0.05-0.2**	**0.01**	**0.3**	**0.05**

All values reported in mg/L except pH, which is reported as s.u.
< denotes less than the specified laboratory method detection limit.
Shaded values exceed the respective Oregon MCLs as regulated by 333-061-0030.

The 2004 groundwater data (along with recent data collected from Test Well #2) are, therefore, not considered valid for the following reasons:

- Test wells were installed with the intent to monitor groundwater elevation only;
- Detailed drill records including field notes, drill logs and well completion logs are not available;
- Test wells were not constructed according to State of Oregon monitoring well construction regulations (OAR 690 Division 240);
- Test wells do not have locking caps and there is no record of the steps taken to maintain the integrity of these wells;
- No records are available for the development and sampling of the test wells during the 2004 sampling event;
- Results from the recently installed monitoring wells that were constructed in accordance with applicable construction regulations, and properly developed and sampled are not comparable to the 2004 results; and

- Poor recovery of groundwater during bailing of Test Well #2 during the 2005 field program resulted in the purging of only one well volume prior to sample collection.

As a result, groundwater data from the EP test wells has not been included in the current evaluation, with the exception of groundwater elevations, for which they provide additional piezometric data.

8. MATERIAL CHARACTERIZATION

As described in Section 5 above, drill core samples collected during the investigation are considered representative of the main geologic rock types for the Celatom Mine including:

1. Alluvium/soil;
2. Oxidized Diatomite;
3. Transitional diatomite (i.e., diatomite demonstrating both unoxidized and oxidized properties);
4. Unoxidized diatomite;
5. Opalized diatomite;
6. Volcanic ash and tuff layers interbedded with diatomite deposit; and
7. Basement volcanic rocks including basalt and andesite.

The number of samples collected for each material type is summarized in Table 4-14. Drill core samples were initially screened using contact pH and EC tests in order to determine the basic characteristics of the materials and to validate the material type delineations. A smaller sub-set of samples was composited for static test work. The results of the geochemical test program are summarized in the following sections and augment the initial assessment of mine material reactivity as documented in the 2004 ARD study.

This static program also includes a characterization of mineral process waste samples that are generated by the Vale processing plant and disposed of onsite as well as in-situ waste samples from the backfilled area in the Kelly Field Pit and Beede Desert Pit. At the request of the BLM, samples were also collected from a sediment basin within Mill Gulch for static testing.

The testing program was designed to address mineralogy, bulk geochemical characteristics, and the potential of the waste rock and pit wall rock to generate acid or release metals in drainage. “Static testing” is a general term describing those analytical methods applied to characterize acid generation and metal leaching characteristics of material at the time of testing, and does not account for temporal changes that may occur in the material as chemical weathering proceeds. Such tests provide a balance of acid generating and acid consuming reactions at an end point, and also may be used to determine the potential magnitude of leaching metals from a given material. They are distinguished from “kinetic tests” which evaluate the rate of sulfide oxidation and metal release over time. The objective of static testing is therefore to obtain a conservative approximation of acid generation and trace metal release potential as a foundation for determining where more comprehensive kinetic testing is warranted.

Based on the results of the static test work, materials that exhibit uncertain or highly variable geochemical behavior may require further characterization using kinetic test methods to determine the rates and character of longer-term leaching. These data are typically collected in support of numerical predictive calculations for waste rock or pit lake risk assessments. As discussed in Section 7, no pit lakes are anticipated to form as a result of the Celatom operations. Therefore, for this geochemical assessment, no kinetic testing was completed and the static test results are believed to provide a valid, although conservative, approximation of acid generation and trace metal release potential.

The static data collected for this project include total acid generating or neutralizing potential of the samples, concentration of constituents in leachates derived from the material, and mineralogy. Static testing was accomplished using the following methodologies:

- Bulk geochemical analysis using the CHEMEX MEMS-61 four acid digest to determine total metal, metalloid and cation chemistry for 27 elements on each sample;
- Net Acid Generating (NAG) test reporting final NAG pH and final NAG value after a two-stage hydrogen peroxide digest;
- Acid Base Accounting (ABA) using the BCAMDTF modified Sobek with Leco sulfur speciation analysis; and
- Meteoric Water Mobility Procedure (MWMP - ASTM E2242-02) and analysis of leachate.

Samples were submitted to McClelland Laboratories (MLI) in Sparks, Nevada for sample preparation, including compositing and MWMP extraction. The MWMP extracts were submitted to ACZ Laboratories, Inc. (ACZ) in Steamboat, Colorado for chemical analysis, along with a split of each composite sample for TIC and NAG testing.

A separate split of each composite sample was sent to SVL Analytical in Kellogg, Idaho for ABA testwork. A discussion of the results of the material characterization is provided in below along with a comparison to the data collected during the 2004 ARD study.

8.1 Contact Test Results and Assessment of Field Reactivity

Contact pH and EC were determined on a total of 117 samples collected from discrete lithologic intervals that are considered to be representative of the main rock types encountered during drilling. The procedure used to determine the potential field reactivity of the selected core samples is the same as that applied during the 2004 ARD study.

Contact pH and EC were measured to determine the degree of oxidation and accumulation of secondary mineral phases, and were conducted by mixing a sample of the fine-grained portion of the material (-4.75 mm) with de-ionized water in a ratio of 1:1 by weight; the contact solution was then decanted, and pH and EC measurements were taken directly from the leachate produced.

Sulfide minerals present in the sample material react with water and oxygen to produce sulfuric acid. Acid, in turn, will leach metals from material and release them into solution. The resulting leachate will have low pH readings and high EC values indicating sulfide and/or metal oxidation resulting in acid generation has occurred. Samples with high pH values indicate either the sample is not generating acid or any acidity produced during oxidation has been neutralized through mineral buffering. The dissolution of carbonate minerals into solution will neutralize acids. High EC levels indicate that there is a store of soluble salts such as sulfates or metal salts. The soluble sulfate and metal salts that are stored in the material are dissolved into solution when the sample material is mixed with water.

Contact test results are qualitative and used as a field screening tool to determine the potential reactivity of a material with water and oxygen. While qualitative, the field test data are indicative of the degree of oxidation and accumulation of secondary mineral phases that have occurred prior to sample collection. Other analytical methods are required to calculate

the total amount of acidity or neutralization that will be produced from a particular rock during weathering.

In Figures 8-1 and 8-2, the pH values are plotted against EC values according to rock type and location, respectively. For the entire data set, contact pH values range from 2.78 to 7.52 s.u and EC values range from 2,618 to less than 10 µS, where the lowest pH values and the highest EC values were obtained from unoxidized diatomite and transitional diatomite. The majority of the high pH values and low EC values were obtained from the oxidized diatomite and the volcanic units including ash, tuff, basalt and andesite. As shown in Figure 8-2, the lowest EC and highest pH values were obtained from core samples collected in the Hidden Valley deposit (i.e., oxidized diatomite). Likewise, the results for core samples from MW-3 show similar results with low EC and high pH values. The remaining drill holes demonstrate a greater range of pH and EC values as a result of the greater variability of rock types and occurrence of various phases of diatomite in these locations.

Figure 8-1: Contact pH versus Contact EC According to Rock Type

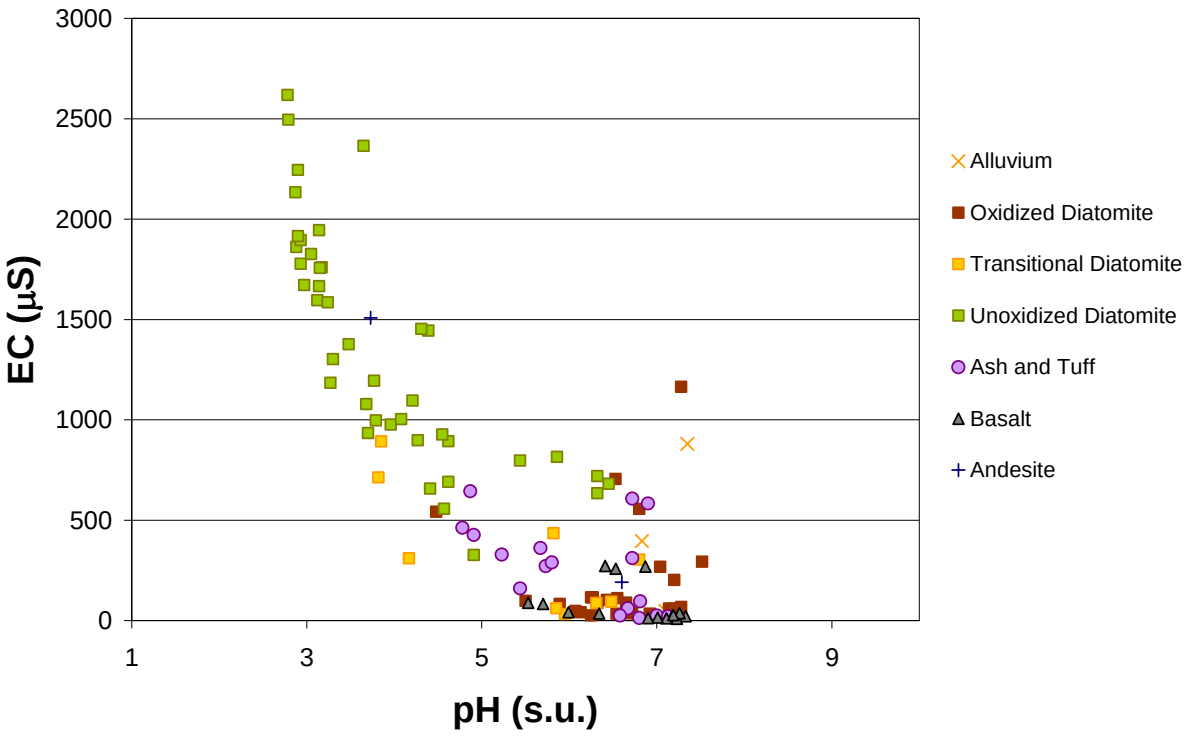
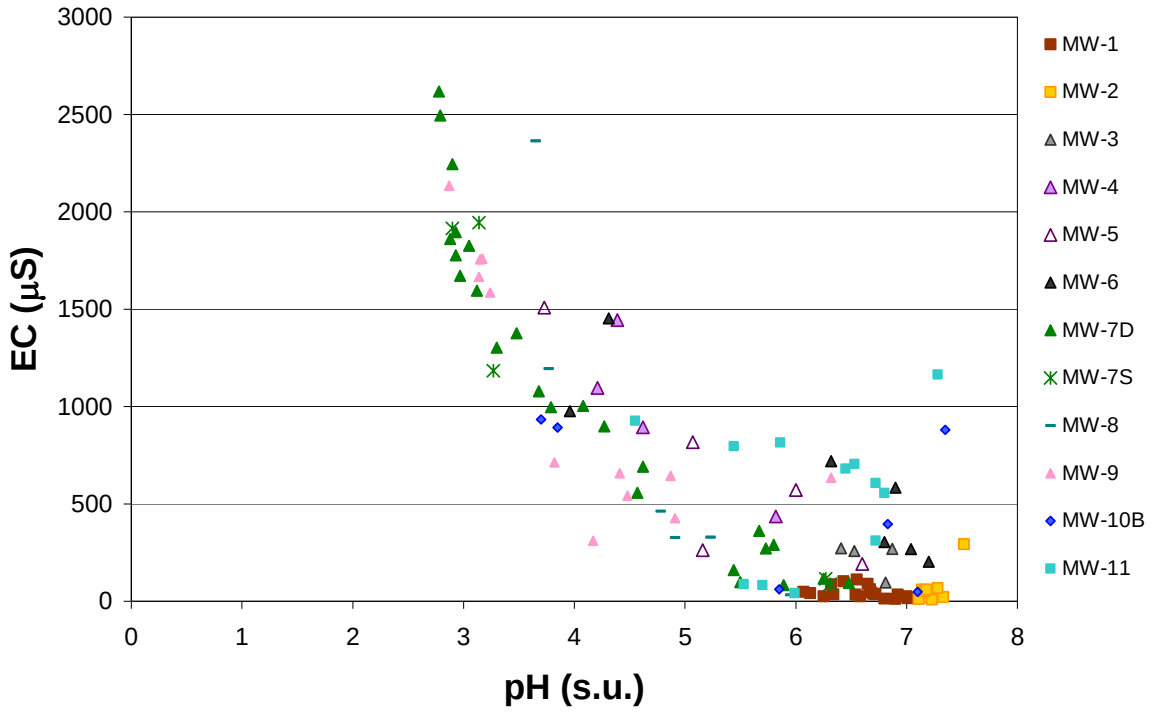


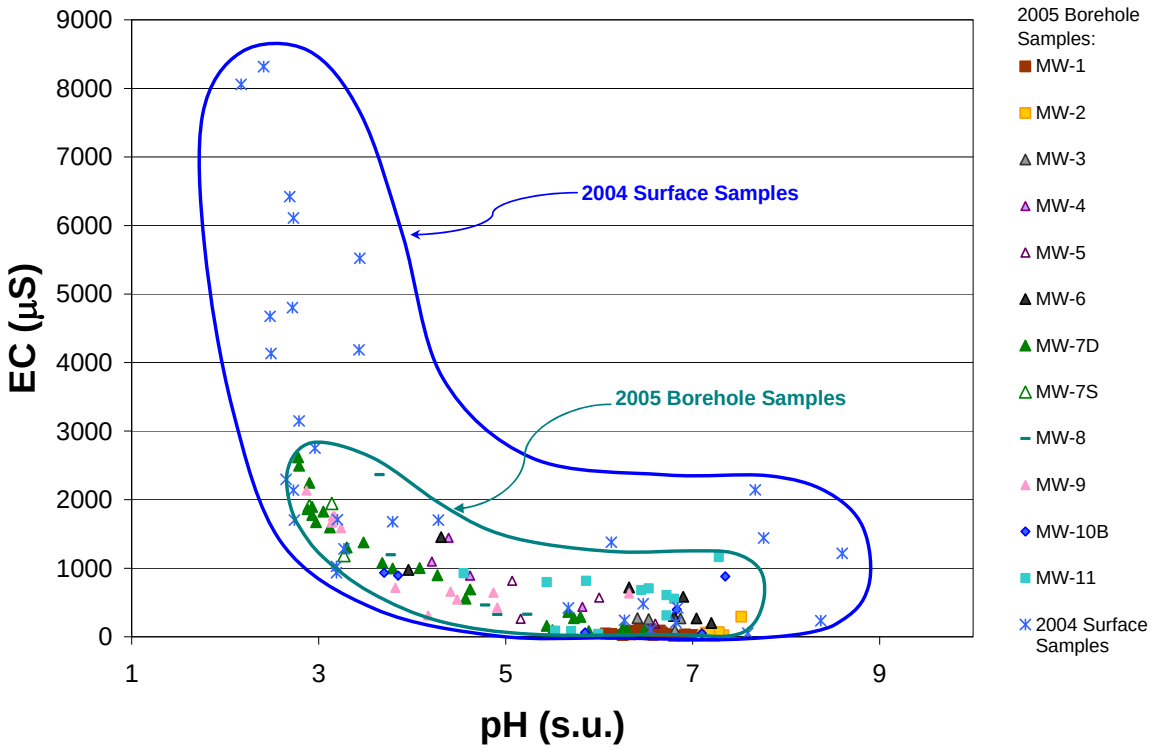
Figure 8-2: Contact pH versus Contact EC for each Drill Hole Location



As part of the current evaluation, the contact test results from drill core samples were compared to the results of the 2004 ARD study. For the 2004 study, the source and extent of acid generation was determined from contact tests of the main rock units exposed in the pits. The rock units tested during 2004 included: 1) unoxidized diatomite, 2) partially oxidized diatomite (i.e., transitional), and 3) oxidized diatomite. Other rock units that occur in association with the diatomite deposit (e.g., volcanic ash and tuff and clay layers) do not account for a significant portion of the exposed rock surfaces within the pits and were not included in the 2004 laboratory test program. Additionally, the volcanic basement rocks are not exposed in the pits, and were also not included in the 2004 laboratory testing program.

In Figure 8-3, the 2004 contact test results are plotted alongside the results from the 2005 study. As shown, the contact test values for the drill hole samples fall within the same range as those obtained during the 2004 ARD study, but EC values are consistently less than those observed from the 2004 surface samples. The greater EC values for the 2004 samples can be attributed to the inclusion of surface exposed samples in the data set compared to the exclusively drill hole derived sample set in 2005. This graph demonstrates the effects of oxidation of sulfide materials within the diatomite under surface conditions.

Figure 8-3: Comparison of 2004 and 2005 Contact Test Results



8.2 Static Test Results

8.2.1 Meteoric Water Mobility Procedure

Leachable metals are a potential source of toxicity in mine waste drainage. The Nevada MWMP test (ASTM E2242-02) was developed to simulate the leaching of mine materials with meteoric water under normal, low precipitation environment, field conditions. The results of the MWMP test can be used to identify the presence of leachable metals and readily soluble salts stored in the material, as well as provide an indication of their availability for dissolution and transport in response to a precipitation event. The leachate chemistry data from the MWMP tests were compared to the Oregon MCLs (333-061-0030) to determine which constituents could potentially be leached at concentrations above these values. However, the MWMP test most likely results in higher concentrations than what would likely be observed in the field as runoff or infiltration. The artificial mixing and leaching of rock and water exposes considerably more surface area of the rock material under laboratory conditions than is likely to occur as a result of simple surface contact with rain and runoff in the field. Furthermore, diatomite has unique surface properties that may result in the material being more responsive to the ionic strength of leaching solutions than other material types. Therefore, the MWMP results for diatomite most likely provide a conservative estimate of metal mobility and any identified exceedence of the Oregon MCLs is not conclusive and serves only to indicate potential constituents of concern for the project.

The MWMP testing and analyses were conducted on 34 drill core samples, 5 waste stream samples, 4 blended ore samples, 24 backfill waste samples and 2 sediment pond samples.

Table 8-1 shows the calculated average concentration by analyte for each material type. A complete tabulation of the MWMP data for individual samples is provided in Attachment K. Laboratory reports associated with Appendix K are provided electronically on the enclosed CD only. The following observations can be made from a comparison of the average MWMP concentrations with the Oregon MCLs in Table 8-1:

1. Oxidized diatomite samples resulted in arsenic and aluminum concentrations elevated above the Oregon MCLs with pH values greater than 7 s.u. The average TDS concentration for oxidized diatomite is also slightly elevated above the Oregon MCL; however, this is due to a single oxidized diatomite sample with a TDS concentration that is an order of magnitude greater than all other oxidized diatomite samples (i.e., an outlier and not considered representative of oxidized diatomite).
2. For the transitional diatomite samples, aluminum, arsenic, manganese, sulfate and TDS are elevated above the Oregon MCLs with circum-neutral pH values.
3. Opalized diatomite samples showed aluminum, iron and manganese concentrations greater than the Oregon MCLs with circum-neutral pH values.
4. Unoxidized diatomite samples show elevated concentrations of aluminum, antimony, arsenic, beryllium, cadmium, fluoride, iron, lead, manganese, selenium, sulfate and TDS under consistently low pH conditions.
5. Samples of ash and tuff show elevated concentrations of aluminum, arsenic, iron, manganese, sulfate and TDS with an average pH value greater than 7 s.u. Due to the syndepositional nature of the ash/tuff and diatomite, the ash/tuff layers interbedded with oxidized diatomite generally show lower MWMP concentrations than samples of ash/tuff that were interbedded with unoxidized diatomite.
6. Only iron and manganese were elevated in the samples of basalt and andesite (i.e., volcanic bedrock). The average pH value for the volcanic bedrock samples is neutral at 7 s.u.
7. Results from blended ore that consists of a mixture of oxidized and unoxidized diatomite collected from the Vale Plant shows elevated concentrations of aluminum, arsenic, beryllium, cadmium, iron, manganese, sulfate and TDS with pH values around 3 s.u.
8. Mineral process waste stream samples show several constituents elevated above Oregon MCLs including aluminum, arsenic, beryllium, cadmium, chromium, fluoride, iron, selenium, silver, sulfate, TDS and uranium.
9. Backfilled waste samples consisting of a mixture of onsite waste materials and mineral process waste indicate aluminum, arsenic, beryllium, iron, manganese, sulfate and TDS have the potential to be leached at concentrations above the Oregon MCLs under neutral pH conditions.
10. Aluminum, manganese, sulfate and TDS are the only constituents elevated above the Oregon MCLs in the two sediment pond samples. The average pH value indicates slightly acidic conditions at 4.7 s.u.

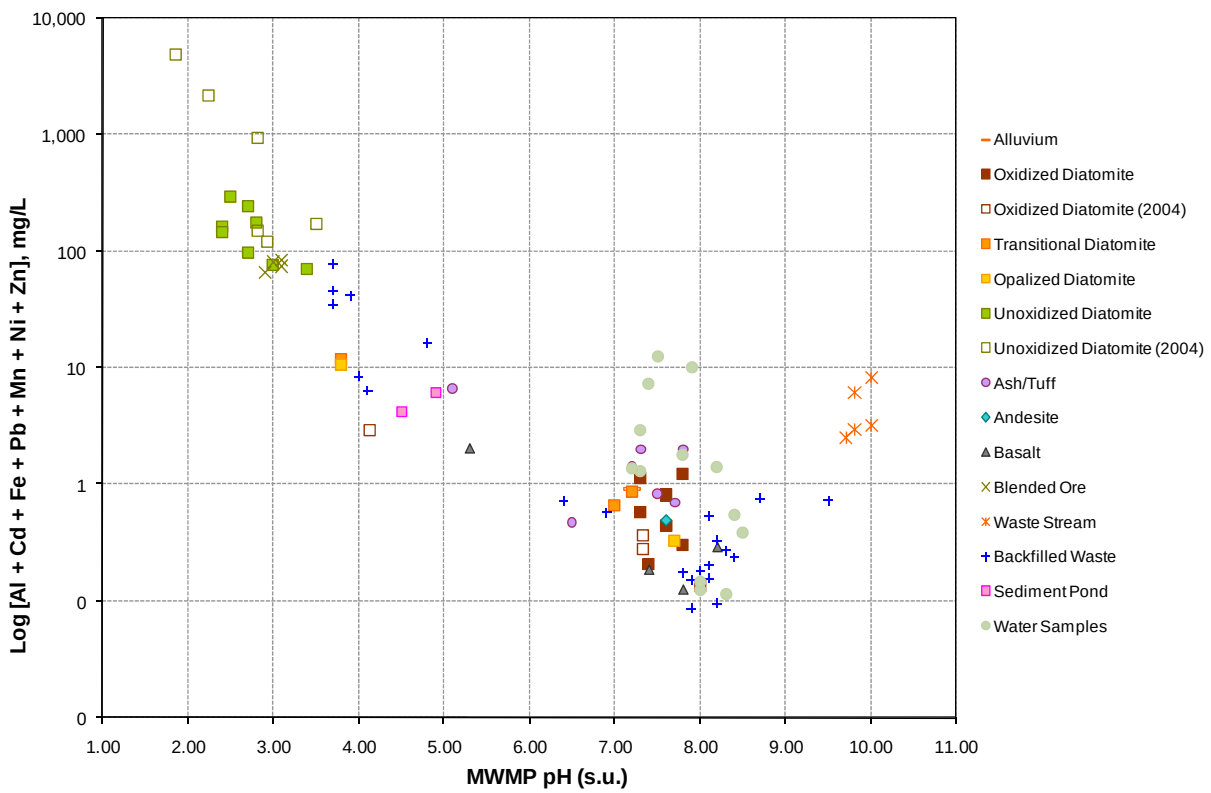
Table 8-1: Summary of Average MWMP Results by Material Type

Parameter	Oregon MCL	Oxidized Diatomite n = 11	Transitional Diatomite n = 3	Opalized Diatomite n = 2	Unoxidized Diatomite n = 14	Ash/Tuff n = 7	Volcanic Bedrock n = 5	Blended Ore n = 4	Waste Stream n = 5	Backfilled Waste n = 23	Sediment Pond n = 2
Acidity	--	7.5	25.7	20.0	2773	2.0	2.6	659.5	2.0	58.9	16.0
Alkalinity	--	22.7	9.7	6.5	1.6	12.1	19.2	2.0	10508.8	50.5	2.0
Aluminum	0.2	0.46	3.25	0.71	172.89	0.50	0.08	68.53	0.48	8.50	1.15
Antimony	0.006	0.0020	0.0007	0.0004	0.0108	0.0006	0.0004	0.0004	0.0058	0.0016	0.0004
Arsenic	0.01	0.034	0.073	0.001	0.948	0.014	0.008	0.023	2.204	0.049	0.007
Barium	2	0.070	0.068	0.028	0.041	0.048	0.059	0.022	0.072	0.044	0.055
Beryllium	0.004	0.0021	0.0030	0.0020	0.0500	0.0020	0.0020	0.0263	0.0160	0.0069	0.0030
Cadmium	0.005	0.0008	0.0009	0.0004	0.0210	0.0003	0.0001	0.0090	0.0108	0.0037	0.0020
Calcium	--	33.5	89.0	31.1	415.9	91.5	23.0	297.5	13.6	194.7	398.0
Chloride	250	70.3	5.0	1.0	8.2	2.7	1.4	13.0	152.4	66.0	38.0
Chromium	0.1	0.009	0.013	0.015	0.098	0.011	0.010	0.020	0.124	0.020	0.015
Copper	1	0.015	0.023	0.030	0.572	0.016	0.010	0.085	0.736	0.033	0.015
Fluoride	2	0.99	1.10	0.35	3.49	0.64	0.24	1.45	31.94	1.90	0.80
Iron	0.3	0.20	0.20	4.21	496.79	0.44	0.31	2.92	3.06	0.46	0.04
Lead	0.015	0.007	0.001	0.001	0.040	0.001	0.001	0.007	0.006	0.002	0.002
Magnesium	150	10.0	22.1	7.9	123.7	21.1	8.2	67.7	12.0	51.3	101.8
Manganese	0.05	0.03	0.81	0.51	7.83	0.88	0.10	2.39	0.04	1.09	3.56
Mercury	0.002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0017	0.0002	0.0003
Nickel	--	0.017	0.080	0.025	2.397	0.113	0.098	0.963	0.792	0.327	0.280
Nitrate+Nitrite	10	1.10	1.40	0.08	1.13	0.43	1.63	1.41	2.76	6.42	2.78
pH (s.u.)	6.5-8.5	7.27	6.00	5.75	2.72	7.01	7.26	3.03	9.86	6.63	4.70
Phosphorus	--	0.45	0.27	0.02	2.43	0.13	0.03	0.03	17.22	0.53	0.08
Potassium	--	1.88	5.73	2.35	16.51	5.19	3.26	5.18	33.60	6.64	11.95
Scandium	--	0.067	0.400	0.100	0.198	0.100	0.100	0.150	12.300	0.200	0.150
Selenium	0.05	0.029	0.027	0.003	0.058	0.004	0.001	0.025	1.249	0.045	0.013
Silver	0.1	0.008	0.010	0.010	0.023	0.010	0.010	0.028	0.204	0.020	0.015
Sodium	--	109.5	53.6	6.0	69.3	25.4	12.9	108.3	7908.0	465.8	109.0
Strontium	--	0.25	0.55	0.13	2.58	0.58	0.10	1.73	0.13	1.21	2.08
Sulfate	250	195	350	130	4283	364	90	1595	4712	1458	1500
Thallium	0.002	0.0007	0.0003	0.0001	0.0014	0.0002	0.0001	0.0003	0.0020	0.0006	0.0001
Tin	--	0.08	0.10	0.10	0.28	0.11	0.10	0.28	18.00	0.21	0.20
Titanium	--	0.007	0.026	0.005	0.076	0.032	0.006	0.008	1.030	0.011	0.008
TDS	500	538	720	190	5712	550	188	2228	22120	2475	2535
Uranium	0.03	0.0002	0.0002	0.0003	0.0171	0.0002	0.0001	0.0112	0.2423	0.0018	0.0001
Vanadium	--	0.10	0.03	0.01	0.43	0.06	0.03	0.01	0.74	0.07	0.01
Zinc	5	0.03	0.09	0.08	3.35	0.10	0.04	0.74	0.24	0.23	0.13

For values less than the method detection limit, the detection limit value was used to calculate the average concentrations.
Shaded values exceed the respective Oregon MCL as defined by 333-061-0030.

A Ficklin diagram was generated from the MWMP results to evaluate the potential for metal mobility and plots total metal concentration (Cd + Fe + Pb + Mn + Ni + Zn) versus pH for each rock type (Figure 8-4). As can be seen from Figure 8-4, the unoxidized diatomite and blended ore samples exhibit the highest reactivity with the greatest release of metals under low pH conditions. These results are consistent with NAG testing values (see discussion in Section 8.2.4 below) and indicate potential for acid release from the unoxidized diatomite. On the other end of the spectrum, the oxidized diatomite and the volcanic units show a negligible potential to be acidic with pH values generally greater than 7 s.u and low potential for metals release. Samples of transitional and opalized diatomite fall somewhere in between these two end points.

Figure 8-4: Ficklin Diagram for Celatom Samples



As shown in Figure 8-4, results for the backfilled waste demonstrate a bimodal distribution; one group of samples have pH values slightly greater than the unoxidized diatomite and a slight reduction in metals release and the other group shows a low potential for metals release with pH values greater than 7 s.u. probably reflecting differences in the amount of unoxidized diatomite, oxidized diatomtie and waste stream material (i.e., soda ash) that were incorporated. The waste stream samples cluster tightly with pH values of around10 s.u. and a moderate metals release that is several orders of magnitude less than that observed for the unoxidized diatomite. The results from the two sediment pond samples are the same with a moderate potential to release metals under slightly acidic pH conditions (4.5 to 5 s.u.).

The leachability of sulfate (and TDS) follows a similar trend as metals leaching with unoxidized diatomite showing the greatest potential for sulfate mobility (Figure 8-5). The

sulfate leaching potential for samples of unoxidized diatomite collected from surface exposures (2004) is several orders of magnitude greater than the potential demonstrated by samples of unoxidized diatomite collected from the subsurface (i.e., drill core). This can be attributed to the effects of oxidation of sulfide minerals and formation of sulfate salts within the diatomite at the surface prior to sample collection. As expected, the leachability of sulfate from the mineral process waste stream samples is high however concentrations are still lower than the unoxidized diatomite from the 2004 surface samples.

As shown in Figure 8-6, the highest concentrations of aluminum are associated with the unoxidized diatomite and the mobility of aluminum increases with decreasing pH. Aluminum is elevated above the Oregon MCLs for all material types except the volcanic bedrock (i.e., basalt and andesite), and can be attributed to the abundance of clay in the deposit (Figure 8-6). Even though the MWMP leachate is filtered prior to preservation and analysis, the probable source of the observed aluminum is ultra-fine grained or colloidal clay particles which are less than 0.45 microns in diameter. Colloidal sized particles are typical of diatomite deposits, which have been shown to contain particles as small as 0.05 microns in size. Based on these results, aluminum is anticipated to be generally elevated in background conditions. Manganese and iron also have a potential to form colloidal sized particles, particularly in the presence of organic matter, and would also be expected to be elevated in background conditions (Ross and Sherrell, 1999).

In Figure 8-7, manganese concentrations for each of the samples are plotted versus MWMP pH values. This graph shows the trend in increasing metals concentrations with decreasing pH for each of the material types, with the exception of the waste stream samples. Also plotted on Figure 8-7 are the concentrations of manganese in groundwater and surface water samples collected from the 2008 sample event. Although the water samples are above the respective MCL for manganese, concentrations are about an order of magnitude lower than in the unoxidized diatomite, with overlap between the low end of the concentration range for the unoxidized diatomite and the high end of the concentration range observed in groundwater.

The waste stream samples show a unique trend, with pH greater than 9 s.u and moderate metals release. Under high pH conditions, oxyanion-forming elements such as arsenic, antimony and selenium, increase in concentration due to a change in mineral surface chemistry which promotes desorption of these elements. This is demonstrated by plotting arsenic concentrations versus MWMP pH values for each sample (Figure 8-8). As shown in Figure 8-8, arsenic shows an increase in mobility above pH of 7 s.u. Samples with pH values in this range include samples collected from the waste stream and to a lesser extent samples from backfilled waste that consist of a mixture of mineral process waste and onsite waste.

In Figure 8-9, fluoride concentrations are plotted versus MWMP pH values. As shown, fluoride is generally below the respective MCL with the exception of of unoxidized diatomite, backfilled waste and waste stream samples. As with the oxyanions, the MWMP fluoride concentrations are significantly greater for the waste stream samples (greater than 20 mg/L) than all other samples tested.

Figure 8-5: MWMP pH versus Sulfate

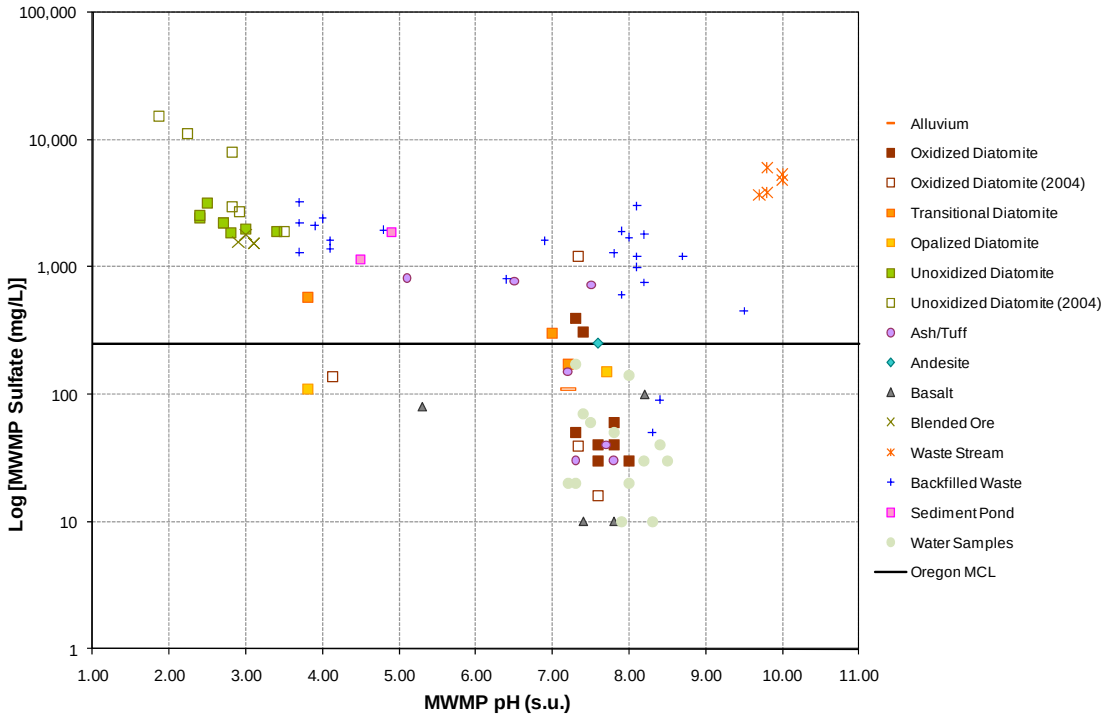


Figure 8-6: MWMP pH versus Aluminum

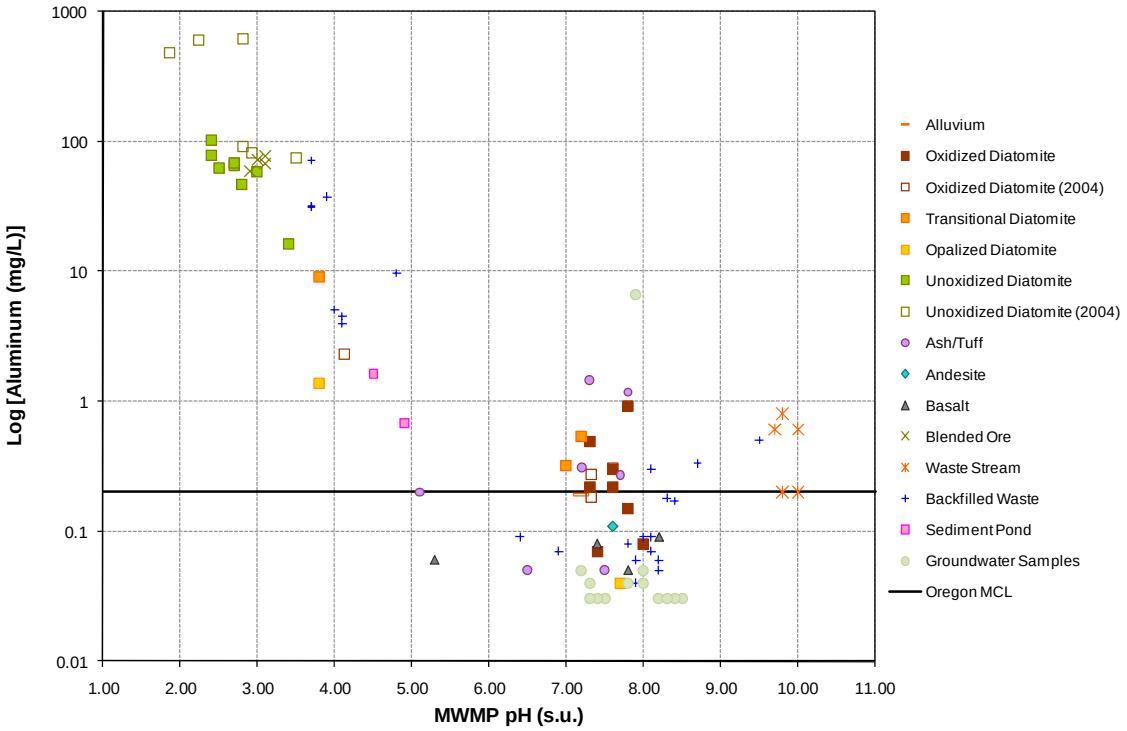


Figure 8-7: Manganese versus pH

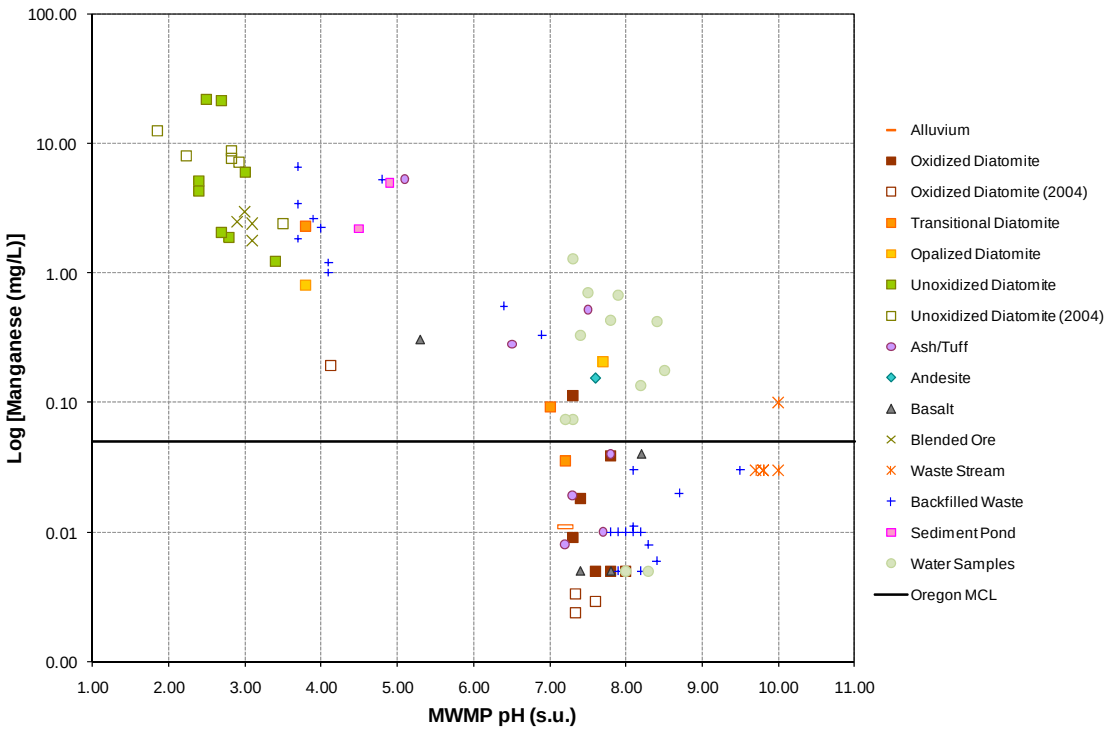


Figure 8-8: Arsenic versus pH

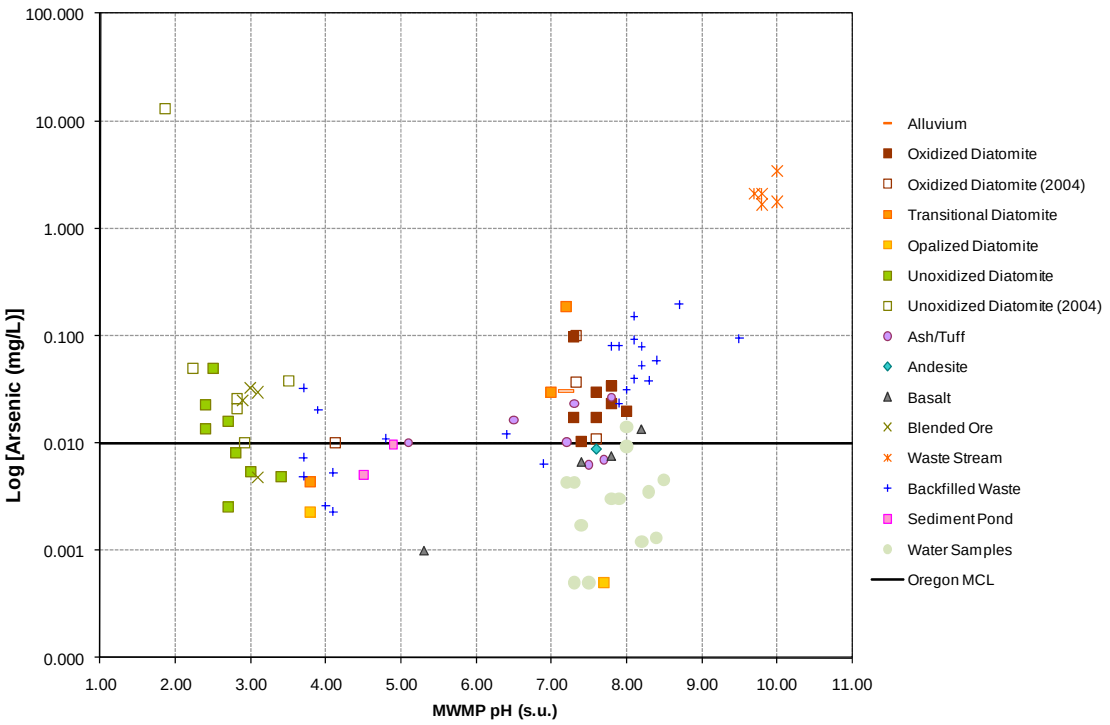
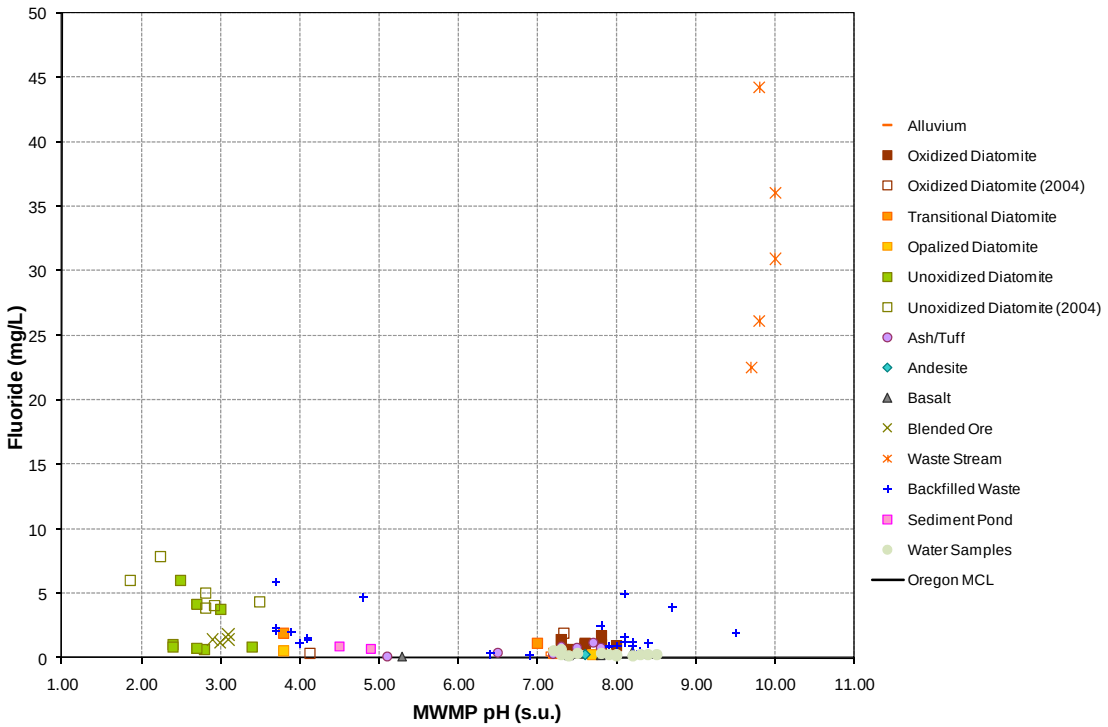


Figure 8-9: Fluoride versus pH



8.2.2 Whole Rock Analysis

Whole rock chemistry involves the near-complete digestion of a solid sample into solution using multiple strong acids. The solution is then analyzed for chemical composition using inductively-coupled plasma/mass spectrometry (ICP/MS). Samples were submitted to Chemex for 4-acid digestion and ICP/MS (ME-MS61) to determine total metal, metalloid and cation chemistry for 48 elements. The whole rock geochemistry is typically compared to average crustal igneous rock composition (Hem, 1985). Where the total concentration exceeds three times the crustal abundance, the element is considered to be anomalously enriched (Price, 1997). A complete tabulation of the whole rock analysis data is provided in Appendix L, along with a comparison to crustal abundance for each element. Laboratory reports associated with Appendix L are provided electronically on the enclosed CD only.

By comparing the metal concentrations from the MWMP analytical results with the total metal concentrations from whole rock chemistry testing, it is possible to assess the magnitude of potential leaching and thus reactivity of the material. The weight percent release was calculated for select constituents according to the following equation:

$$\text{Wt. \% release} = \frac{\text{(concentration in mg/L in MWMP leachate)}}{\text{(concentration in mg/kg in rock)}} \times 100$$

Average values of the weight percent of MWMP leachate mass to whole rock mass for select constituents is summarized in Table 8-2 according to material type. In Figures 8-10 through 8-15, the weight percent release values were plotted against the whole rock results for aluminum, arsenic, cadmium, iron, lead, and manganese. Based on this assessment, the greatest weight percentage release of these constituents correlates with the unoxidized

diatomite samples that show a potential for mobilization of aluminum, cadmium, iron, manganese. Backfilled waste shows a moderate potential for mobilization of aluminum, cadmium, lead and manganese.

Analytical limitations prevented this type of comparison for sulfate because total sulfur is underestimated by the ICP method due to incomplete extraction of sulfur during the 4-acid digest. Therefore, although the MWMP data should theoretically be less than the total sulfur in the sample (as measured by ICP), this is not always the case. Consequently, a direct correlation between the ICP sulfur and MWMP sulfate cannot be made and the potential release of sulfur has not been included in this analysis.

Table 8-2: Average Potential Constituent Release for Select Constituents

Material Type	n	% Al	% As	% Cd	% Fe	% Pb	% Mn
Alluvium	1	0.0	0.1	0.1	0.0	0.0	0.0
Oxidized Diatomite	9	0.0	0.5	0.3	0.0	0.0	0.0
Transitional Diatomite	3	0.0	0.3	2.5	0.0	0.0	1.2
Opalized Diatomite	2	0.0	0.0	0.4	0.0	0.0	0.2
Unoxidized Diatomite	8	0.3	0.1	18.0	0.6	1.3	8.7
Ash/Tuff	7	0.0	0.3	0.3	0.0	0.0	0.3
Basalt	4	0.0	0.8	0.1	0.0	0.0	0.0
Andesite	1	0.0	1.0	0.2	0.0	0.1	0.0
Blended Ore	4	0.3	0.2	19.1	0.0	0.2	4.4
Waste Stream	5	0.0	6.3	7.7	0.0	0.1	0.1
Backfilled Waste	16	0.0	0.4	3.4	0.0	0.0	0.9
Sediment Pond	2	0.0	0.1	1.3	0.0	0.0	0.9

Overall, the mass of metals stored in the volcanic units (i.e., ash, tuff, andesite and basalt) is significantly greater than the oxidized and unoxidized diatomite units. However, the availability for dissolution and mobility of these constituents is considerably lower as demonstrated by lower weight percent release calculated for these units. The one exception to this trend is arsenic (Figure 8-11), which shows a slightly greater propensity to be leached from the volcanic units and the oxidized diatomite, even though the whole rock results indicate the unoxidized diatomite contains more arsenic than these units.

During processing of ore at the Vale Plant, the chemical composition of the ore is altered, as demonstrated by whole rock results for the waste stream samples. As shown in Table 8-2, the concentration and mobility of arsenic increases for the waste stream samples in comparison to the source materials (i.e., diatomite ore). Due to the mixing of the waste stream material with onsite waste, backfilled samples generally appear to exhibit arsenic mobility intermediate between that of the waste stream samples and that of the on-site waste material. However, the geochemistry of the backfilled waste appears to be mostly controlled by the onsite waste material which would be expected since the onsite waste comprises the majority of the backfill waste.

Figure 8-10: Potential Release of Aluminum

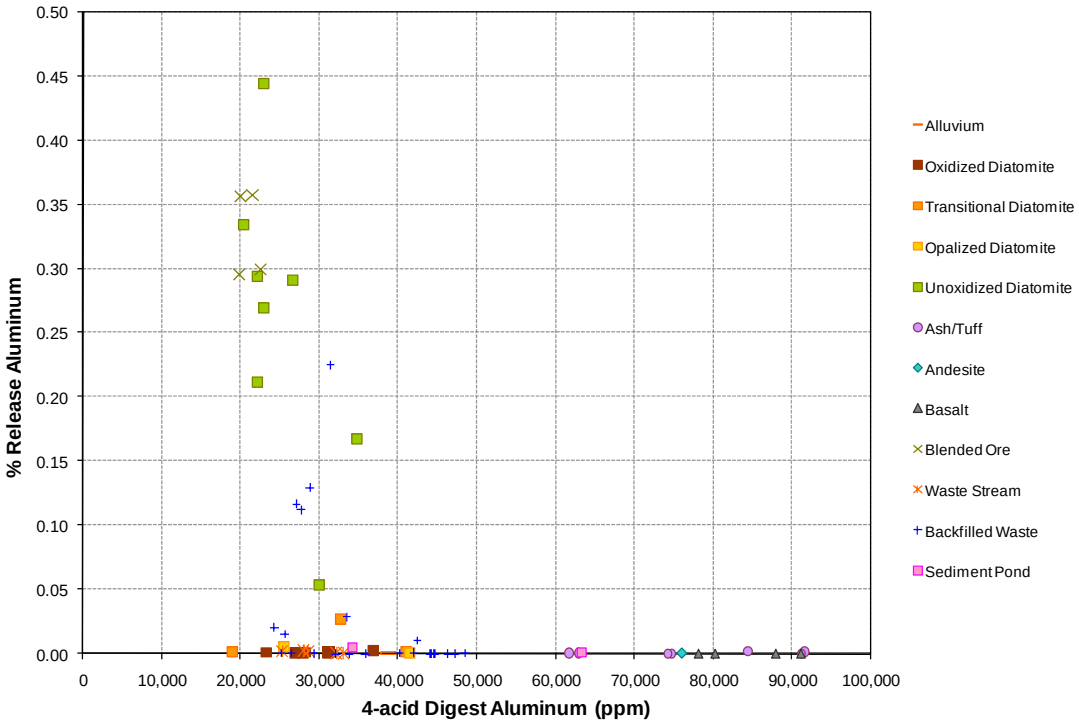


Figure 8-11: Potential Release of Arsenic

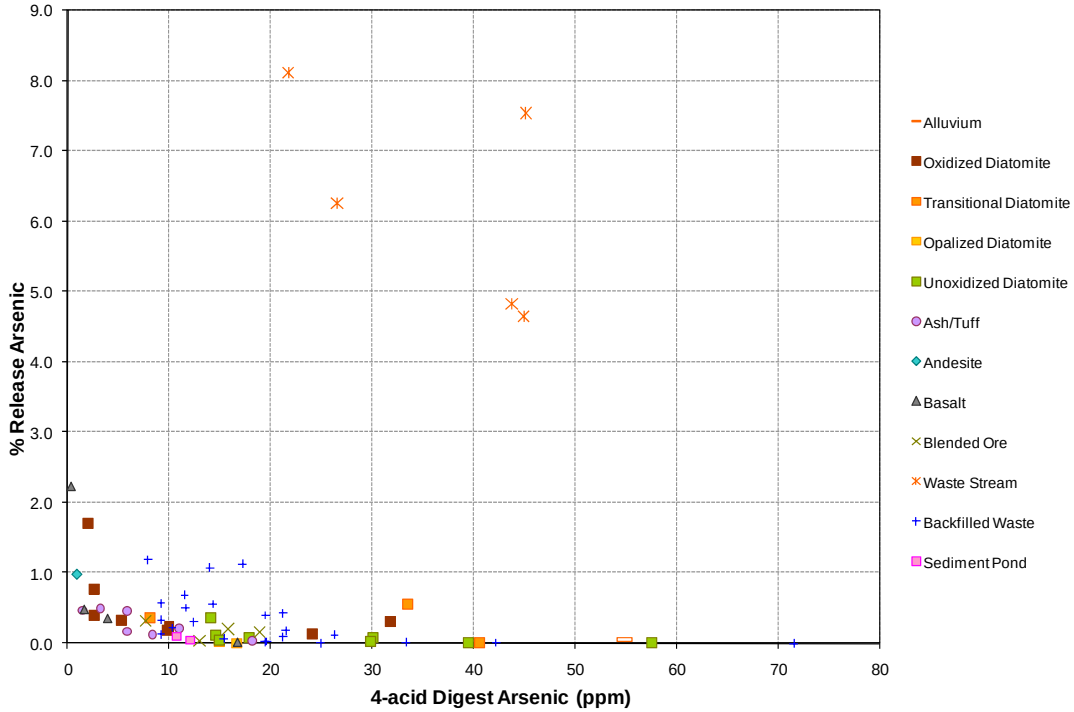


Figure 8-12: Potential Release of Cadmium

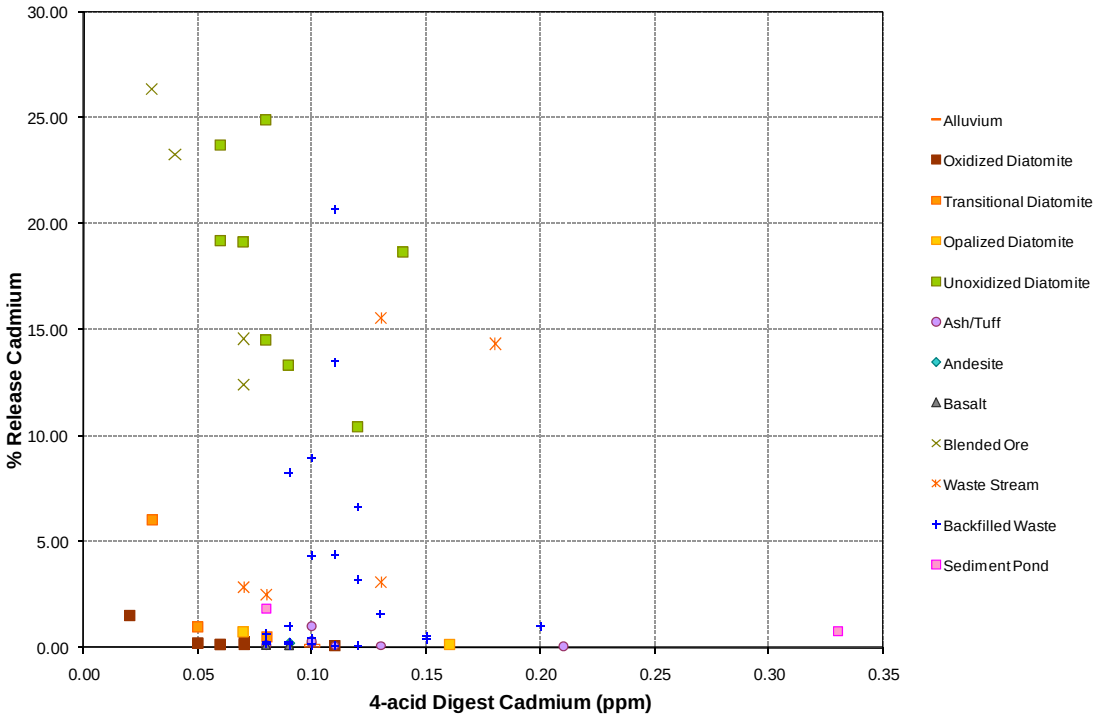


Figure 8-13: Potential Release of Iron

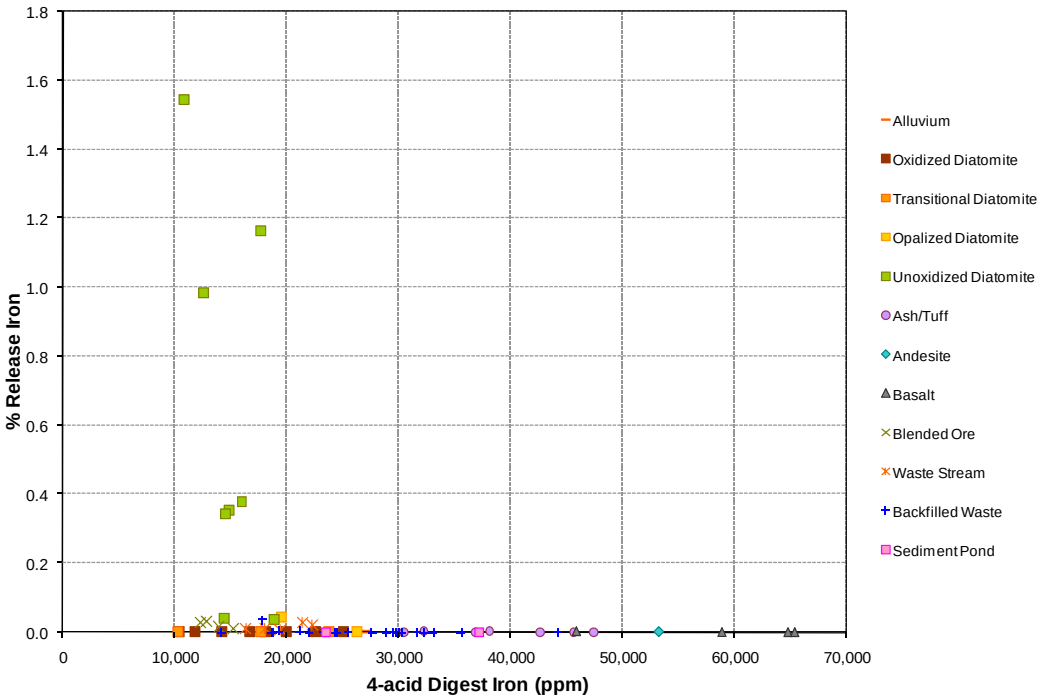


Figure 8-14: Potential Release of Lead

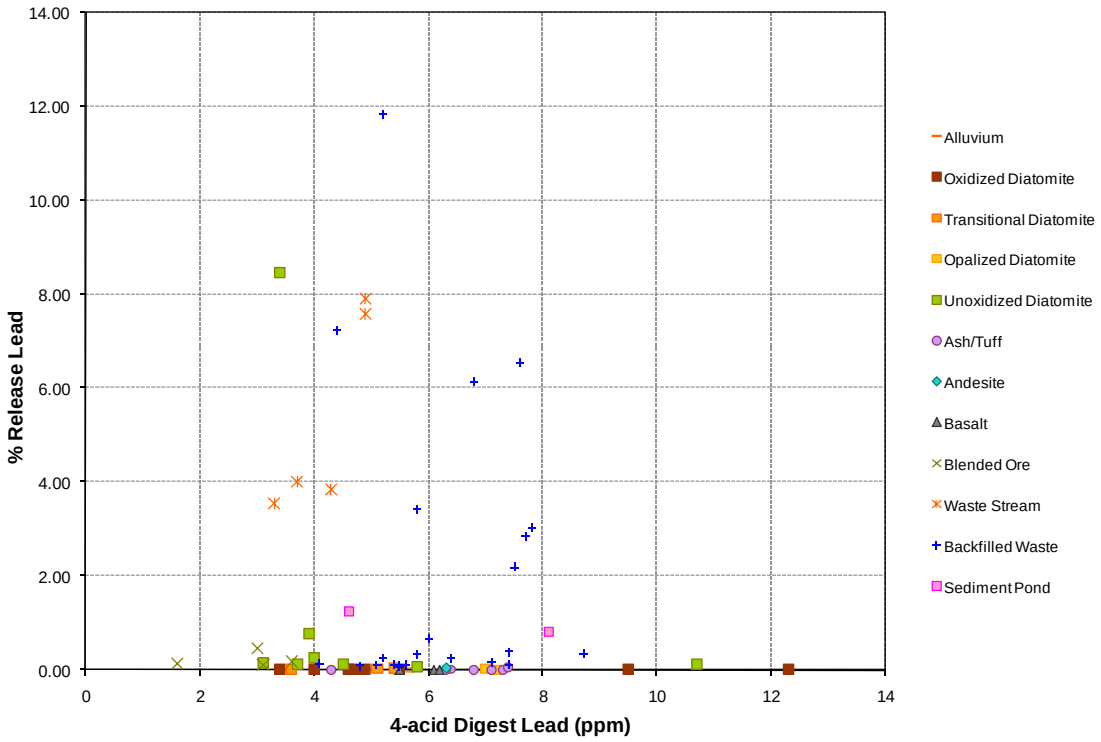
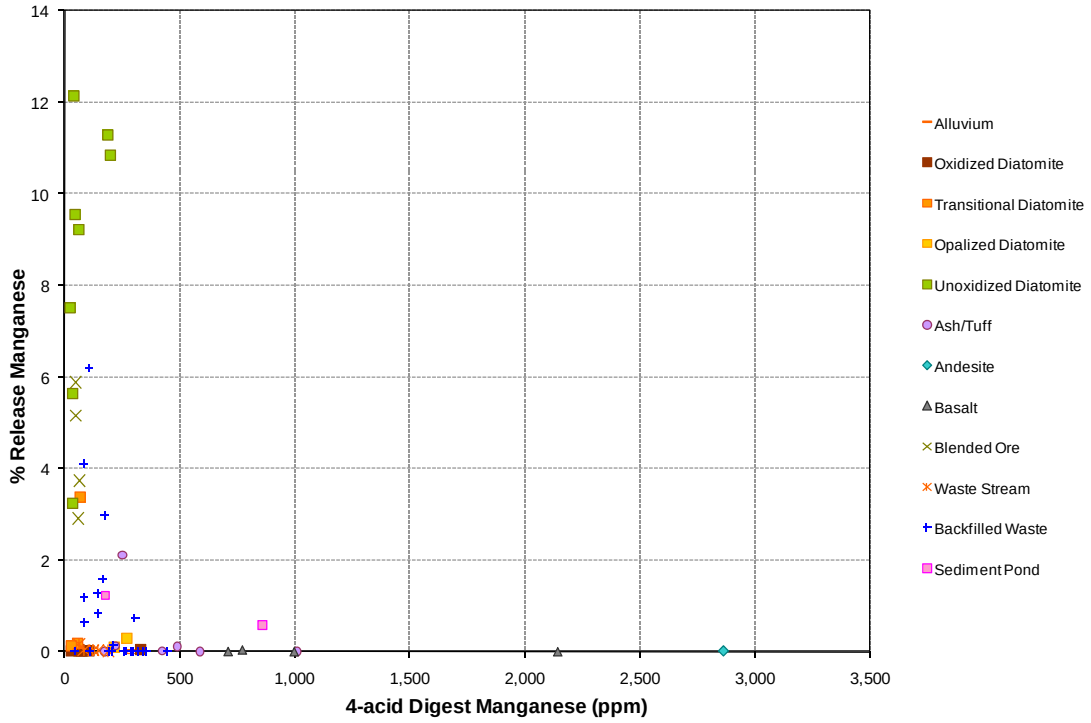


Figure 8-15: Potential Release of Manganese



8.2.3 Acid-Base Accounting

Acid-base accounting (ABA) provides a standardized approach to the assessment of the acid generation or acid neutralization potential of rock materials. The ABA method used for this study is the Modified Sobek ABA method, which includes both laboratory analysis and theoretical calculations based on two parameters; acidification potential (AP) and neutralizing potential (NP). First, the total mass of potentially acid generating and acid neutralizing components in a sample is quantified through laboratory analysis. Then an estimate of acid generation is made by assuming complete reaction between minerals with acid generating potential (e.g., pyrite) and minerals with neutralizing potential (i.e., essentially dissolution of carbonate minerals and to a very limited extent silicate minerals as the latter have very slow reaction kinetics, Bowell et al., 2000).

For this study, the AP value was calculated using sulfide sulfur speciation chemistry from LECO analysis. The AP calculation is based on the assumption that two moles of acid will be generated for each mole of sulfur and one mole of calcium carbonate will neutralize the two moles of acid. In order to calculate the AP value in units of equivalent (eq.) kg $CaCO_3$ per ton, the percent sulfide sulfur obtained from LECO analysis was multiplied by 31.25. The ABA test assumes that all alkaline and acid phases react completely and that all available sulfide is FeS_2 (i.e., pyritic). The presence of monosulfides (i.e., AVS) with variable iron to sulfur ratios in the lake sediments can complicate predictions using this stoichiometric calculation and likely underestimates the resulting AP value. Furthermore, by using this approach, iron oxidation and hydrolysis of secondary minerals (e.g., acid sulfate minerals such as jarosite) are not accounted for in the calculated AP values. For these reasons, the ABA results do not provide the most reliable prediction of acid generation for diatomite samples containing monosulfides (i.e., unoxidized diatomite). As described in the following section, the net acid generation test (NAG) is considered a better method for determining acid generation potential for the rock at the Celatom mine.

Values of NP are indicative of the capacity of rock materials to buffer acidity produced by sulfide oxidation or other proton-generating reactions. For this study, NP was determined using the Modified Sobek protocol that includes a digestion to expel any CO_2 followed by a back titration with NaOH to a pH of 8.3 s.u. Neutralizing potential is reported as $CaCO_3$ equivalent tons per 1,000 tons of rock.

The balance between the acid generating mineral phases and acid neutralizing mineral phases is referred to as the net neutralization potential (NNP), which by convention is equal to the difference between NP and AP, reported in units of equivalent (eq.) kg $CaCO_3$ per ton. The NNP value allows classification of the samples as potentially acid consuming or acid producing. As such, a positive value of NNP indicates the sample neutralizes more acid than is produced during oxidation. A negative NNP value indicates there are more acid producing constituents and, as such, is classified as a potentially acid generating material. Material that would be considered to have a high potential for acid neutralization would produce a net neutralizing potential of greater than 20 eq. kg $CaCO_3$/ton and material that would be considered to have a high potential for acid generation would produce a net neutralizing potential of less than -20 eq. kg $CaCO_3$/ton. Another criterion used to evaluate the ABA data is the Neutralization Potential Ratio (NPR) which is calculated by dividing the NP by the AP. The NPR provides another predictive tool for distinguishing between potentially acid generating and non-acid generating samples.

ABA results are typically compared to criteria provided by the BLM (2008) in order to determine the potential for the waste rock material to generate acid. The BLM considers waste rock to be non-acid generating without kinetic testing if there is 300 percent neutralizing capacity (i.e., NPR>3) and the NNP is greater than 20 eq. kg $CaCO_3$/ton. According to BLM guidance (2008), samples that do not meet these criteria require kinetic testing to address the uncertainties of the ABA testing. These BLM criteria conservatively assume that any sample having more AP than NP, even by a very small amount, is potentially acid generating. When both values get small, the ratio varies widely and misrepresents the potential for acid generation. Because there is a deficit of acid neutralizing minerals in the Celatom deposit, and many of the samples contained very little sulfur, the BLM criteria cannot be used to meaningfully classify this material. Therefore, samples with non-detectable sulfide sulfur were considered "inert" from a static testing perspective. The remaining samples were categorized using the BLM criteria. Therefore, samples that are considered non-acid generating in this study include those with NPR values greater than 3 and NNP values greater than 20 eq. kg $CaCO_3$/ton in addition to those samples that are considered inert. The criteria used to assess the acid generating potential of the Celatom samples based on ABA data are shown in Table 8-3.

Table 8-3: Criteria Used in the Determination of Acid Generation Potential

Sulfide Sulfur (wt%)	NNP	NPR	Acid Generation Potential
<0.01	--	--	Inert – non-acid generating
>0.01	> 20	>3	Non-acid generating
	< 20	<3	Potentially acid generating

ABA testing was conducted on 34 drill core samples, 5 waste stream samples, 4 blended ore samples, 24 backfill waste samples and 2 sediment pond samples. A tabulation of the ABA testing results is provided in Appendix M. Laboratory reports associated with Appendix M are provided electronically on the enclosed CD only. In Figure 8-16, the net neutralizing potential (NNP) is plotted against the NPR for each sample. In Figure 8-17 and 8-18 the sulfide sulfur concentrations are plotted against the NPR and NNP values, respectively. In these figures, the unoxidized diatomite and opalized diatomite demonstrate the greatest potential for acid generation with the lowest NNP and NPR values. The potential for unoxidized diatomite to produce acid is confirmed by Figure 8-19, where sulfide sulfur concentrations are plotted versus the pH of the MWMP leachates. In Figure 8-19, the pH values of the MWMP leachate from unoxidized diatomite were consistently less than 4 s.u. The acid generating potential of the unoxidized diatomite can be attributed to the presence of highly reactive AVS phases including mackinawite and amorphous iron monosulfides. Although potentially acid generating, the unoxidized diatomite contains only a limited amount of sulfide (on average less than 0.5 wt%). The opalized diatomite is from MW-6 south of the Section 36 pit and contains euhedral pyrite that is not observed in other drill hole locations. The presence of pyritic sulfur, at concentrations slightly greater than 0.5 wt%, results in a slightly greater potential for acid generation. However, the NNP values for unoxidized and opalized diatomite are consistently greater than -20 eq. kg $CaCO_3$/ton indicating a low to moderate potential for acid generation.

None of the oxidized diatomite samples contain measurable levels of sulfide sulfur and therefore are considered inert and are not predicted to generate acid. Therefore, even though the NPR is less than 3 and NNP values are less than 20 eq. kg $CaCO_3$/ton, kinetic testing of the oxidized diatomite is not warranted. This prediction is supported by the MWMP pH values for oxidized diatomite that are greater than 6 s.u. for all but one sample. Samples of transitional diatomite fall in between the oxidized and unoxidized diatomite.

The greatest neutralization potential is demonstrated by a few samples representing the volcanic and ash/tuff units as well as the waste stream samples. These samples are considered non-acid generating with NNP values greater than 20 eq. kg $CaCO_3$/ton and NPR values greater than 3.

Both pond berm samples have a NPR value greater than 3 but an NNP value less than 20 eq. kg CaCO3. Therefore, based on the BLM criteria, the sediment pond samples have an uncertain potential to be acid generating. However, both of these samples contain low to non-detect sulfide sulfur concentrations. Because these samples were not submitted for NAG testing, the acid generation potential of this material cannot be confirmed with NAG pH and NAG values.

In Figure 8-20, sulfate sulfur is plotted versus sulfide sulfur. As a general rule, sulfate sulfur content is significantly greater than sulfide sulfur content. In all cases, the sulfide sulfur content is less than 2 percent, and in most cases is less than 0.5 percent.

Figure 8-16: Net Neutralizing Potential versus Neutralization Potential Ratio

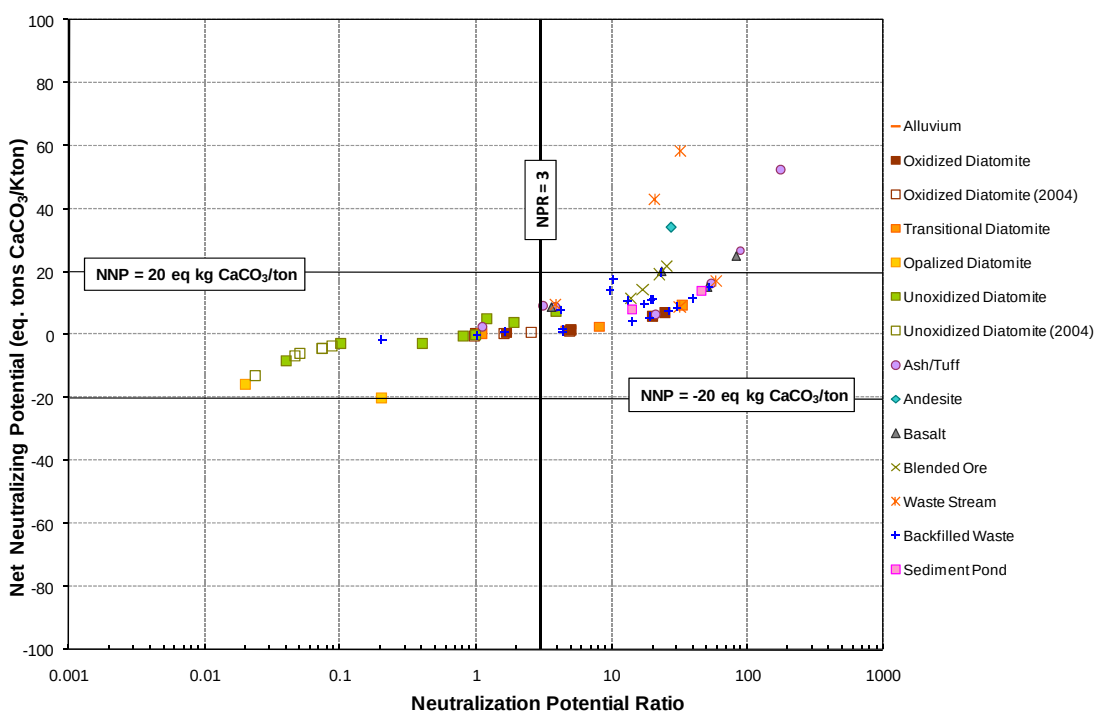


Figure 8-17: Neutralization Potential Ratio versus Sulfide Sulfur

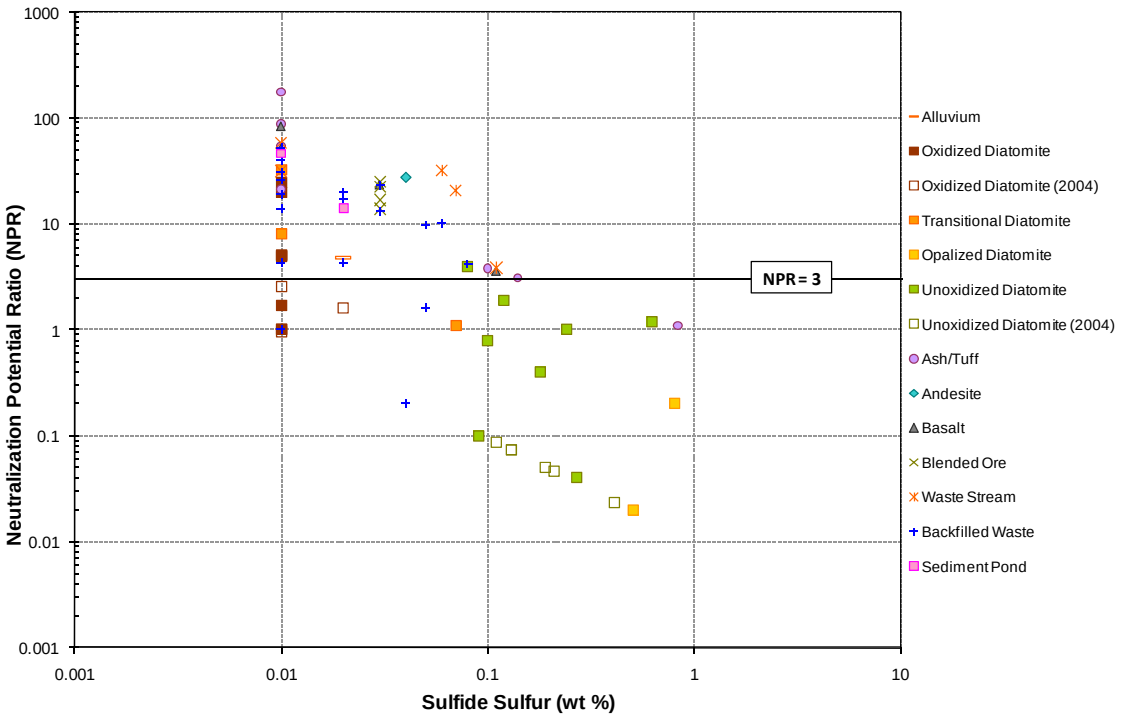


Figure 8-18: Net Neutralization Potential versus Sulfide Sulfur

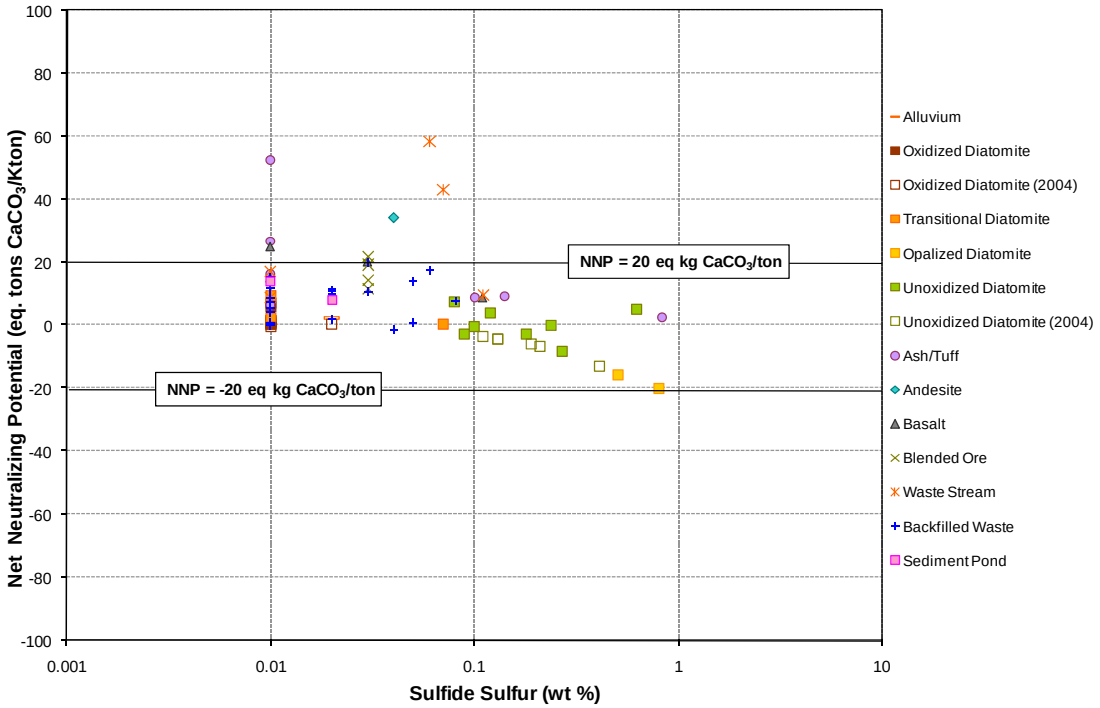


Figure 8-19: MWMP pH versus Sulfide Sulfur

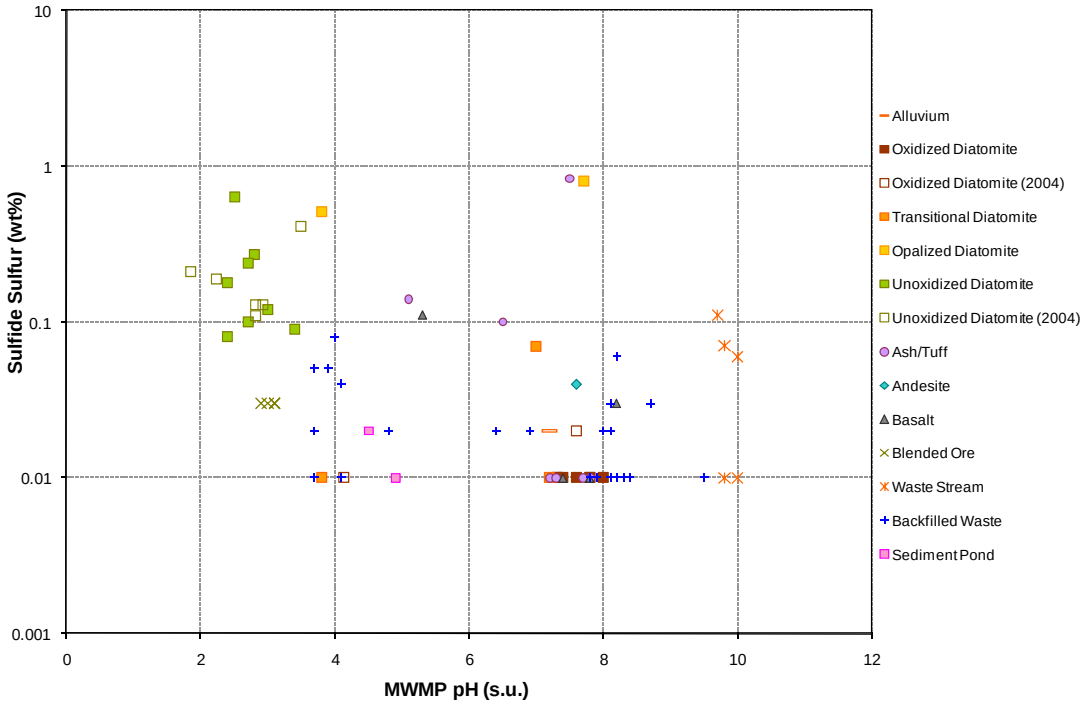
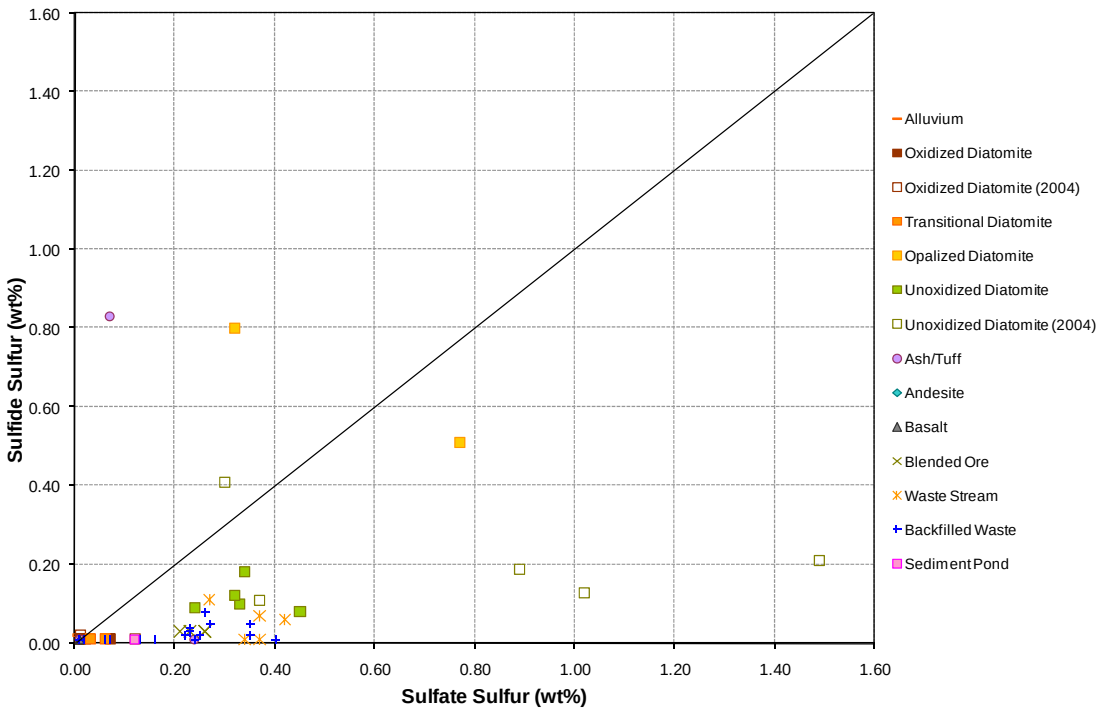


Figure 8-20: Sulfide Sulfur versus Sulfate Sulfur



8.2.4 Net Acid Generation Testing

For this study, net acid potential was determined using the NAG test method of Miller *et al*. (1997). This test is a modification of the hydrogen peroxide method of Sobek *et al*. (1978), which involves the laboratory oxidation of sulfides in a weak hydrogen peroxide solution (a very aggressive oxidant). This reaction releases the acid produced by sulfide oxidation, oxidation of ferrous to ferric iron, and the oxidation of any other metals. Because the reaction takes place in water, the dissolution of secondary salts also contributes to the acid potential. Any acid that is released will react with any buffering materials (e.g., carbonate minerals) that are present, yielding a net pH indicative of overall acid generation potential.

NAG testing was conducted to determine the final NAG pH (s.u.) following H_2O_2 digestion and the NAG value (expressed in kg H_2SO_4/ton) following NaOH titration to raise the pH of each sample to 6 s.u. and 7 s.u., respectively. The NAG test provides a direct assessment of the potential for a material to produce acid after a period of exposure and weathering (i.e., sample reactivity). NAG values were not determined for samples with a NAG pH value greater than 4 s.u. and for these samples the NAG value is reported as 0 eq. kg H_2SO_4/ton.

This test differs from the ABA test in that it oxidizes sulfides present through a two-stage hydrogen peroxide digest, and then establishes acid generation potential through a one-step titration rather than through back titration as is done in the Sobek test. The benefit of using the NAG test is that it does not differentiate between the different sulfur forms and therefore provides a direct empirical estimate of the overall sample reactivity, including semi-soluble acid-generating sulfate minerals (e.g., jarosite) as well as other acid-generating sulfide minerals. As such, the NAG testing is considered a better estimate of the "reactive" or "field" acid generation than the ABA method, which defines acid potential based solely on sulfide content. For the Celatom Mine, the NAG test are expected to be a more reliable indicator of acid generation potential for those samples containing amorphous iron sulfide (i.e., unoxidized diatomite).

The BLM have not established guidelines for evaluating NAG test results. However, based on the test procedure (EGI, 2002), pH values less than 4 s.u. indicate the sample will generate some acidity in excess of available alkalinity. The guidelines used for assessing the acid generation potential based on NAG results are summarized in Table 8-4. By convention, samples with a NAG pH less than 4 and NAG values below 10 equivalent kg H_2SO_4 per ton of material have a low to moderate potential for acid generation and samples with a NAG value greater than 10 eq. kg H_2SO_4 per ton have a higher capacity for acid generation. When dealing with low sulfide material that demonstrates a low to moderate potential for acid generation, the NAG final pH becomes more important as it can be used to identify samples that are likely to generate acid empirically, under steady state conditions.

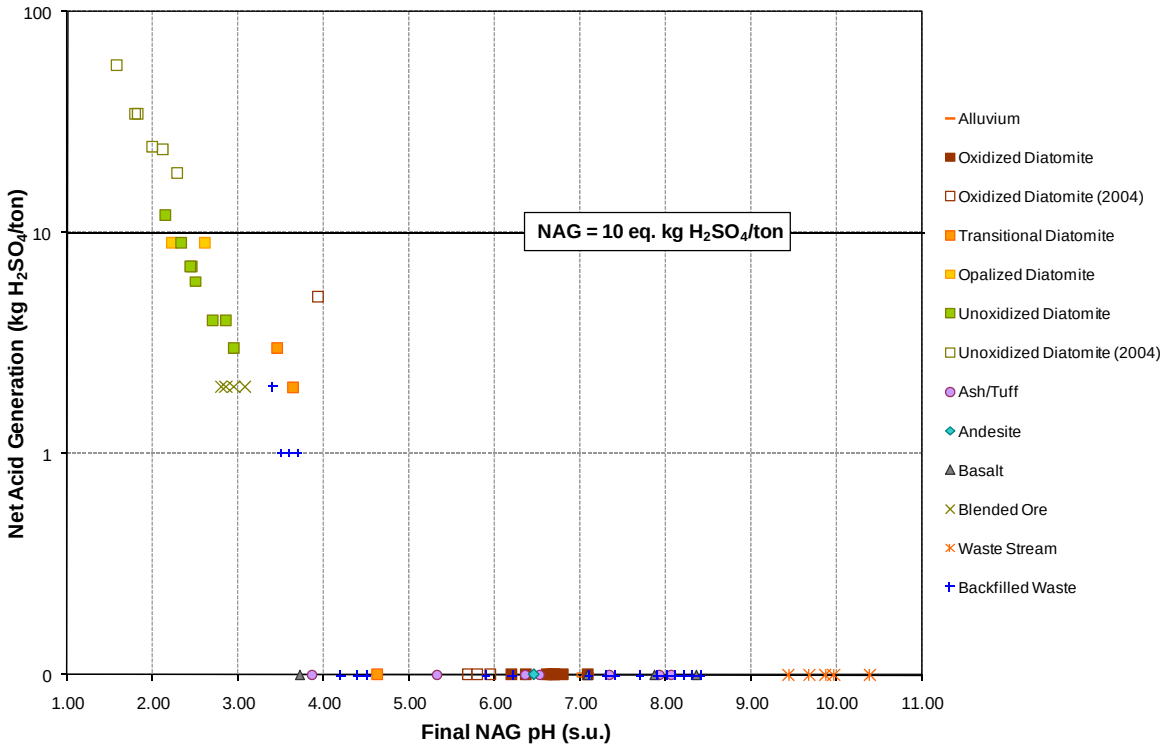
Table 8-4: Acid Generation Criteria for NAG Results (Miller *et al*., 1997)

Acid Generation Capacity		Final NAG pH (s.u.)	Static NAG (kg H_2SO_4/ton)
Potentially Acid Forming	Higher Capacity	< 4	>10
	Lower Capacity	< 4	$\leq$10, >0
Non-Acid Forming		$\geq$ 4	0

NAG testing was conducted on 34 drill core samples, 5 waste stream samples, 4 blended ore samples and 24 backfill waste samples. A tabulation of the NAG test results is provided in Appendix M. Laboratory reports associated with Appendix M are provided electronically on the enclosed CD only.

In Figure 8-21 the NAG values are plotted against NAG pH values according to material type. Most of the samples have NAG pH values greater than 4 s.u. and are predicted to be non-acid forming. The greatest NAG values and the lowest NAG pH values were obtained from the unoxidized diatomite samples with greater potential demonstrated by the weathered surface samples from the 2004 ARD study collected from existing pit walls. The unoxidized samples show a moderate to strong potential for acid generation with NAG pH values less than 4 s.u. and NAG values ranging from about 5 to 60 eq. kg H_2SO_4/ton. Samples of opalized diatomite, transitional diatomite and a few of the blended ore samples demonstrate a moderate potential to generate acid with NAG values greater than 0 but less than 10 eq. kg H_2SO_4/ton. The remaining onsite material types (i.e., oxidized diatomite, ash/tuff, andesite and basalt) are predicted to be non-acid forming with pH values greater than 4 s.u., indicating these material types will not generate acidity in excess of available alkalinity. This is also the case for the mineral process waste stream samples with the highest NAG pH values that can be attributed to the addition of soda ash during ore processing. The samples of backfilled waste show a bimodal distribution with some samples showing a low to moderate potential for acid generation and the remaining samples showing no potential to be acid generating.

Figure 8-21: NAG Values versus NAG pH



8.3 Summary of ARD Assessment by Material Type

The conclusions from the material characterization program are summarized below for each of the different sources of material.

8.3.1 Drill Core Samples

1. Unoxidized diatomite demonstrates a moderate to high potential to generate acid based on the NAG results. This potential to generate acid is confirmed by low pH values (<3 s.u.) observed for the unoxidized diatomite in the MWMP tests;
2. The acid generating potential demonstrated by the unoxidized diatomite results from the presence of highly reactive AVS phases including mackinawite and amorphous iron monosulfides that will generate acid if exposed to air and water. Given the mineralogy of sulfide in the samples, sulfide oxidation will be fairly rapid;
3. The weathered samples of unoxidized diatomite collected from the existing pit walls in 2004 show a greater potential for acid generation and metals release than the unweathered samples of unoxidized diatomite collected from drillcore. This increase in predicted acid generation potential provides an indication of how the unoxidized diatomite will behave in response to weathering of the material (i.e., in lieu of kinetic tests);
4. Constituents that have the potential to be leached from the unoxidized diatomite under low pH conditions at concentrations above Oregon MCL values include aluminum, antimony, arsenic, beryllium, cadmium, fluoride, iron, lead, manganese, selenium, sulfate and TDS;
5. Sulfide sulfur was not detected in the oxidized diatomite samples, and this material type is considered inert in terms of geochemical reactivity. The MWMP and NAG results for oxidized diatomite support this prediction.
6. The average MWMP values for oxidized diatomite are lower than the Oregon MCLs for all parameters except aluminum and arsenic. Aluminum concentrations are an artifact of the high clay content of the deposit and the average arsenic concentrations are just slightly above the Oregon MCL of 0.01 mg/L. Therefore, based on the MWMP results, the oxidized diatomite samples show a low potential to release metals and sulfate. Furthermore, weathered samples of oxidized diatomite collected from the existing pit walls in 2004 do not show an increase in the potential for acid generation and metals release due to weathering (as is observed with the unoxidized diatomite);
7. The partially oxidized diatomite (i.e., transitional) demonstrates a moderate potential for acid generation based on the NAG results and shows a low to moderate potential to release metals and sulfate. Constituents that have the potential to be leached from the transitional diatomite at concentrations above the Oregon MCLs include aluminum, arsenic, manganese, sulfate and TDS. The concentration of the constituents, however, are lower than observed for the unoxidized diatomite;
8. The diatomite observed in MW-6 differs from the diatomite at the other locations and has been altered by heat and pressure to form opalized diatomite. In this location, the opalized diatomite contains euhedral pyrite that is not seen in any of the other drill locations. The presence of pyritic sulfur at concentrations slightly greater than 0.5

wt% in this location results in a slightly greater potential for acid generation based on the ABA and NAG results;

9. Only a few samples of the volcanic units (ash, tuff, andesite and basalt) demonstrate some neutralization potential indicating there is a general absence of minerals capable of buffering acidity (i.e., carbonates) in the system. Based on the NAG results, the volcanic samples are non-acid generating. This prediction is confirmed by pH values observed in the MWMP tests. Based on these results, the volcanic rock types are considered relatively benign and neither acid generation nor acid neutralization is anticipated. Furthermore, based on MWMP results, only a minor amount of metals and sulfate are expected to be leached from the volcanic units; and
10. The results for each material type are consistent from one mine area to another, demonstrating the geochemistry of the lithologic units are generally uniform for the different mine areas The majority of the waste rock associated with the existing and proposed operations will consist of either oxidized diatomite or unoxidized diatomite. The oxidized diatomite contains no sulfide material and is essentially inert. The unoxidized diatomite contains monosulfides and is considered acid generating based on NAG and MWMP data. Any acid generated is not likely to be buffered under normal field conditions due to the limited acid neutralizing capacity of this material type and the very slow reaction kinetics of silica buffering. Under these conditions, water rock interactions will result in low pH conditions thereby increasing the leachability of metals from the unoxidized diatomite.

8.3.2 Mineral Process Waste Samples

1. During processing of ore at the Vale Plant Site, the chemical composition of the ore is altered. Because of the addition of the soda ash, the neutralizing potential of the mineral process waste materials is increased as demonstrated by ABA results;
2. The MWMP leachate from waste stream samples has very basic pH values (i.e., greater than 9 s.u.) and very high alkalinity in comparison to the corresponding source material. However, in addition to the increased neutralization capacity of the mineral process waste, the leachability is also increased for some metals and sulfate;
3. MWMP for the waste stream samples shows an increase in the potential release of oxyanion forming elements (e.g., arsenic and selenium) after the blended ore is heated and oxidized during processing; and
4. This assessment is based on a relatively short time frame and, as a result, only provides a snap-shot of the characteristics of the waste stream materials that have been back-hauled to the mine in the past, rather than a comprehensive range.

8.3.3 Backfill Waste Samples

1. The backfilled waste samples consist of a mixture of mineral process waste as well as onsite waste material. The characterization results reflect this mixing and show the potential for metals leaching is reduced in comparison to the waste stream material that comprises only a small percentage of the backfilled waste;
2. The MWMP results for the backfilled waste show a bimodal distribution with some samples showing a low potential for metals release and some samples showing a

moderate potential for metals release that is slightly less than that observed for the unoxidized diatomite;

3. Constituents that have the potential to be leached from the backfill waste include aluminum, arsenic, beryllium, iron, manganese, sulfate and TDS. However concentrations observed for the backfill waste are generally lower than those observed for the waste stream samples indicating dilution has taken place with the addition of onsite waste materials that consist of clay, ash and diatomite;
4. For samples of backfill waste with high pH leachate chemistry, oxyanion forming elements such as arsenic, antimony and selenium increase in concentration due to a change in mineral surface chemistry which promotes the desorption of oxyanions. However, the magnitude of these element concentrations is lower in comparison to the mineral process waste samples; and
5. There is no distinguishable difference between the geochemistry of the backfilled waste in the Kelly Field Pit versus backfilled waste material in the Beede Desert Pit.

8.3.4 Sediment Pond Samples

1. The sediment pond samples have NPR values greater than 3 and positive NNP values on the order of 10 eq. kg $CaCO_3$. This is in part due to sulfide sulfur concentrations near or below the detection limit and presence of measureable neutralization potential. However, according to the BLM criteria, the ABA results for the sediment pond samples are inconclusive. Because these samples were not submitted for NAG testing, the acid generation potential of this material cannot be verified with NAG pH and NAG values. However, based on the low to non-detect sulfide sulfur concentrations, the sediment pond samples are generally considered inert.
2. From the MWMP test, the sediment pond samples generated leachate with a pH around 4.5 to 5 s.u. and these samples showed a moderate potential to leach aluminum, manganese and sulfate at concentrations above the Oregon MCLs. The overall concentration of these constituents is lower than those observed for the unoxidized diatomite. Therefore, it can be concluded that pumping water from the pits to the sediment ponds may increase the acid and metal loading within the pond areas; however, the concentrations are still below those observed for background conditions (i.e., unoxidized diatomite).

In summary, the majority of the waste rock associated with the existing and proposed operations will consist of either oxidized diatomite or unoxidized diatomite. Likewise, the final pit walls in the Mill Gulch pits and Eagle Mine Pit will mainly consist of these two material types. Based on the results of the material characterization, the oxidized diatomite contains no sulfides and is essentially inert. The unoxidized diatomite contains sulfide minerals and is considered acid generating based on NAG and MWMP data. The waste backfilled in the Kelly Field area consists of a mixture of oxidized and unoxidized diatomite as well as mineral process waste and the acid generating potential of this material falls within the middle of these two endpoints. The remaining materials types (i.e., interbedded ash/tuff and basalt) comprise a small percentage of the total material to be mined or will not be encountered or exposed during mining and therefore will not contribute to the overall acid generating potential of the waste rock or pit walls associated with the project.

9. SCREENING LEVEL RISK ASSESSMENT

A Screening-Level Ecological Risk Assessment (SLERA) has been prepared for the Celatom project to evaluate the potential toxicological threats posed by the acid generation and seasonal accumulation of meteoric water in the open pits at the Celatom Project (SRK 2010). This SLERA is provided under separate cover; however, a summary of the approach and results are provided below.

The quantitative evaluation of ecological risk associated with the seasonally accumulated meteoric water in the Celatom open pits is based on surface water quality samples collected in 1995 and again in 2010 from open pits in which unoxidized diatomite has been exposed in the pit walls and bottom.

The principal objectives of the investigation were to:

- Identify those inorganic chemical constituents and chemical characteristics (e.g., pH, TDS, etc.) in the seasonal pit water that may have the potential to contribute to adverse effects on terrestrial and avian wildlife;
- Identify ecological receptors, and/or appropriate surrogate species occupying similar niches, with the highest potential for exposure to chemical constituents in the pit water;
- Identify complete exposure pathways between the seasonal pit water and the identified receptors; and
- Quantitatively and/or qualitatively assess the ecological risks to select terrestrial and avian wildlife receptors exposed to water chemicals that exceed the calculated screening-level threshold criteria.

The SLERA was designed to evaluate estimated concentrations in the seasonal pit water using conservative assumptions and exposure parameters for ecological wildlife receptors. It is an early-stage, decision-making tool, the results of which will be used by EPM, in coordination and cooperation with the BLM, the Oregon Department of Environmental Quality (ODEQ), and the Oregon Department of Fish and Wildlife (ODFW), to evaluate the potential risks posed by the seasonal accumulation of meteoric water in the Celatom Project open pits, and to support the decision-making process with respect to the possible need for additional mitigation activities.

The general approach to this SLERA is similar to that developed by the Environmental Sciences Division and Life Sciences Division of Oak Ridge National Laboratory for the U.S. Department of Energy (Sample et al., 1996). In addition, the SLERA incorporated more recent toxicity reference values (TRVs) for certain inorganic chemical constituents derived by the EPA (2003). Together, these were used to develop species-specific toxicity criteria to which the predicted constituents in the pit water were compared.

The toxicity criteria were developed based on species-specific No-Observed-Adverse-Effects-Levels (NOAELs) and TRVs, published and calculated water ingestion rates, and average individual body weights. Criteria were developed for 11 mammalian and avian wildlife species considered reasonable surrogate species for the populations inhabiting the region in and around the Celatom Project site. A surrogate species, while not necessarily occurring at the investigation site, typically occupies similar niches, has similar body masses, and similar exposure parameters to the known occupants of the area. For example, because literature data are limited on mule deer (a common animal in the Western United

States), the white-tailed deer was selected as a substitute species for evaluation. The same rationale holds for the other test species.

Protective toxicity criteria for the surrogate species are likely to be protective of local species occupying similar ecological niches at the Celatom Project site. Additionally, it was assumed that the wildlife receptors would consume the seasonal water from the pits; and, that this water would constitute 100 percent of each animal's individual daily water requirements (i.e., no outside sources of water would be utilized over the lifetime of the organism). This is considered an extremely conservative assumption.

In general, the seasonal accumulation of meteoric water in the Celatom Project open pits (as estimated from the chemistry of water samples collected in the Kelly Field and Section-36 open pits in 1995 and again in 2010) represents a Low risk to terrestrial and avian wildlife, even with the slightly elevated aluminum concentrations that could occur.

The assumption that the wildlife receptor species selected for this study would utilize the water for 100 percent of their daily intake is considered extremely conservative. For the smaller mammalian species, travel to and from the water would require a considerable effort. In addition, smaller wildlife would have an increased probability of predation in the open environment around the water. Overall, utilization of this water by mammalian species (with the exception of perhaps bats) is considered minimal. Utilization by the local avian species is also considered limited. Migratory birds, such as the mallard, may use the water for short periods during their journeys (if the seasonal water is present) to and from more suitable feeding and breeding grounds. With limited numbers of rodents and lagomorphs using the water, raptor activity in and around the pits would correspondingly be limited as well.

Based on the seasonality, the estimated chemistry, and the anticipated utilization of the Celatom Project open pits by local wildlife for drinking water, the ecological risk posed by the seasonal accumulation of meteoric water in the open pits is considered to be *Low*.

10. SUMMARY AND CONCLUSIONS

Baseline data have been collected for the Celatom Mine in support of an Environmental Impact Statement being prepared by the BLM. Baseline information for the site that has been compiled into this report includes data and analyses related to climate, geology, hydrology, hydrogeology, and geochemistry and acid rock drainage characteristics, surface water and groundwater occurrence and quality, and potential pit lake development. In addition, a SLERA has been completed for the Celatom project to evaluate the ecological risk posed by the seasonal accumulation of meteoric water in the open pits.

Baseline data have been developed for the Hidden Valley, Beede Desert, Eagle Mine and Mill Gulch mine areas. The conclusions of the baseline data assessment specific to each of these mine areas are presented in the following sections.

10.1 Hidden Valley

1. The diatomite in the Hidden Valley area is unsaturated and the proposed pit is located above the water table. As a result, any water that may collect in the proposed pit will be limited to seasonal runoff.
2. Unoxidized diatomite does not occur in the Hidden Valley diatomite deposit and oxidized diatomite will be the main rock type exposed in the final Hidden Valley Pit. As a result, no potentially acid generating materials will be exposed during mining and there is no potential to develop low pH water in the pit.
3. The only surface water resource located within the Hidden Valley mine area is the Hidden Valley Pond. This pond is an ephemeral man-made pond located immediately downgradient of the proposed pit. Water quality results indicate aluminum, iron, manganese and sulfate are elevated in the pond water, and are attributed to evapoconcentration. These results indicate that these constituents are naturally elevated in the environment (i.e., background conditions) since there are no anthropogenic activities in the area.

10.2 Beede Desert

1. The diatomite ore deposit located at the Beede Desert mine consists mainly of oxidized diatomite with a small amount of unoxidized ore; however, EPM is not planning on mining the unoxidized ore material in this location.
2. The Beede Desert ore deposit is shallow and has been backfilled during operations with a combination of mine waste and mineral process waste to an elevation approximating the original topography.
3. Similar to the Hidden Valley deposit, the Beede Desert deposit is located above the water table and the diatomite is unsaturated. Pit dewatering has never been required at this location and sediment ponds downgradient capture runoff from the disturbed areas.
4. Any water that may collect in the sediment ponds will be limited to seasonal runoff and is anticipated to be of good quality since the sediment ponds were constructed in alluvium and the shallow oxidized diatomite deposit.
5. Surface disturbance in the Beede Desert mine area has been partially reclaimed including backfilling of the pit and the regrading of waste dump areas. The only remaining evidence of past mining includes growth medium stockpiles, a few small

out-buildings, and well maintained haul roads. Vegetation has reestablished on most of the reclaimed surfaces.

10.3 Eagle Mine

1. Both oxidized and unoxidized diatomite will be encountered during mining of the Eagle Mine Pit. The diatomite deposit in this location is shallow and based on past exploration drilling appears to be relatively uniform in thickness (~100 feet).
2. Groundwater in the Eagle Mine area occurs within fractures in the basalt at a depth of about 188 feet bgs, and the Eagle Mine Pit excavation will be underlain by about 100 feet of unsaturated basalt.
3. Water quality for the two basalt bedrock wells in the Eagle Mine area (MW-13 and MW-14) is similar and all of the constituents are below the Oregon MCLs with the exception of total aluminum, iron and manganese.
4. A shallow groundwater system does not occur in the Eagle Mine area, and any water that may collect in the proposed pit will be limited to seasonal accumulation of meteoric water.
5. Sulfides in the unoxidized diatomite that are exposed in the Eagle Mine Pit walls will oxidize, and may result in the seasonal, temporary accumulation of low pH surface water in the pit. The chemistry of this water is anticipated to be similar to the pit water samples collected from the Kelly Field and Section 36 pits in 1995 and again in 2010 with elevated aluminum, iron, manganese, sulfate and TDS. Low-*K* diatomite pit walls and floors will minimize seepage of the meteoric water until it is evaporated in the dry-season. Based on the SLERA, the ecological risk posed by the seasonal accumulation of meteoric water in the open pit is considered low.
6. There are no surface water resources within the Eagle Mine area. Perennial water sources located immediately west and downgradient of the proposed pit include the Cottonwood Creek, Altnow Reservoir and Altnow Ditch. The Cottonwood Reservoir is located upgradient of the proposed pit. For these water resources, constituents were generally below the respective Oregon Aquatic Life Criterion with the exception of aluminum in all but the Altnow Reservoir. In comparison to Oregon MCLs, total iron and total manganese were elevated above the Oregon MCLs in the Cottonwood Reservoir, Cottonwood Creek, and Altnow Ditch. All constituents were below the Oregon Aquatic Life Criterion and Oregon MCLs in the Altnow Reservoir except pH values that exceed the upper limit.

10.4 Mill Gulch

1. EPM has been conducting mining activities at the Celatom Mine for over 20 years. During this period of time, both oxidized and unoxidized diatomite ore have been mined from the Mill Gulch pits (Section 36 and Kelly Field). Sulfide minerals within the unoxidized diatomite have been exposed to air and water resulting in the potential for ephemeral low pH surface water to collect in the pits.
2. Future pits within the Mill Gulch area (Section 36, Kelly Field, North Kelly Field and Section 25 pits) may encounter saturated conditions. The diatomite deposit can be divided into an upper and lower aquifer with contrasting flow properties. Higher *K* values observed in the shallow diatomite unit can be attributed to increased permeability from varying degrees of plant-root disturbance of the aquifer materials

and lower *K* values in the deep diatomite unit represent undisturbed diatomite. The *K* of the underlying volcanic rocks is variable but most values are in the range of about 1×10^{-0} ft/day. The pit expansions proposed for the Mill Gulch pits are generally above the water table, but may extend below the water table at the deepest portions of the pits in some areas. In these areas, groundwater will seep into the pits from the sides and the bottoms of the excavations as soon as they are deepened below the water table. However, the rate of groundwater inflow will depend upon numerous factors including precipitation rates, evaporation rates, hydraulic properties of the diatomite in the pit floor and walls and the thickness of the diatomite floor barrier above the volcanic basement rocks.

3. A numerical groundwater model has not been developed for the Mill Gulch pits due to the inherent difficulties in modeling very low flow systems. Rather, groundwater inflow rates to the pits were estimated using the principle of superposition where inflows through the upper and lower diatomite in the pit wall and inflows through the pit bottom were analyzed separately. The results of this evaluation indicate that, as long as mining activities are conducted to ensure a sufficient floor barrier of diatomite is maintained, inflows to the pit would be less than net yearly evaporation and the open pit would act as a perpetual groundwater sink drawing groundwater toward the pit from all directions and no pit lake would form. The minimum thickness of the floor barrier would be different for each pit, and would depend on the depth of excavation below the basement water table.
4. Unoxidized diatomite will be exposed in the final pit walls in the Mill Gulch pits (Section 36, Section 25, Kelly Field and North Kelly Field pits). Sulfides in the unoxidized diatomite that are exposed in the pit walls will oxidize which may result in the seasonal accumulation of low pH surface water in the pits. The chemistry of this water is anticipated to be similar to the pit water samples collected from the Kelly Field and Section 36 pits in 1995 and 2010 with elevated aluminum, iron, manganese, sulfate and TDS. Concentrations of all these constituents are similar to background conditions observed for a sample collected in a tributary to Mill Gulch (DR-C07) with the exception of sulfate which is lower in the background sample. Low-*K* diatomite pit walls and floors will minimize seepage of the meteoric water until it is evaporated in the dry-season. Based on the SLERA, the ecological risk posed by the seasonal accumulation of meteoric water in the open pit is considered low.
5. Groundwater chemistry is available for upgradient, onsite and downgradient wells within Mill Gulch. The only constituent elevated above the Oregon MCLs in the monitoring well located downgradient of the Mill Gulch mining operations is manganese. Groundwater constituent concentrations in onsite wells exceed the Oregon MCLs for arsenic, iron and manganese. These elements are also elevated at similar levels in the upgradient wells that are representative of background conditions for the site. As a result, the observed concentrations of these constituents in the Mill Gulch wells are considered naturally occurring and can be attributed to mobilization from the local aquifer formation (i.e., unoxidized diatomite), rather than anthropogenic effects from the existing mining operations.
6. The Mill Gulch drainage is ephemeral, and flows only during and after significant precipitation events. One seep area was identified and sampled within the Mill Gulch drainage and downgradient of the active mining areas. Water chemistry from this

sample indicates total aluminum, iron, and manganese are elevated above the Oregon MCLs. The upgradient seep located within a tributary to Mill Gulch (i.e., background conditions) also shows elevated aluminum, iron and manganese, in addition to concentrations of arsenic that are elevated above the Oregon MCL.

7. Some of the proposed open pits may be excavated to elevations below the water table, potentially resulting in nominal groundwater flow into those particular pits. If the pits that intersect groundwater are left open after mine closure (i.e., no backfill), groundwater is likely to continue to flow toward and into each pit, resulting in a localized groundwater sink. Although no pit lake is anticipated to form due to the low groundwater inflow rates and high evaporation rates, there is the potential for accumulation of transient water (influent groundwater + meteoric runoff) in the pit.
8. The pH levels of transient pit water are predicted to be low (3 to 4 s.u.) for pits with unoxidized diatomite exposed in the final pit walls. However, the SLERA indicates that the metal concentrations are sufficiently low in accumulated pit water and would not pose a credible risk to wildlife or livestock when, and if, present.
9. If the pits are backfilled to above the water table, groundwater levels would likely recover within the backfill to pre-mining levels, resulting once again in a flow-through groundwater system. In this scenario, any sulfide oxidation products and readily leachable constituents within the backfill materials and pit walls could potentially migrate away from the pits and potentially degrade downgradient groundwater resources.
10. The surface expression of groundwater (albeit transient) could possibly be mitigated through the partial backfilling of the open pits that intersect groundwater. The intent of this closure strategy would be to maintain the pit as an evaporative sink for groundwater (i.e., no flow-through), while reducing the potential for free-standing water with low pH. This could be achieved by backfilling the pit to an elevation where evapo-transpiration losses through the uppermost portions of the backfill would equal the rate of groundwater inflow.

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