Geochemical and Hydrogeologic Investigation of Groundwater Impacted by Wastes Left in Place in the Butte Priority Soils Operable Unit Butte, MT

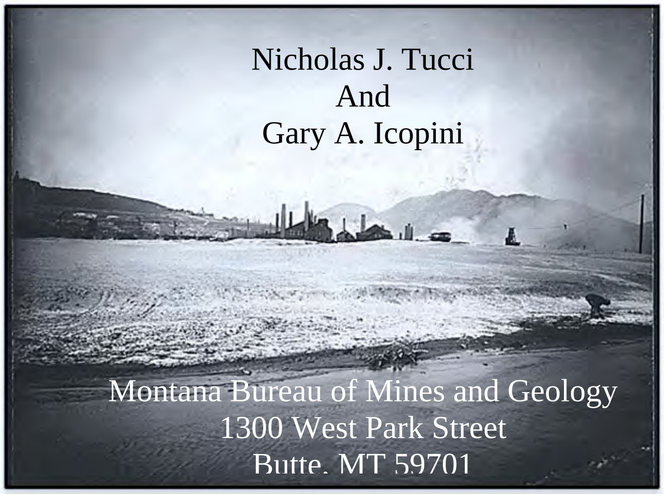
MBMG Open-File Report 613

1955 Aerial Photograph showing areas of waste left in place in Upper Silver Bow Creek

Copper from groundwater plated on metal teeth of backhoe, Joe Griffin MDEQ

Parrot Tailings groundwater

May-2012



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LIST OF ACRONYMS

ACM—Anaconda Mining Company
BP/ARCO—British Petroleum Atlantic Richfield Company
BPSOU—Butte Priority Soils Operable Unit
BTC—Blacktail Creek
cfs—Cubic feet per second
COCs—Contaminants of concern
DA—Deep alluvial aquifer
DO—Dissolved oxygen
DOC—Dissolved organic carbon
Eh—Oxidation-reduction potential
EPA—Environmental Protection Agency
GWIC—Groundwater Information Center
kj/mol—kilojoules per mole
MA—Middle alluvial aquifer
MBMG—Montana Bureau of Mines and Geology
MDEQ—Montana Department of Environmental Quality
meq/L—milliequivalents per liter
mg/L—milligram per liter
MSD—Metro Storm Drain
NRDP—Natural Resource Damage Program
SA—Shallow alluvial aquifer
SC—Specific conductance
SBC—Silver Bow Creek
SBC/MSD—Silver Bow Creek/Metro Storm Drain
SI—Saturation index
TDS—Total dissolved solids
TOC—Total organic carbon
µg/L—micrograms per liter
USGS—United States Geological Survey

EXECUTIVE SUMMARY

In the spring of 2010, the Montana Bureau of Mines and Geology (MBMG), in cooperation with the Montana Department of Justice-Natural Resource Damage Program (NRD), Montana Department of Environmental Quality (DEQ), the U.S. Environmental Protection Agency (EPA), and British Petroleum/Atlantic Richfield Company (BP/ARCO), conducted extensive groundwater/surface-water sampling in the Butte Priority Soils Operable Unit (BPSOU). This work was conducted to link contaminated groundwater at different depths in the alluvial aquifer to the various contaminate sources in the Upper Silver Bow Creek/Metro Storm Drain (SBC/MSD) corridor. Data evaluated to investigate these linkages included unique chemical signatures (fingerprints), chemical trends, geochemical attenuation mechanisms, and hydrogeology. The plumes emanate from at least three different tailings areas: the Parrot, Diggings East, and Northside Tailings. Previous studies (Tucci and Icopini, 2010; BP/ARCO, 2010a) clarified the hydrogeologic relationships within the BPSOU alluvial aquifer and refined its hydrogeologic characteristics.

This investigation builds upon previous work by further defining the extent of groundwater contamination as well as assessing the evolution of the groundwater plumes found at various depths within the alluvial aquifers. Metals loading to Blacktail and Silver Bow Creeks was also evaluated throughout the potential discharge area for these plumes. Although unique chemical signatures were not linked to each source area, data collected during this study were sufficient to track individual groundwater plumes when combined with our current understanding of the hydrogeology, spatial and temporal groundwater-quality trends, and an understanding of the geochemical redox conditions.

As a result of the data and analysis presented here, the known extent of the Parrot Tailings plume has more than doubled, extending its boundary by approximately 0.5 miles farther than estimated in 2004 (Metesh and Madison, 2004). Furthermore, this report is the first publication to present a hypothesis on the fate and transport of contaminants in deeper flow zones of the alluvial aquifer in the SBC/MSD corridor. Temporal trends, provided in this report, show decreasing metals concentrations in areas where sources have been removed; this new information provides evidence that the contaminant concentrations in the alluvial aquifer will decrease to acceptable levels faster than previously assumed (EPA, 2006b). Based on the aqueous geochemistry and our understanding of the hydrogeology, we conclude:

- There is a source of copper (Cu) and zinc (Zn) loading to Blacktail Creek in its reach between Oregon Avenue and George Street. Currently, data are insufficient to determine the source for the Cu and Zn observed in this reach of the creek.
- Multiple source areas appear to be loading the shallow alluvial (SA) unit in the SBC/MSD corridor. These sources can be traced to the Parrot, Diggings East, and Northside Tailings. These sites are known to contain mining-related waste that has been left in place. Concentrations of contaminants in SA plumes originating from these sources decrease substantially downgradient of their source areas, which may be an indication that the MSD Subdrain is effectively capturing the SA plumes. However, determining the overall effectiveness of the MSD Subdrain collection system was beyond the scope of this investigation.

- The middle alluvial (MA) unit hosts a plume that contains the highest concentrations of contaminants measured in the study area; this plume is the farthest-reaching and most expansive in the SBC/MSD area. The Parrot Tailings appears to be the primary source for arsenic (As), cadmium (Cd), copper (Cu), and zinc (Zn) in the plume. The MA plume can be traced from the Parrot Tailings area to Kaw Avenue (AMC-24), which more than doubles the previously documented extent of the Parrot plume (MSD-02B; Metesh and Madison, 2004).
- The maximum downgradient extent of the Parrot Plume beyond AMC-24 (MA unit) remains undefined but is likely controlled by three possible scenarios, or combinations thereof:
    1) The plume's contaminants naturally attenuate within the aquifer;
    2) The MSD Subdrain effectively captures the plume west of Kaw Avenue; or
    3) The plume is, or will be, discharging to Blacktail Creek or Silver Bow Creek.
- Within the MA unit, sorption of metals onto alluvial sediments and, to a lesser extent, dilution appear to be the attenuation mechanisms responsible for reducing contaminants of concern (COCs; Cu, Zn, As, and Cd) as the water moves downgradient. Sorption of COCs onto existing alluvial sediments is a finite attenuation mechanism, as dissolved COCs will be progressively less attenuated as the available sorption sites on alluvial sediments are exhausted. Although dilution reduces COC concentrations, COCs are only dispersed and not removed from solution.
- Green rust precipitation appears to be the most likely mechanism for the attenuation of iron (Fe) observed in the MA unit between wells MSD-01B and GS-09.
- In some SA and MA unit wells near the Diggings East and Parrot Tailings areas, the COC concentrations have increased markedly since 2003.
- The MA unit south and upgradient of the Parrot Tailings area appears to have been contaminated from historic discharges of contaminated mine water to Silver Bow Creek that ended in 1982. Since 1983, aqueous metals concentrations have steadily declined in this area, which is the expected concentration trend for metal desorption and dilution of a contaminated aquifer continually flushed with relatively clean groundwater. However, dilution alone is not sufficient to explain the concentration trends. The rates of decreasing metals concentrations suggest a flushing/desorption process that is much faster than previously assumed (EPA, 2006b).
- Some COCs (Cd, Cu, and Zn) have penetrated to the deep alluvial (DA) unit, and water samples show concentrations above background levels. However, concentrations are 1 to 2 orders of magnitude lower than in the MA unit. The source area for the COCs in the DA unit is most likely the Parrot Tailings. Elevated metals in the DA unit are present as far downgradient as well GS-08.

Defining the MA Parrot Plume boundaries and groundwater flow paths (vertical and horizontal) west of Kaw Avenue was hampered by the lack of deeper wells (> 35 ft). In winter 2011/2012, 40 additional wells were drilled by BP/ARCO under an EPA Unilateral Administrative Order (EPA, 2011). The information gathered during the drilling program is preliminary and results are still being compiled. These additional wells should provide the additional data necessary to further the characterization of the Parrot Tailings plume and other waste plumes, and enhance the current understanding of the hydrogeology, geochemistry, and fate and transport of contaminants in the alluvial aquifer. It should be noted that this report does not include data from the recent drilling project; however, we believe the preliminary results are consistent with the conclusions of this report.

MBMG responses to comments on a draft version of this report submitted by EPA and BP/ARCO are provided in Appendices F and G of this report.

1.0 INTRODUCTION AND SITE DESCRIPTION

In the spring of 2010, the Montana Bureau of Mines and Geology (MBMG), in cooperation with the Montana Department of Justice-Natural Resource Damage Program (NRDP), Montana Department of Environmental Quality (MDEQ), the Environmental Protection Agency (EPA), and British Petroleum/Atlantic Richfield Company (BP/ARCO), conducted a comprehensive, synoptic groundwater/surface water monitoring investigation within the Butte Priority Soils Operable Unit (BPSOU). Groundwater within and adjacent to several source areas was sampled at multiple depths.

1.1 Objectives

To date, the lateral and vertical extent of groundwater plumes emanating from three known source areas (fig. 1, inset) within the Silver Bow Creek/Metro Storm Drain (SBC/MSD) corridor have not been fully delineated. Prior investigations (Metesh and Madison, 2004; Tucci, 2010) identified contamination in the different flow units (shallow alluvial, SA; middle alluvial, MA; and deep alluvial, DA) of the upper alluvial aquifer (at depths less than 150 ft below ground surface), but did not conclusively delineate plume extents or identify the source areas. The objective of this study was to determine if geochemical signatures (fingerprints) were identifiable and could be used to track individual contaminant plumes in the SBC/MSD corridor. Special emphasis was placed on the Parrot Tailings area, because plumes emanating from this source contain the highest concentrations of cadmium, copper, and zinc of any water in the Butte area (Tucci, 2010). Although it is likely that the tailings in the three source areas originated from the same or similar mine/smelter processes and therefore may have similar chemical signatures, the premise was that other available contamination sources (such as deicing chemicals in the Parrot Tailings area) may have imprinted unique geochemical signatures on one or more of the plumes, allowing source differentiation. In the event that unique geochemical signatures could not be identified, the hydrogeology and potential attenuation mechanisms were to be evaluated in order to better identify and track the plumes' movement and extent.

1.2 Site Background

The alluvial groundwater system along the historic floodplain of upper Silver Bow Creek (SBC) between Continental Drive and Montana Street has been impacted by several contamination sources (PRP Group, 2002). This reach of SBC is also known as the Metro Storm Drain (MSD) portion of the BPSOU. The contamination sources are related to more than a century of mining and milling activities that occurred along the floodplain. Mining-related wastes generated by extractive, smelting, and milling activities produced waste rock, slag, and tailings that now act as contamination sources. Metals have leached into the alluvial groundwater system predominantly from tailings located above or below the water table. Chemical and mineralogical characterization of the mining-related waste was beyond the scope of this study.

The mine wastes in this area (fig. 1, inset) were emplaced either as part of milling and smelting, or through erosion and deposition by SBC. A distinct volume of mine waste was placed by the Parrot Smelter complex and a tailings impoundment dam located at the present-day Parrot Tailings area (fig. 1, inset). Mine wastes at the Northside and Diggings East areas were deposited by SBC and are mixed materials from numerous upstream smelters (Parrot, Pittsmont, Montana Ore Purchasing, Clark's Colusa, Montana Copper

Company, Boston & Montana, or other smelters). Lithologic logs of wells in the Northside and Diggings East areas show that tailings deposits are located at or near ground surface, and generally less than 1ft thick [Groundwater Information Center (GWIC) Online Database, http://mbmggwic.mtech.edu/].

The Parrot Tailings are distributed along the historic SBC floodplain and range from 4 to 12 ft thick (fig. 1, inset). Due to their large volume (roughly 369,000 cubic yards), the Parrot Tailings are the most significant source of known contamination to the groundwater (Tucci, 2010); the contaminants of concern (COCs) include arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), and zinc (Zn; PRP Group, 2002). Groundwater in the Parrot Tailings area has the highest dissolved metal concentrations in the Butte area (Tucci, 2010).

The tailings associated with the Parrot, Northside, and Diggings East areas were designated by the EPA as waste to be left in place, and not removed under remedial action (EPA, 2006a). Between 2002 and 2005, a French-drain collection system, the MSD Subdrain, was installed below the SBC/MSD channel from near well AMW-1 to near well BPS07-21B (highlighted in yellow, fig. 1) to capture shallow contaminated groundwater (EPA, 2006a).

In addition to leachate from the tailings and mine wastes, another historic source of alluvial aquifer contamination was surface-water discharge to SBC from mining activities on the Butte Hill. From 1881 to 1982, the Anaconda Copper Mining Company (ACM) used the SBC/MSD channel as an industrial sewer (Hydrometrics, 1983). Prior to 1972, roughly 29 cubic feet per second (cfs) of untreated water was discharged to SBC at a point just north of Continental Drive (fig. 1); 9 cfs came from the underground mines (pH = 2.01), 11 cfs from the milling operations, and 9 cfs was spent leach pad water (pH = 2.13; Spindler, 1977). While contaminant concentrations varied, this untreated discharge water served as a significant source of As, Cd, Cu, and Zn to surface water and the alluvial aquifer (Hydrometrics, 1983). On September 29, 1972, ACM began operating a primary lime treatment process to control pollution that resulted in the discharge of pH 11.0 water to SBC at 15 cfs (Spindler, 1977). By 1975, ACM was operating primary and secondary treatment systems that discharged 20 lb/day of Cu and 31 lb/day of Zn to the SBC/MSD channel (Spindler, 1977). The effluent discharges from the mining operations ceased in 1982, when the ACM converted to a zero-discharge system. Silver Bow Creek northeast of Harrison Avenue was a losing stream, so the underlying alluvial aquifer received significant metal loading for over a century. Today, the mine wastes left in place along SBC represents the only primary source of groundwater contamination (fig. 1, inset).

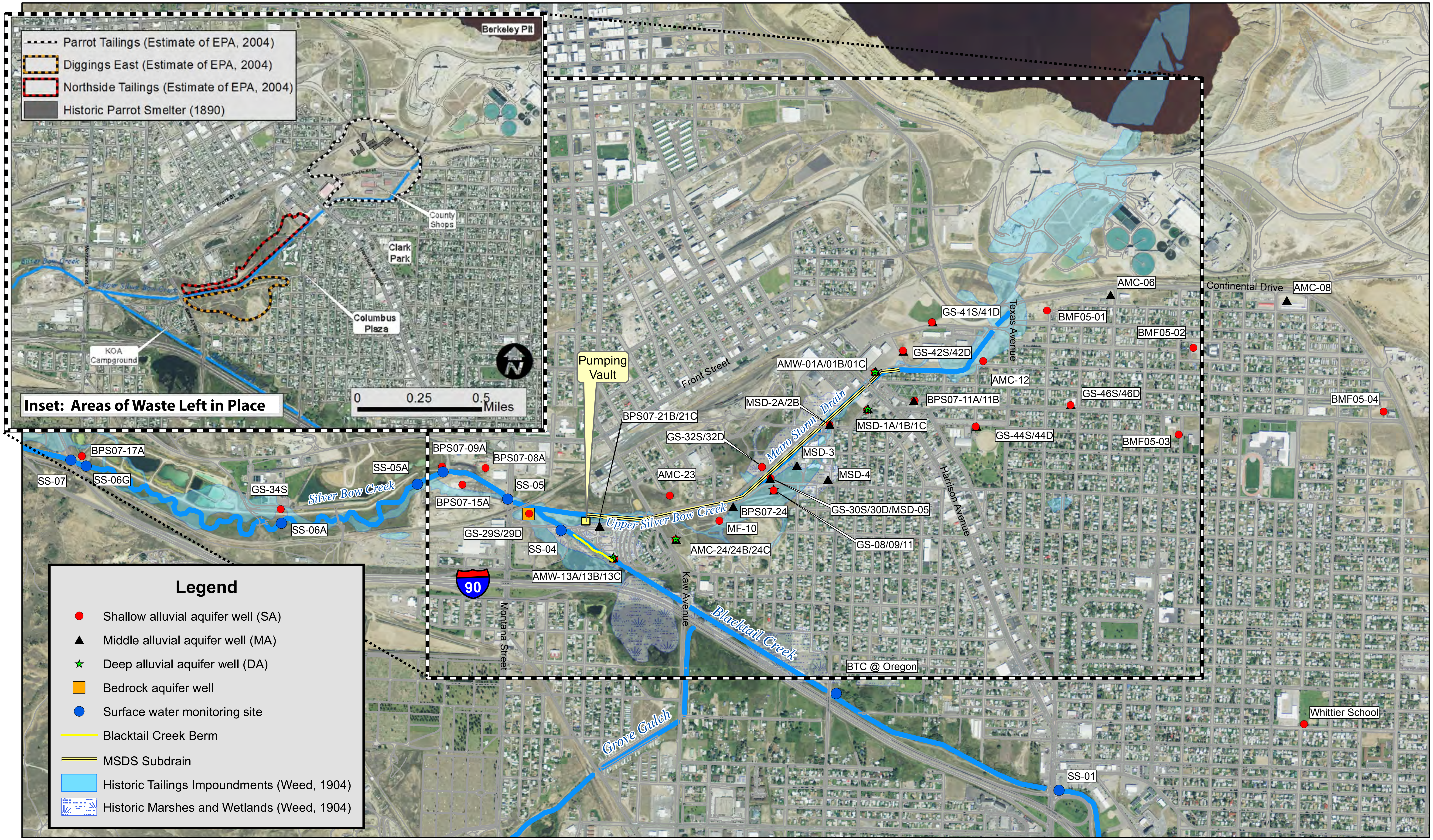

Figure 1. Location map showing groundwater (SA,MA, DA, and bedrock wells) and surface-water sampling sites. Inset shows areas of waste left in place.

0 0.25 0.5 1 Miles

1.3 Previous Investigations

Groundwater and surface-water investigations concerning water quality and quantity in the upper SBC/MSD area date back to ACM monitoring reports in the 1970s (Spindler, 1977; Hydrometrics, 1983). These reports provide historic data regarding the metal loading to Silver Bow Creek; groundwater data are limited because few monitoring wells were available. The current study area was included in the original Phase I Silver Bow Creek Remedial Investigation (MultiTech, 1987), which contains historic water-quality and aquifer-test data for the upper SBC/MSD corridor. The hydrology and geochemistry of the BPSOU groundwater and surface-water systems were first characterized in the Phase II Remedial Investigation (PRP Group, 2002). This report described the aquifer materials within 250 ft of ground surface as discontinuous units of clay, silt, silty-sand, and sand that did not appear to be spatially correlatable.

Because of data gaps in the Phase II Remedial Investigation, EPA conducted a Focused Feasiblility (EPA, 2004) that concentrated primarily on the upper SBC/MSD corridor (current study area). The Focused Feasibility Study concluded that groundwater movement from the Parrot Tailings area would be minimal due to low hydraulic gradients, low aquifer hydraulic conductivity, and little connectivity between permeable units.

A MBMG investigation (Metesh and Madison, 2004) identified three separate alluvial aquifer units consisting of coarse sand to medium gravel within 150 ft below the ground surface that were laterally continuous and more transmissive than previously reported (PRP Group, 2002; EPA, 2004). Metesh and Madison (2004) also determined that two gravel units greater than 40 ft below ground surface were contaminated near and downgradient of the Parrot Tailings area to at least MSD-02B.

In a 2006 Record of Decision (EPA, 2006a), EPA mandated that several investigations be conducted in the upper SBC/MSD area to reconcile discrepancies between the reports. In 2010, BP/ARCO conducted a series of investigations, including a 72-hour aquifer test on well AMW-01B; a middle-level, alluvial-aquifer well located just downgradient of the Parrot Tailings, which helped redefine the area’s hydrogeologic framework (BP/ARCO, 2010a; Tucci and Icopini, 2010). As a result of these investigations, the hydrogeologic framework of the upper alluvial aquifer (<150 ft deep) near the Parrot Tailings area is well understood.

1.4 Hydrogeology

The three alluvial aquifer units described by Metesh and Madison (2004) are referred to as the shallow alluvial (SA), middle alluvial (MA), and deep alluvial (DA) units for purposes of this report. The SA (<35 ft below ground surface, bgs) is an unconfined water table aquifer unit bounded below by a locally continous clay/silt layer that restricts vertical flow. The MA (40–60 ft bgs) and DA (100–130 ft bgs) are highly transmissive semiconfined aquifers (Tucci and Icopini, 2010). Groundwater in the SA along the upper SBC/MSD corridor flows to the west–southwest and discharges to the MSD Subdrain and Blacktail Creek (fig. 2). Available potentiometric data for the MA and DA units indicate that the groundwater in these units also flows west–southwest. The lateral extent of the MA and DA units is unknown, although they extend from th**e** Parrot Tailings area to at least well AMC-24 just east of Kaw Avenue (fig. 1). Near Montana Street (fig. 1), bedrock is closer to the surface and alluvial deposits appear to thin.

The confined nature of the MA (and by corollary the DA) unit varies along the SBC/MSD corridor. In the Parrot Tailings area, the MA unit appears to be connected to the SA unit, as indicated by:

1) downward vertical gradients in SA/MA nested wells (GS-41 S&D and 42 S&D, appendix A),
2) similar water quality in samples from SA-MA wells,
3) drawdown responses in SA wells (GS-41S and GS-42S, fig. 1) to pumping MA well AMW-01B (Tucci and Icopini, 2010), and
4) a response in the MSD Subdrain near Harrison Avenue to pumping during a 72-hour MA aquifer test in AMW-01B (BP/ARCO, 2010a).

Downgradient of the Parrot area (between Harrison Ave and Well GS-09, fig. 1), the following aquifer test data suggest that the MA unit is locally confined:

1) upward vertical gradients in SA/MA nested wells,
2) thick confining beds of silt and clay between SA and MA units (Tucci and Icopini, 2010),
3) no noticeable impact of pumping MA well GS-09 on water levels in adjacent SA wells (MultiTech, 1987),
4) widespread drawdown in MA wells (MSD-1B, MSD-2B, MSD-3, MSD-4, MSD-5, and GS-09, fig. 1) in response to pumping MA well AMW-01B during a 72-hour aquifer test (Tucci and Icopini, 2010),
5) lack of a response in the MSD Subdrain near MSD-2 to pumping during a 72-hour aquifer test in AMW-01B (BP/ARCO, 2010a), and
6) lack of drawdown response in SA wells MSD-2A, GS-11, GS-32S, and GS-30S.

Downgradient of GS-09, confining conditions of the MA unit are less apparent, as indicated by:

1) a response in the MSD Subdrain near Kaw Avenue to pumping during a 72-hour aquifer test in AMW-01B (BP/ARCO, 2010a), and
2) general thinning of alluvial sediments.

1.4.1 The Metro Storm Drain Subdrain

A French-drain collection system, known as the Metro Storm Drain Subdrain (MSD Subdrain), buried directly under the current SBC/MSD channel, extends from the Civic Center to a pumping vault west of Kaw Avenue (fig. 1). The MSD Subdrain is designed to capture shallow contaminated groundwater and prevent it from discharging to SBC/MSD; dewatering and construction began in 2003 and the drain became operational in 2005. The MSD Subdrain has lowered water levels in the SA 1 to 3 ft (appendix A, A.7) and most likely has altered groundwater flow paths along the SBC/MSD corridor. The subdrain’s impacts on water levels in deeper units (MA, DA) are not well known; most water-level data from these units date to 2004, a year after dewatering for the MSD Subdrain began. The subdrain’s effect on vertical hydraulic gradients is unknown; however, upward vertical gradients that existed prior to construction remain (PRP group, 2002).

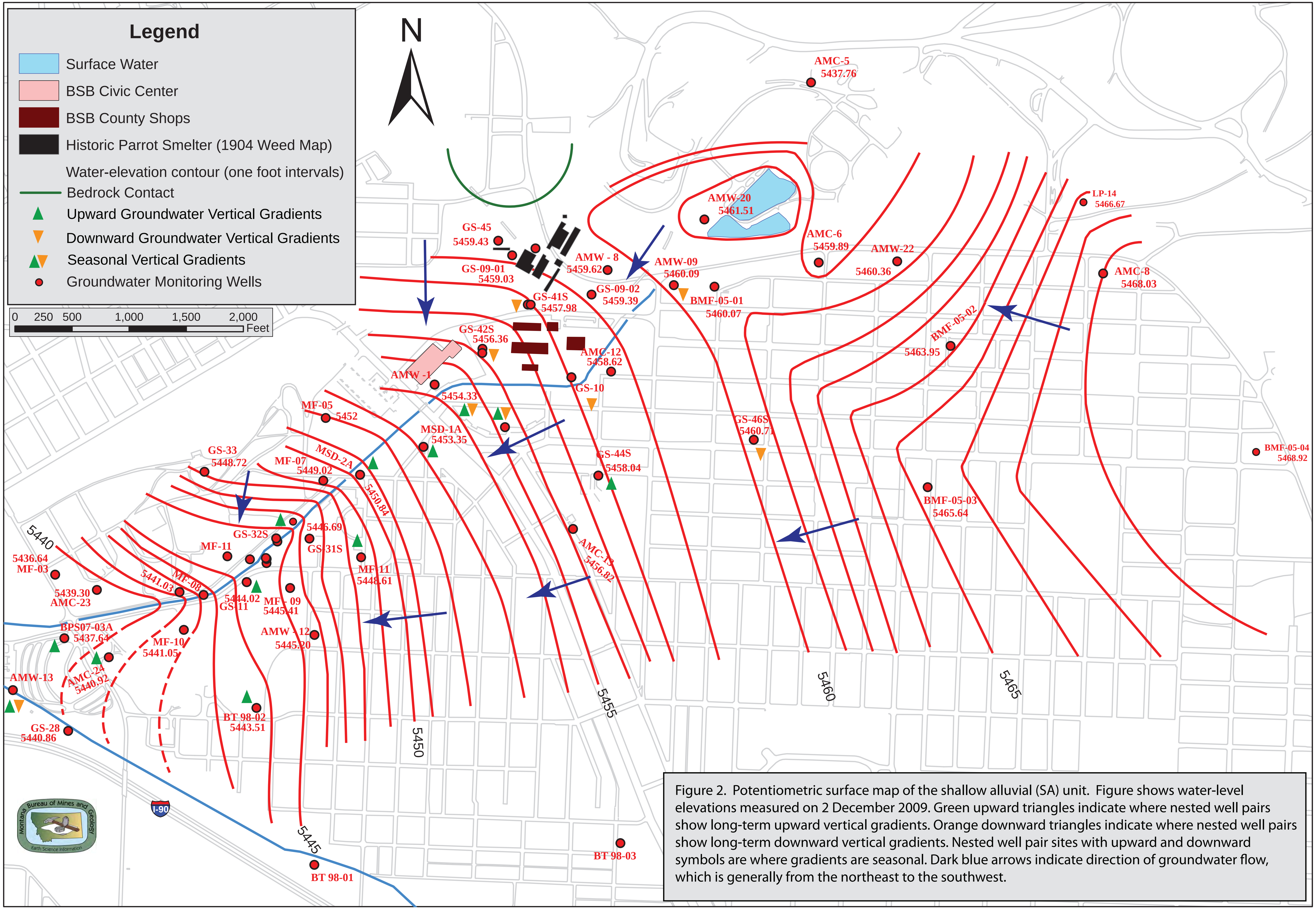

Figure 2. Potentiometric surface map of the shallow alluvial (SA) unit. Figure shows water-level elevations measured on 2 December 2009. Green upward triangles indicate where nested well pairs show long-term upward vertical gradients. Orange downward triangles indicate where nested well pairs show long-term downward vertical gradients. Nested well pair sites with upward and downward symbols are where gradients are seasonal. Dark blue arrows indicate direction of groundwater flow, which is generally from the northeast to the southwest.

1.4.2 Lithology

Wells AMC-24C, AMW-13C, BPS07-21C, and BSP07-24 were drilled by the EPA in 2010 to determine the downgradient extent of the MA unit. Split-spoon samples show that the alluvial sediments generally are interbedded fine-grained and coarse-grained materials. The SA is primarily coarse sand to fine gravel bounded below by silts and clays. Iron oxide stain was noted in the vadose zone just above the water table (fig. 3A); however, little staining was observed in the saturated zone. The MA unit was encountered at each boring and consisted of coarse sand to fine-medium gravel (fig. 3B). Individual clasts within the MA unit appeared to have an iron oxide stain or coating, but the majority of the aquifer material was not iron-stained (fig. 3B, representative of MA unit at sampled locations).

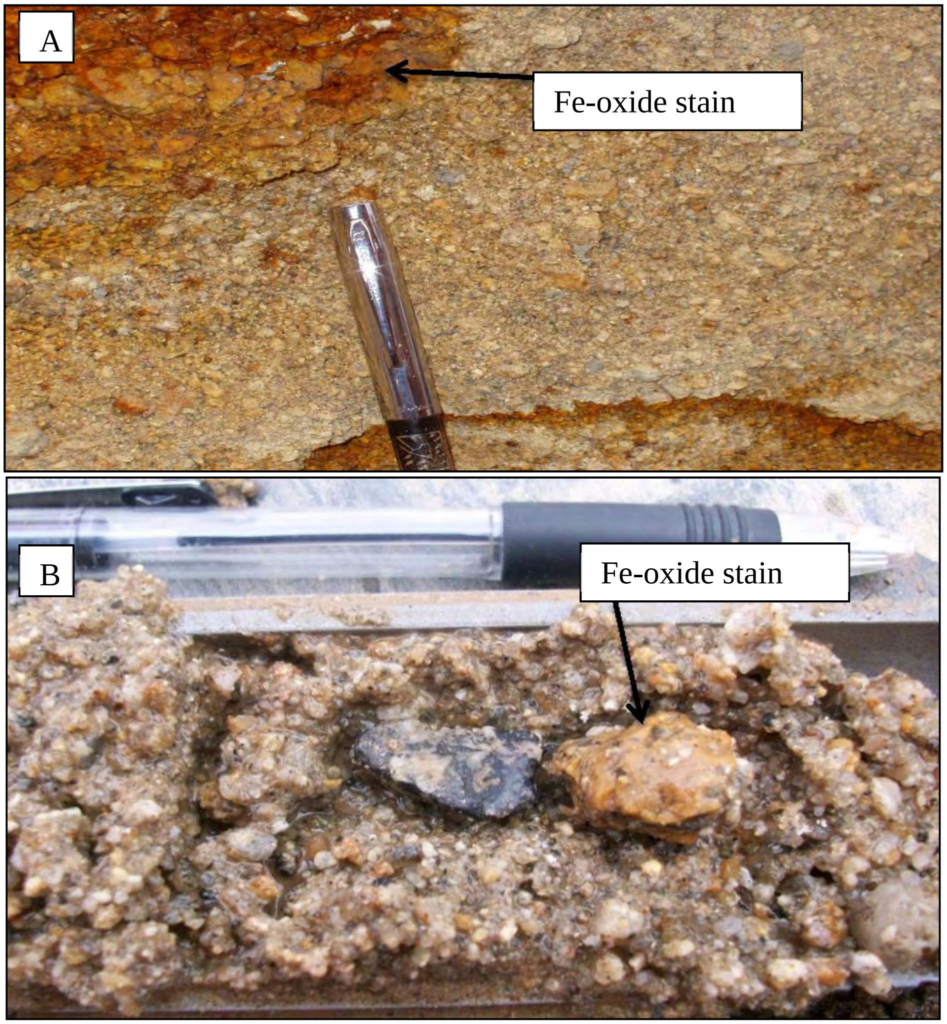

Figure 3. (A) SA aquifer sediments from near well AMW-01A. (B) MA aquifer sediments from well BPS07-24. General Fe staining was observed in SA vadose-zone samples (A); Fe staining of discrete clasts was observed in the MA alluvial sediments (B).

1.4.3 Vertical Hydrologic Gradients

Previous work identified the vertical hydraulic gradients between the SA and the MA (Tucci and Icopini, 2010). Hydrographs for nested wells installed in the SA, MA, and/or DA alluvial units are presented in appendix A, and the relative vertical gradients between the SA and MA aquifers are shown in figure 2. In the Parrot Tailings area, the vertical gradient between the SA and MA units is downward (fig. 2). Consequently, contaminant concentrations in the SA and MA wells are similar (wells GS-41 S&D and GS42 S&D; fig. 2), which suggests that contaminant loading to the SA by the Parrot Tailings impacts both units (Tucci and Icopini, 2010). South of the Parrot Tailings area (BPS07-11; fig. 2 and appendix A, A.3) the vertical gradients vary seasonally in response to recharge. Downgradient from the Parrot Tailings area (southwest of Harrison Avenue), vertical gradients between the SA and MA aquifers are predominantly upward. The vertical gradient at well AMW-13 (next to Blacktail Creek) appears to be controlled by seasonal fluctuations in stream stage; occasionally a downward vertical gradient exists when stream stage is high. Between Harrison Avenue and Blacktail Creek there is no evidence for downward vertical gradients between SA-MA and SA-DA units. Therefore, it is unlikely that source loading to the SA from the Diggings East or Northside Tailings areas impacts the MA or DA units.

In summary, contaminant loading to the MA, and by corollary the DA, unit in the Parrot Tailings area seems likely, and contaminants entering the MA unit from the Parrot Tailings are vertically confined in the MA unit downgradient to well GS-09 (Tucci and Icopini, 2010). Downgradient of GS-09, contaminants in the MA have the the potential to move upward toward the SA unit because confining beds apparently thin and vertical gradients are upward. Upward vertical gradients between Harrison Avenue and Blacktail Creek (AMW-13) prevent loading of the MA and DA by the Diggings East and Northside Tailings.

2.0 METHODS

All monitoring sites sampled for this project were selected collaboratively by MBMG, MDEQ, NRDP, EPA and its consultants, and BP/ARCO and its consultants. Groundwater sites were chosen from the three upper alluvial aquifer units (<150 ft) and the bedrock aquifer. In total 64 sites (32 SA wells, 18 MA wells, 5 DA wells, 1 bedrock well, and 8 surface-water sites) were sampled for water quality (table 1). All groundwater and surface-water samples were collected in April 2010, except for wells MF-10 (sampled August 2010), AMW-13C (installed and sampled June 2010), AMC-24C (installed and sampled June 2010), and BPS07-24 (installed and sampled August 2010). Previously collected analytical data from other projects were also used to assess temporal water-quality trends. Sample bottles were rinsed three times with sample solution prior to being filled. Filtered aliquots were collected using 0.45-µm disposable filters. Water-quality samples were preserved on ice and refrigerated prior to being submitted to the MBMG lab for analysis. All data used for this report can be found on the MBMG Groundwater Information Center’s projects page, code BPSOU-2010GWQ (http://mbmggwic.mtech.edu).

Table 1. A list of monitoring sites used for this report.

Site	Lithology	GWIC Id	Site	Lithology	GWIC Id
AMC-12	Shallow Alluvial	4656	AMC-06	Middle Alluvial	4604
AMC-23	Shallow Alluvial	5018	AMC-08	Middle Alluvial	4611
AMC-24	Shallow Alluvial	5034	AMC-24B	Middle Alluvial	240858
AMW-01A	Shallow Alluvial	137596	AMW-01B	Middle Alluvial	211600
AMW-13	Shallow Alluvial	137597	AMW-13B	Middle Alluvial	240863
BMF05-01	Shallow Alluvial	222920	BPS07-21B	Middle Alluvial	253710
BMF05-02	Shallow Alluvial	222921	BPS07-21C	Middle Alluvial	257404
BMF05-03	Shallow Alluvial	224152	BPS07-24	Middle Alluvial	257403
BMF05-04	Shallow Alluvial	224153	GS-09	Middle Alluvial	890532
BPS07-08A	Shallow Alluvial	240866	GS-41D	Middle Alluvial	150402
BPS07-09A	Shallow Alluvial	240857	GS-42D	Middle Alluvial	150405
BPS07-11A	Shallow Alluvial	240860	GS-44D	Middle Alluvial	150411
BPS07-11B	Shallow Alluvial	240859	GS-46D	Middle Alluvial	150413
BPS07-15A	Shallow Alluvial	248557	MSD-1B	Middle Alluvial	211606
BPS07-17A	Shallow Alluvial	248567	MSD-2B	Middle Alluvial	215787
BPS07-18A	Shallow Alluvial	248568	MSD-3	Middle Alluvial	211593
GS-11	Shallow Alluvial	890538	MSD-4	Middle Alluvial	215790
GS-13A	Shallow Alluvial	5004	MSD-5	Middle Alluvial	237726
GS-29S	Shallow Alluvial	126154	AMC-24C	Deep Alluvial	255974
GS-30D	Shallow Alluvial	150391	AMW-01C	Deep Alluvial	211601
GS-30S	Shallow Alluvial	150390	AMW-13C	Deep Alluvial	255975
GS-32D	Shallow Alluvial	150394	GS-08	Deep Alluvial	890529
GS-32S	Shallow Alluvial	202166	MSD-1C	Deep Alluvial	211603
GS-34S	Shallow Alluvial	150396	GS-29D	Bedrock	126152
GS-41S	Shallow Alluvial	150401	BTC @ Oregon	Blacktail Creek	191287
GS-42S	Shallow Alluvial	150404	SS-01	Blacktail Creek	226754
GS-44S	Shallow Alluvial	150409	SS-04	Blacktail Creek	127593
GS-46S	Shallow Alluvial	150412	SS-05	Silver Bow Creek	127536
MF-10	Shallow Alluvial	4695	SS-05A	Silver Bow Creek	249187
MSD-1A	Shallow Alluvial	212801	SS-06A	Silver Bow Creek	262080
MSD-2A	Shallow Alluvial	237725	SS-06G	Silver Bow Creek	249189
Whittier School	Shallow Alluvial	4716	SS-07	Silver Bow Creek	4930

2.1 Surface Water

Surface-water grab samples were collected in clean, acid-rinsed 5-gallon plastic buckets and transferred to sample containers using a peristaltic pump. Equipment was decontaminated between sample locations using soapy tap-water rinse, 5% nitric acid, and deionized water. Stream flow was measured using a Marsh-McBirney Flo-Mate 2000 portable flowmeter following standard cross-sectional area techniques outlined in the Open Channel Profiling Handbook (Marsh-McBirney, 1994). Surface-water samples were collected during base flow. Metal loading used for comparison purposes was calculated by multiplying metal concentration from analytical results by stream flow.

Water-quality samples were analyzed for the following parameters:

1. *In situ* field parameters —stream flow (cfs), pH, temperature, specific conductance (SC), oxidation-reduction potential (Eh), and dissolved oxygen (DO).
2. General laboratory or calculated parameters – lab pH, lab SC, total dissolved solids (TDS), total alkalinity, and hardness;
3. Major cations and anions—Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, SO_4^{2-}, HCO_3^{-}, CO_3^{2-}, F^{-}, Br^{-}, and Cl^{-};
4. Nutrients and other non-metals—nitrate (NO_3^{-}), nitrite (NO_2^{-}), orthophosphate (PO_4^{3+}), SiO_2, and dissolved and total organic carbon (DOC/TOC);
5. Dissolved minor and trace metals—Ag, Al, As, Ba, Be, B, Cd, Co, Cr, Cs, Cu, Fe, Ga, Li, Mn, Mo, Nb, Nd, Ni, Pb, Pd, Pr, Rb, Sb, Se, Sn, Th, Ti, Tl, U, V, W, Zn, and Zr;
6. Total minor and trace metals—Ag, Al, As, Ba, Be, Cd, Co, Cr, Cs, Cu, Fe, Ga, Li, Mn, Mo, Nb, Ni, Pb, Pd, Rb, Se, Sb, Sn, Sr, Th, Ti, Tl, U, V, W, Zn, and Zr; and
7. Rare earth elements—Ce, La, Nd, and Pr.

2.2 Groundwater Sampling

The EPA-approved Clark Fork River Superfund Investigation Standard Operating Procedures for sampling groundwater were followed during this investigation (BP/ARCO, 1992). A minimum of three bore volumes were purged from each well. Physical parameters were typically monitored at 5-minute intervals during purging to note changes, and to ensure all parameters stabilized prior to sampling. During purging, flow was measured periodically using the bucket-and-stopwatch method.

Water-quality samples were analyzed for the following parameters:

1. *In situ* field parameters—static water level, pH, temperature, SC, Eh, and DO.
2. General laboratory or calculated parameters—lab pH, lab SC, TDS, total alkalinity, and hardness;
3. Major cations and anions—Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, SO_4^{2-}, HCO_3^{-}, CO_3^{-}, F^{-}, Br^{-}, and Cl^{-};
4. Nutrients and other non-metals—nitrate (NO_3^{-}), nitrite (NO_2^{-}), orthophosphate (PO_4^{3+}), SiO_2, and DOC/TOC;
5. Dissolved minor and trace metals—Ag, Al, As, Ba, Be, B, Cd, Co, Cr, Cs, Cu, Fe, Ga, Li, Mn, Mo, Nb, Nd, Ni, Pb, Pd, Pr, Rb, Sb, Se, Sn, Th, Ti, Tl, U, V, W, Zn, and Zr; and
6. Rare earth elements—Ce, La, Nd, and Pr.

2.3 Geochemical Diagrams and Modeling Methods

Stiff diagrams help visualize analyte concentrations. A Stiff diagram connects horizontal lines representing ionic concentrations that extend from both sides of a vertical axis. A greater distance from the vertical axis represents a larger ionic concentration. Cations are plotted on the left of the axis and anions are plotted on the right, both in milliequivalents/liter (meq/L). The cation and anion concentrations are connected to form an asymmetric polygon. Stiff diagrams were constructed using the geochemical software program AquaChem, version 2011. 1.40.

In order to understand attenuation mechanisms within the aquifer, the waters were geochemically modeled using two different thermodynamic approaches. Eh–pH (Pourbaix) diagrams were used to visualize the geochemical state of the waters. Creation of an Eh–pH diagram assumes thermodynamic equilibrium and is based on concentrations of select analytes in a representative sample. Other samples are then plotted on the diagram using only the pH and Eh values for those samples. Eh–pH diagrams showing aqueous and mineral stability fields were generated with the software program W32-STABCAL (Huang, 2010) using the MINTEQ.v4 thermodynamic database (Allison and others, 1990). Ionic strengths used were calculated using PHREEQC (Parkhurst and Appelo, 1999). The following four systems were plotted on Eh–pH diagrams:

1) Fe-O-H_2O-S-K (Fe, 352 mg/L; S, 1,202 mg/L; K, 22 mg/L; O, 0.85 mg/L);
2) Mn-O-H_2O-CO_3 (Mn, 31 mg/L; C, 13 mg/L; O, 0.17 mg/L);
3) Cu-O-H_2O-CO_3 (Cu, 10 mg/L; C, 13 mg/L; O, 0.17 mg/L); and
4) Zn-O-H_2O-CO_3 (Zn, 38 mg/L; C, 13 mg/L; O, 0.17 mg/L).

Well MSD-02B water-quality data were chosen for the Fe-O-H_2O-S-K diagram because that well is the farthest downgradient site from the Parrot Tailings area that contains detectable dissolved iron concentrations. Well GS-09 data were used to create the Cu, Mn, and Zn Eh–pH diagrams because at this site observed downgradient changes in metals concentrations were greatest, and bicarbonate was present.

Water chemistries were modeled using PHREEQC (Parkhurst and Appelo, 1999) using the MINTEQ.v4 thermodynamic database (Allison and others, 1990) to assess the oxidation state and potential mineral associations. PHREEQC provides aqueous speciation and mineral saturation index (SI) estimates for each water sample based on the assumption of thermodynamic equilibrium. The PHREEQC model uses the concentrations of analytes present along with the reported Eh and pH values to identify each aqueous species that should occur in the solution and estimate the concentration of each predicted aqueous species. The model then uses the aqueous speciation results to calculate mineral saturation indices, which can be used to assess which minerals may be precipitating from solution. A positive saturation index indicates that a mineral is supersaturated or thermodynamically favored to precipitate from the modeled solution. A saturation index of 0 indicates the mineral is in equilibrium with the solution, and a saturation index within ±0.5 is generally considered near equilibrium (or ±0.25 for normalized SI; see below). Mixing and reaction path models were created for this system; however, the results are not presented because the modeling outcomes were dependent on assumptions and arbitrary values that could be manipulated to support multiple opposing hypotheses.

The primary goal of the geochemical modeling was to assess the possible mineral phases that may be forming along groundwater flow paths and to assess the aqueous chemistry evolution. Special focus was given to the iron-mineral phases, because the precipitation of iron oxides can result in the co-precipitation or adsorption of contaminant metals (Cu, Zn, and Cd), thereby removing them from solution. Along with the saturation indices calculated by PHREEQC, the iron mineral saturation indices were also normalized. The normalization consisted of dividing the saturation index by the total number of ions in the formula unit for the mineral (Zhang and Nancollas, 1990). This normalization allowed for a more direct comparison between the saturation indices of different iron minerals, because it expresses the saturation state independent of the way formula was written. In addition to the normalization, green rust [$Fe^{2+}_4Fe^{3+}_2(OH)_{12}(SO_4)$] was added to the thermodynamic database.

Green rust is a mixed Fe^{2+}/Fe^{3+}, highly unstable group of minerals (e.g., Genin and others, 1998), but has been shown to form when the pH of Berkeley Pit water is adjusted upward

(C. Gammons, pers. comm.). Due to the instability of green rust, few thermodynamic data are available. Modeling in PHREEQC requires both the Gibbs free energy and the enthalpy of formation. The Gibbs free energy is used in the calculation of the saturation index. Enthalpy is used by the model to compensate for temperatures different than the standard temperature (25°C). The Gibbs free energy used for this analyis was -3,590 kj/mol (Genin and others, 1998). An approximate enthalpy value of -1,079 kj/mol (Maziena and others, 2008) was used for this modeling effort. Maziena and others (2008) provide the only published enthalpy values for green rust minerals; the four enthalpy values presented range from -1,036 to -1,084 kj/mol, representing a range of Fe^{2+} to Fe^{3+} ratios from 0.5 to 1.34. The mineral composition for the enthalpy chosen was most similar to the mineral composition for the Gibbs free energy that was used for this analysis.

To support the numerical modeling, simple acid-neutralization experiments were conducted on groundwater samples collected from an MA unit well (MSD-2B) to assess the potential for the precipitation of iron minerals within the aquifer. This location was chosen for acid-neutralization experiments for the following reasons:

1) elevated Fe concentration,
2) low pH, and
3) MSD-02B is the farthest downgradient well with detectible concentrations of iron.

This was a visulization experiment based on the assumption that Fe(III) oxide/hydroxides would form red to orange precipitates and the Fe(II) green rust minerals would be green. Filtered water samples were collected from MSD-02B (Fe^{2+}=352 mg/L; pH=4.11) in sampling containers with zero headspace to maintain *in situ* anoxic conditions (DO=0.85 mg/L). After sample collection and preservation on ice, samples were immediately transported to the MBMG laboratory. Neutralization experiments were conducted in the sample bottle to limit oxygen contamination, and in a beaker to better visualize the results. The pH adjusted to an endpoint of pH >6.0 with 0.25N NaOH solution. Precipitate formation and color were monitored visually over a period of 24 hours.

3.0 RESULTS

3.1 Surface Water

Surface-water samples from Blacktail and Silver Bow Creeks were collected on 12 April 2010; Blacktail Creek at SS-04 flow was 12 cfs, and had been at or lower than this rate for 8 days (fig. 4). Base flow conditions at this location ranged from 9 to 12 cfs. At this rate, the stream is dominated by groundwater discharge. Water-quality sampling in several reaches along Blacktail and Silver Bow Creeks showed continual downstream increases in dissolved and total recoverable (tables 2, 3; surface-water quality in appendix B) copper and zinc loading during base flow between Oregon Avenue (BTC @ Oregon Ave) and SS-05A, a sampling site at the upper end of Lower Area One. Increases in dissolved and total copper and zinc loading were observed in Blacktail Creek between Oregon Avenue and the USGS gauging station at SS-04 (George Street).

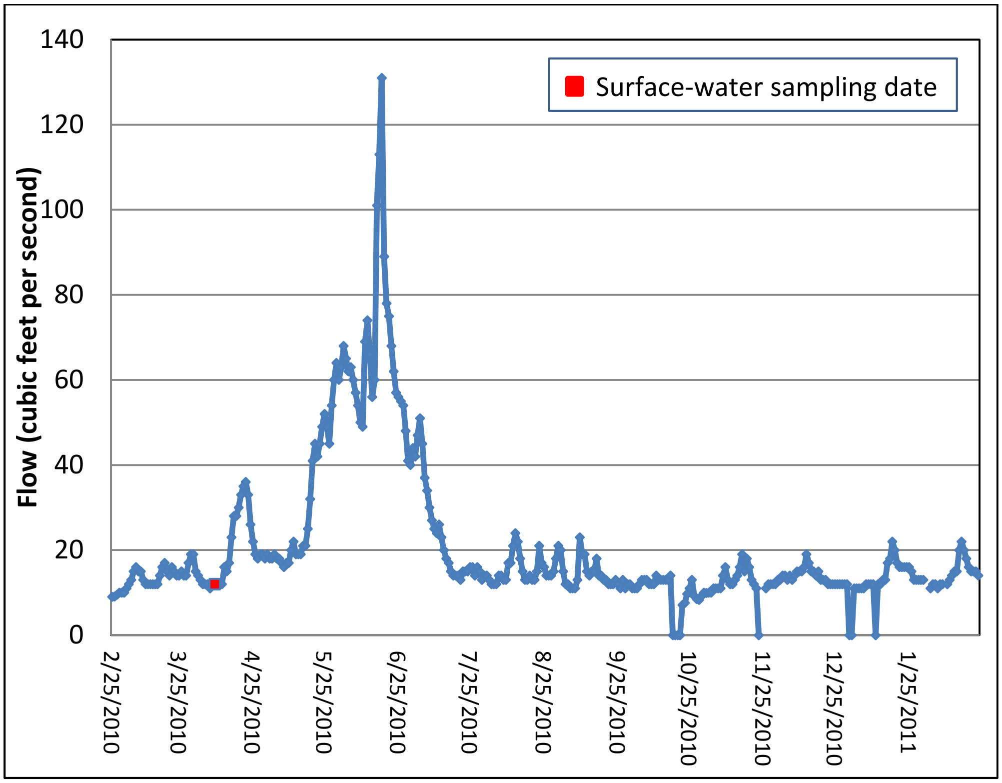

Figure 4. Time-series hydrograph of Blacktail Creek at SS-04 showing stream flow (data from USGS online database (http://waterwatch.usgs.gov/new/index.php).

Table 2. Dissolved copper and zinc loading to Blacktail and Silver Bow Creeks.

GWIC	Site	Flow (cfs)	Cu (µg/L)	Cu Load (lbs/day)	Zn (µg/L)	Zn Load (lbs/day)
226754	SS-01	8.39	1.60	0.07	3.12	0.14
191287	BTC @ Oregon Ave	8.39	1.73	0.08	3.39	0.15
127593	SS-04	13.65	3.42	0.25	7.99	0.59
127536	SS-05	13.21	1.88	0.13	6.37	0.45
249187	SS-05A	12.65	5.66	0.39	5.26	0.36

Table 3. Total recoverable copper and zinc loading to Blacktail and Silver Bow Creeks.

GWIC	Site	Flow (cfs)	Cu (µg/L)	Cu Load (lbs/day)	Zn (µg/L)	Zn Load (lbs/day)
226754	SS-01	8.39	3.50	0.16	6.13	0.28
191287	BTC @ Oregon Ave	8.39	3.47	0.16	6.39	0.29
127593	SS-04	13.65	7.00	0.52	14.20	1.05
127536	SS-05	13.21	3.84	0.27	10.10	0.72
249187	SS-05A	12.65	10.50	0.72	21.50	1.47

3.2 Groundwater

3.2.1 Background Groundwater Quality

Understanding the geochemistry of the contaminant plumes in groundwater within the SBC/MSD corridor requires an understanding of the area's background groundwater quality. Fortunately, water-level and chemical data for many background and mining-impacted locations have been monitored for at least 30 years and summarized annually by the MBMG (e.g., Duaime and Tucci, 2010). The geochemistry of three background wells (Duaime and Tucci, 2010) near the study area (BMF05-03, BMF05-02, and Whittier School, fig. 1) all show that groundwater in non-impacted areas has near-neutral pH, high DO concentrations, low SC, and low concentrations of SO_4^{2-}, Li, and contaminants of concern (table 4, appendix C).

Table 4. Background groundwater quality in selected wells in non-impacted areas.

Site	pH (s.u.)	SC (µs/cm)	DO (mg/L)	Cd (µg/L)	Cu (µg/L)	Pb (µg/L)	Zn (µg/L)	Li (µg/L)	SO_4^{2-} (mg/L)
BMF05-02	6.09	482	8.38	0.5	5.1	< 0.2	41.7	2.6	99.1
BMF05-03	6.55	397	8.17	<0.2	3.1	<0.2	9.9	<2.0	49.8
Whittier	7.18	355	7.08	<0.1	<0.6	<0.2	<0.7	2.5	41.7

3.2.2 General Groundwater Quality along the SBC/MSD Corridor

In SA and MA aquifers the water chemistry changes downgradient (horizontally) from the Parrot Tailings area (groundwater chemistry data in appendix C). A cross section showing the vertical relationships among the aquifers along the MSD corridor and Stiff diagrams of the water quality is presented in figure 5. The cross section bisects the Parrot, Northside, and Diggings East Tailings waste areas. All of the Stiff diagrams were plotted using the same scale, and the water chemistry for the Whittier School well is plotted in the upper right for reference. Lithologies are depicted in a simplified form. The figure should not be interpreted as representative of the entire aquifer. Downgradient of the GS-11/09 well pair, the MA aquifer appears less confined and it is difficult to correlate strata between boreholes (illustrated in fig. 5 by red dashed lines).

Groundwater beneath the Parrot Tailings area has the highest concentrations of COCs in the SA and MA (GS-41 S&D) aquifers (fig. 5); Fe and SO_4^{2-} are the dominant ions. Analytical results for GS-41 S and D are very similar (fig. 5, Stiff diagrams, water types), with comparable TDS concentrations, which is not true at any other SA/MA nested sample sites along the cross section.

In the SA and MA units, water chemistry evolves downgradient from an Fe-SO_4^{2-} (Parrot Tailings) to a Ca-Na-HCO_3^- (AMW-13) dominated water; however, there are notable differences in water chemistry between the units. The TDS in the SA unit decreases (water quality improves) immediately downgradient from the Parrot Tailings area; however, TDS concentrations increase at two downgradient locations (fig. 5, GS-11 and AMW-13). In the MA unit, TDS concentrations generally decline downgradient from the Parrot Tailings area to AMW-13. Ionic composition in both units, as symbolized by the size of Stiff diagrams, is consistent with calculated TDS concentrations.

3.2.3 Groundwater Quality Relative to Contaminant Source Areas

Water-quality data from all source areas were evaluated in an attempt to identify a unique chemical signature that could be used to track migration of individual plumes. Ratios of typical tailings-related contaminants, such as Cu/Zn, Cd/Zn, Zn/Cl, Cu/SO_4, and Zn/SO_4, were reviewed, but no ratio produced a unique chemical signature not explained by dilution. Rare earth elements (Ce, La, Nd, and Pr), trace elements, magnesium, and chloride were also evaluated as possible tracers; however, these elements were generally below detection outside the immediate source areas. For these reasons, a unique chemical signature for each plume could not be identified.

Sample results from three SA/MA nested sites (GS-41S&D; GS-42S&D; AMW-01A&B; fig. 1) show that the groundwater beneath the Parrot Tailings area has the lowest pH, highest SC, and highest concentrations of dissolved Cd, Cu, and Zn in the BPSOU (table 5A). Water from SA and MA wells at GS-41 had similar pH, SC, DO, Cd, Cu, Zn, and SO_4^{2-} concentrations, showing the SA and MA are hydraulically connected. However, just 500 ft downgradient to the southwest, at GS-42, Cu and SO_4^{2-} concentrations in the SA well were greater than in the MA well, suggesting less of a connection. The SA and MA south of the Parrot Tailings area (table 5C) also produce water with elevated concentrations of Cd, Cu, Zn, and SO_4^{2-}, even though these sampling locations are outside a direct flow path through the Parrot Tailings.

Water in the SA contains elevated metals concentrations along the MSD corridor (table 5A–F). The most significant source of contamination impacting the SA is the Parrot Tailings (table 5A), although Parrot impacts to the SA appear to diminish downgradient of MSD-1A (table 5B). Water from SA wells completed in the Northside Tailings area (table 5D) has low metals concentrations relative to other SA wells in the MSD corridor. The Northside Tailings SA wells are downgradient from the Parrot Tailings area, and elevated Cd, Cu, and Zn concentrations observed in the SA at the Parrot were not observed. The SA well water in the Diggings East area has elevated Cd, Cu, and Zn concentrations, similar to the water from wells along the southern boundary of the Parrot Tailings area (table 5E). Downgradient of the Diggings East area, metals concentrations decrease (table 5F).

Water in the MA unit is anoxic (0.2 to 1 mg/L DO) and contains elevated concentrations of Cu, Zn, and SO_4^{2-} from the Parrot Tailings area (GS-41D) to Kaw Avenue (AMC-24B; table 5A–F). Similar to the SA, the highest concentrations of COCs were observed in the Parrot Tailings area (GS-41D, table 5A). Downgradient of the Parrot Tailings area (between AMW-1 and AMC-24), the Cu and Zn concentrations decrease continuously, but at Kaw Avenue are still elevated above background concentrations (table 4).

Exceedances of the 5 µg/L Cd DEQ-7 human health standard (MDEQ, 2010) were widespread in the MA; 84 percent of the samples exceeded the standard. Concentrations ranged from 3,500 µg/L near the Parrot to 7 µg/L at AMC-24 (table 5). Comparatively, 39 percent of MA samples exceeded the human health standard for Cu, and 70 percent exceeded the human health standard for Zn.

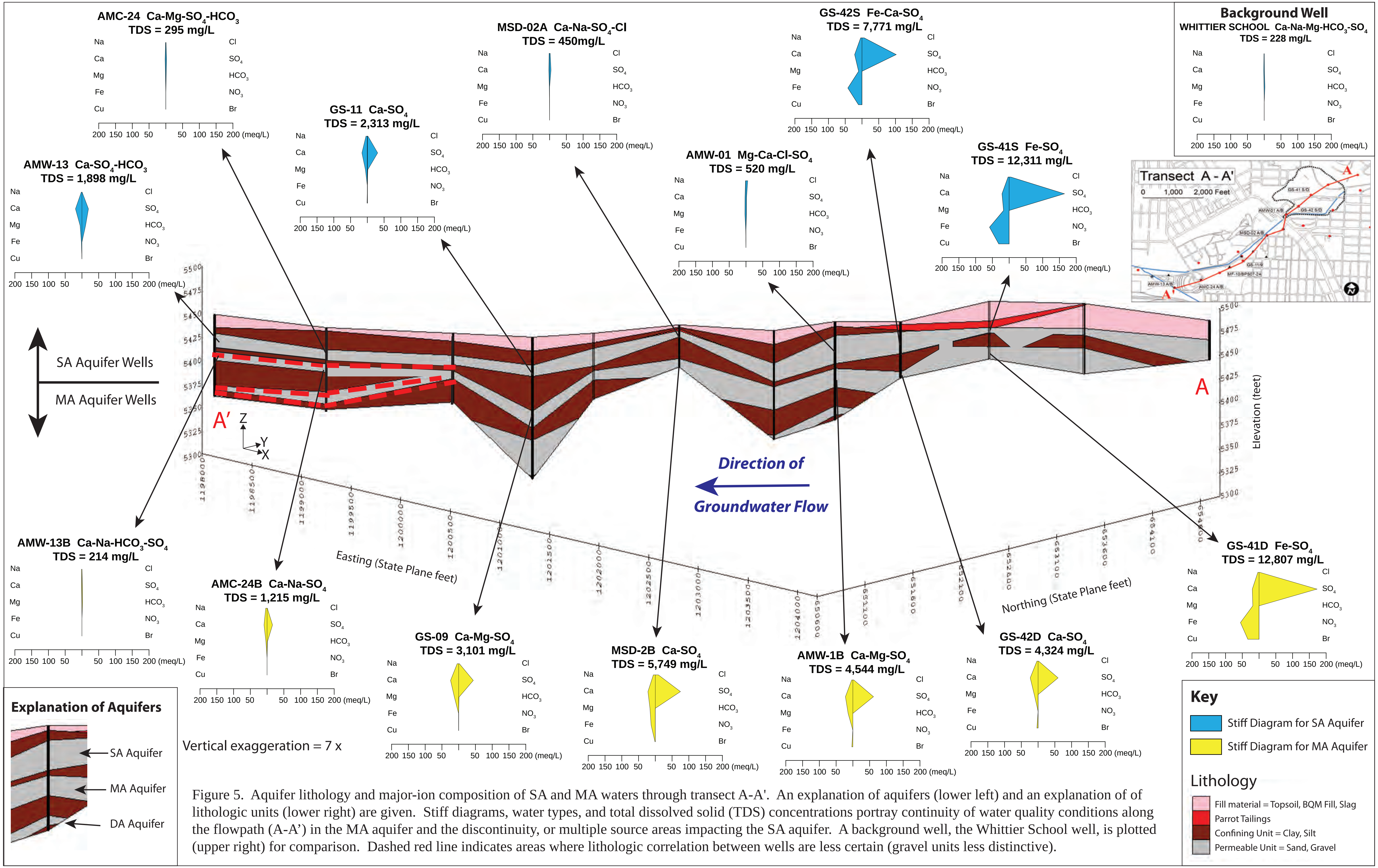

Figure 5. Aquifer lithology and major-ion composition of SA and MA waters through transect A-A'. An explanation of aquifers (lower left) and an explanation of of lithologic units (lower right) are given. Stiff diagrams, water types, and total dissolved solid (TDS) concentrations portray continuity of water quality conditions along the flowpath (A-A') in the MA aquifer and the discontinuity, or multiple source areas impacting the SA aquifer. A background well, the Whittier School well, is plotted (upper right) for comparison. Dashed red line indicates areas where lithologic correlation between wells are less certain (gravel units less distinctive).

Table 5. Nested wells showing groundwater quality within all flow units of the SBC/MSD alluvial aquifer: (A) Parrot Tailings area, (B) downgradient of the Parrot Tailings area, (C) south of the Parrot Tailings area, (D) Northside Tailings area, (E) Diggings East Tailings area, and (F) the area downgradient of the Diggings East.

(A) Parrot Tailings area								
	Unit	pH	SC (µs/cm)	DO (mg/L)	Cu (µg/L)	Cd (µg/L)	Zn (µg/L)	SO_4^{2-} (mg/L)
GS-41S	SA	4.04	7,620	0.19	1,060,000	4,230	526,000	7,920
GS-41D	MA	3.93	7,910	0.2	987,000	3,520	624,000	8,290
GS-42S	SA	3.84	5,650	0.57	331,000	768	208,000	4,910
GS-42D	MA	4.03	3,700	0.2	114,000	942	205,000	2,870
AMW-01A	SA	6.43	868	1.58	2.24	0.13	2,700	87.9
AMW-01B	MA	4.27	4,030	0.31	102,000	1,200	223,000	2,950
AMW-01C	DA	5.49	2,570	0.17	4,920	104	25,900	1,640
(B) Downgradient of the Parrot Tailings area								
	Unit	pH	SC (µs/cm)	DO (mg/L)	Cu (µg/L)	Cd (µg/L)	Zn (µg/L)	SO_4^{2-} (mg/L)
MSD-01A	SA	4.82	1,400	1	3,620	60.4	9,640	458
MSD-01B	MA	4.9	3,330	0.95*	1,600	153	57,300	2,230
MSD-01C	DA	5.75	3,150	0.35	330	68.8	15,700	2,100
(C) South of the Parrot Tailings area								
	Unit	pH	SC (µs/cm)	DO (mg/L)	Cu (µg/L)	Cd (µg/L)	Zn (µg/L)	SO_4^{2-} (mg/L)
BPS07-11A	SA	5.21	1,040	0.36	312	31.2	4,600	520
BPS07-11B	MA	4.99	2,070	0.18	1,540	140	36,500	1,190
GS-44S	SA	5.23	350	3.5	1,220	25	6,120	75
GS-44D	MA	5.5	359	0.2	1,090	26	5,360	124
(D) Northside Tailings area								
	Unit	pH	SC (µs/cm)	DO (mg/L)	Cu (µg/L)	Cd (µg/L)	Zn (µg/L)	SO_4^{2-} (mg/L)
MSD-2A	SA	5.32	638	1.54	68.3	33.7	4,920	205
MSD-2B	MA	4.11	5,310	0.85	33,600	1,030	249,000	3,600
GS-30S	SA	6.37	1,720	0.22	<3.00	<0.50	<3.30	739
MSD-05	MA	5.48	3,070	0.19	12,800	118	42,000	1,900
(E) Diggings East Tailings area								
	Unit	pH	SC (µs/cm)	DO (mg/L)	Cu (µg/L)	Cd (µg/L)	Zn (µg/L)	SO_4^{2-} (mg/L)
GS-11	SA	6.19	2,670	8.29	31,700	455	127,000	1,480
GS-09	MA	5.59	3,140	0.17	9,997	97.1	37,550	2,096
GS-08	DA	6.38	1,400	0.29	13.1	5.07	547	698
MF-10	SA	4.9	1,303	3.1	6420	481	6,180	663
BPS07-24	MA	6.27	1,850	0.82	834	19.8	5,380	1,400
(F) Downgradient of the Diggings East area								
	Unit	pH	SC (µs/cm)	DO (mg/L)	Cu (µg/L)	Cd (µg/L)	Zn (µg/L)	SO_4^{2-} (mg/L)
AMC-24	SA	6.37	440	0.19	<3.00	<0.50	69.6	108
AMC-24B	MA	6.23	1,460	2.27*	158	7.07	1,570	775
AMC-24C	DA	7.64	1,080	0.75	52.9	3.74	473	477
AMW-13	SA	6.47	2,282	2.86	3.65	0.58	190	935
AMW-13B	MA	7.09	305	1.81	1.24	0.25	23.8	60.4
AMW-13C	DA	7.82	805	0.84	0.97	2.56	293	378
Human health standard MDEQ, 2010					1,300	5	2,000	

*Sample collected without a flow-through cell.

In water from the deep alluvial unit (DA), elevated concentrations of Cd, Cu, Zn, and SO_4^{2-} exist at two sites immediately downgradient of the Parrot Tailings area (AMW-01C and MSD-01C, table 5B). Near the Diggings East area, concentrations of the COCs are at or below human health standards (GS-08, table 5E).

Sample results from nested wells along a northeast–southwest transect following the general direction of groundwater flow from the Parrot Tailings area to Blacktail Creek show that concentrations of Cu and Zn in the SA and MA exhibit different spatial patterns (fig. 6). Nearby shallow well MF-10 was used as the SA pair for BPS07-24 (MA). Cu concentrations in SA water at wells GS-41S, GS-42S, MF-10, and GS-11 are 1 to 3 orders of magnitude higher than concentrations in the other SA transect wells and are orders of magnitude above the human health standard of 1,300 µg/L (MDEQ, 2010). Elevated Cu concentrations in SA well water occur below areas where mining-related wastes are left in place. Cu concentrations in the SA well water outside of areas containing near-surface mine waste are below the human health standard (fig. 6; table 5). The pattern of Zn concentrations in SA water is similar to that of Cu (fig. 6).

In the MA, Cu and Zn concentrations decrease steadily downgradient from a maximum of more than 100,000 µg/L at the Parrot Tailings area to less than 100 µg/L near Blacktail Creek (fig. 6). A slight apparent increase in Zn between AMW-1B and MSD-2B is less than 10 percent and is considered to not be significant. Near the western end of the transect, concentrations of Cu and Zn in MA water at well AMC-24B remain elevated above background and above the concentrations in water from AMC-24, the SA well at this site.

Because Cu and Zn can adsorb or precipitate onto aquifer sediments, downgradient concentration trends for more conservative (less likely to sorb or precipitate) analytes in water from the SA and MA were also evaluated (fig. 7). No element or compound is completely conservative. However, sulfate (SO_4^{2-}) and lithium (Li) are present at elevated concentrations in mine wastes and are more conservative analytes that have low concentrations in background wells (table 4). Concentrations of SO_4^{2-} and Li are elevated in SA wells near areas with waste left in place but not in areas without waste. In the SA, the variable fluctuations of conservative analyte concentrations along the flow path were consistent with the concentrations observed for Cu and Zn in figure 6.

In the MA unit, SO_4^{2-} and Li concentrations are highest at the Parrot Tailings area and decrease continuously downgradient. The rate decrease is relatively constant between AMW-1 and AMC-24B; at AMW-13B (far west end of the transect), SO_4 and Li concentrations are much lower. AMW-13 is close to Blacktail Creek, and based on potentiometric surface mapping and water-quality data, may be located outside of contaminant plumes.

Weight ratios for Mn/Zn, Cd/Zn, Cu/Zn, and Co/Ni were plotted against sulfate concentrations (fig. 8) to assess dilution as a likely attenuation mechanism in the MA. Dilution effects along a flow path should not change the metal weight ratios with respect to sulfate concentrations in the absence of other attenuation mechanisms (Nordstrom, 2011). According to figure 8, metal ratios decline by more than an order of

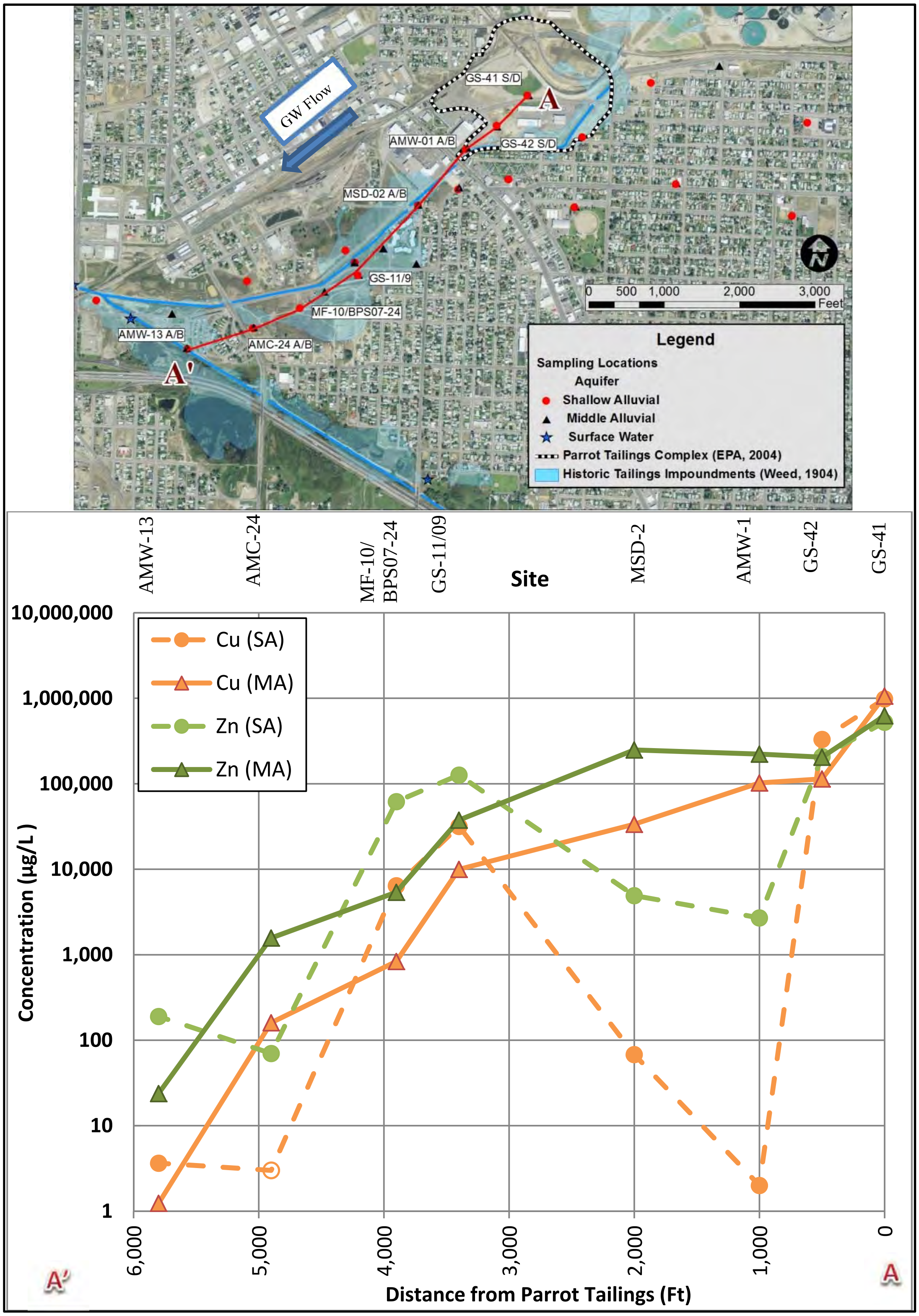

Figure 6. Cu and Zn concentrations in water from SA (dashed lines)/MA (solid lines) wells along a northeast–southwest transect (A–A') following the direction of groundwater flow. An open symbol represents results that fell below the analytical detection limit (detection limit was plotted for graphical purposes).

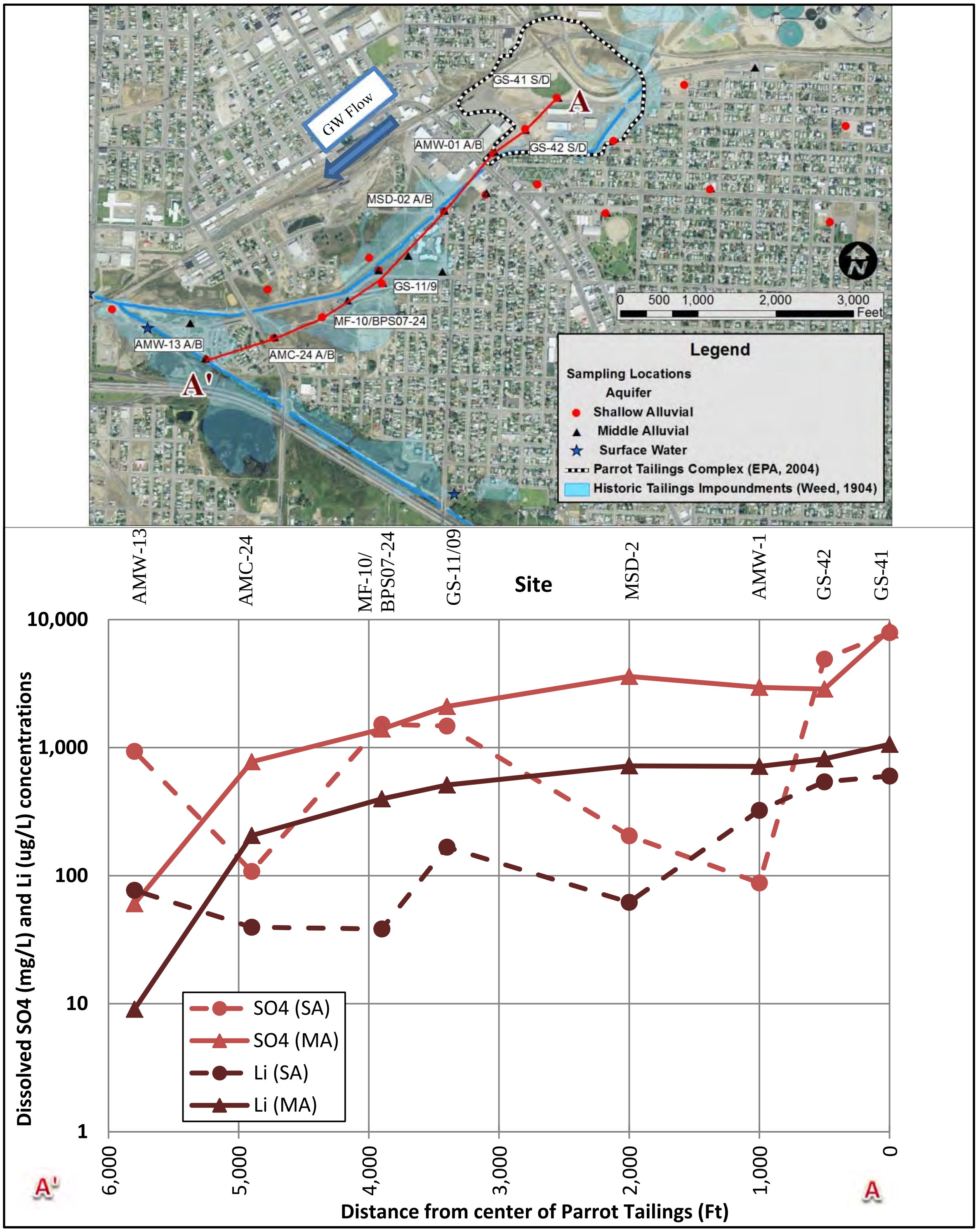

Figure 7. SO_4^{2-} and Li concentrations in water from SA (dashed lines) /MA (solid lines) wells along a northeast–southwest transect section (A–A') following the direction of groundwater flow.

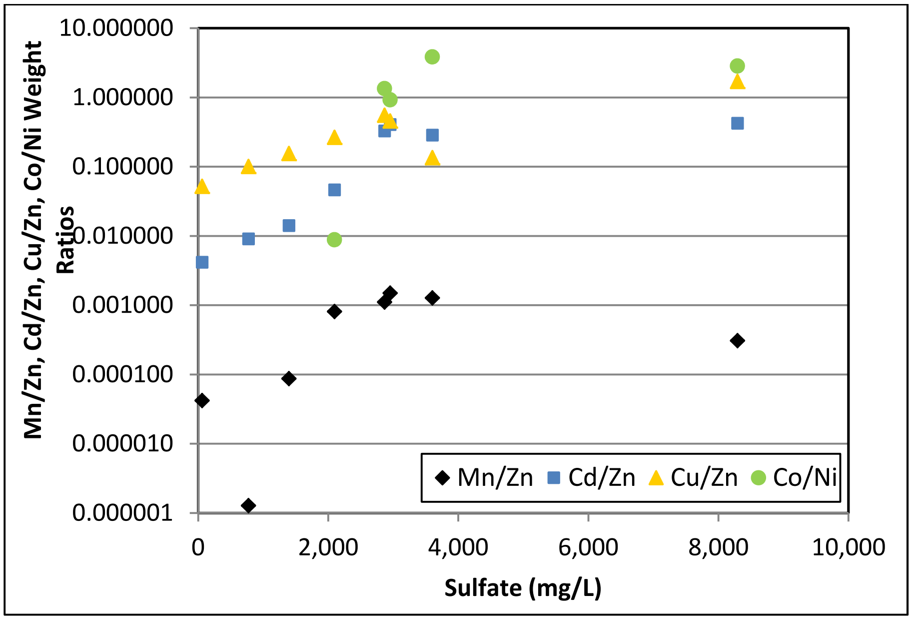

Figure 8. Plot of Mn/Zn, Cd/Zn, Cu/Zn, and Co/Ni weight ratios versus sulfate for the MA unit along the transect A to A'.

magnitude as SO_4^{2-} concentrations approach zero, showing non-linear relationships with respect to sulfate. This evidence suggests that attenuation mechanisms other than dilution are responsible for the observed decreases in metals concentrations in MA water.

Total iron (Fe) and manganese (Mn) concentration trends in water from the SA (fig. 9) downgradient from the Parrot Tailings area are somewhat similar to the concentration trends for Cu and Zn (fig. 6). The highest Fe and Mn concentrations occurred in areas where waste was left in place. However, elevated concentrations of Fe and Mn were also observed in wells not associated with waste left in place (e.g., AMW-13). Detectable concentrations of Fe and Mn were present in water from all wells completed in the SA unit.

The downgradient Mn concentration trend in MA water was similar to the trends observed for Cu and Zn (fig. 9); though a greater Mn concentration decrease was observed between GS-09 and BPS07-24. A significant decrease (3 orders of magnitude) in Fe concentration was observed in the Parrot Tailings area (between GS-41 and GS-42), which was not observed for any other analyte (downgradient of the Parrot Tailings area, Fe concentrations peak in the MA at MSD-2 and then decrease to below detection until AMW-13B).

In general, the divalent metal concentrations show similar trends in water from the MA unit downgradient of the Parrot Tailings area (AMW-1B), except for Fe concentrations (fig. 10). Concentrations decrease downgradient of MSD-2 with increasing pH, but different elements decrease more rapidly than others. Iron is the first divalent cation to decrease, followed by Cd, Mn, Cu and Zn. Dissolved Fe is the only metal that decreases to below detectable concentrations (<6 µg/L) and is not detectable in wells GS-09, BPS07-24, and AMC-24B. The other metals have detectable concentrations throughout the sampled portion of the MA unit.

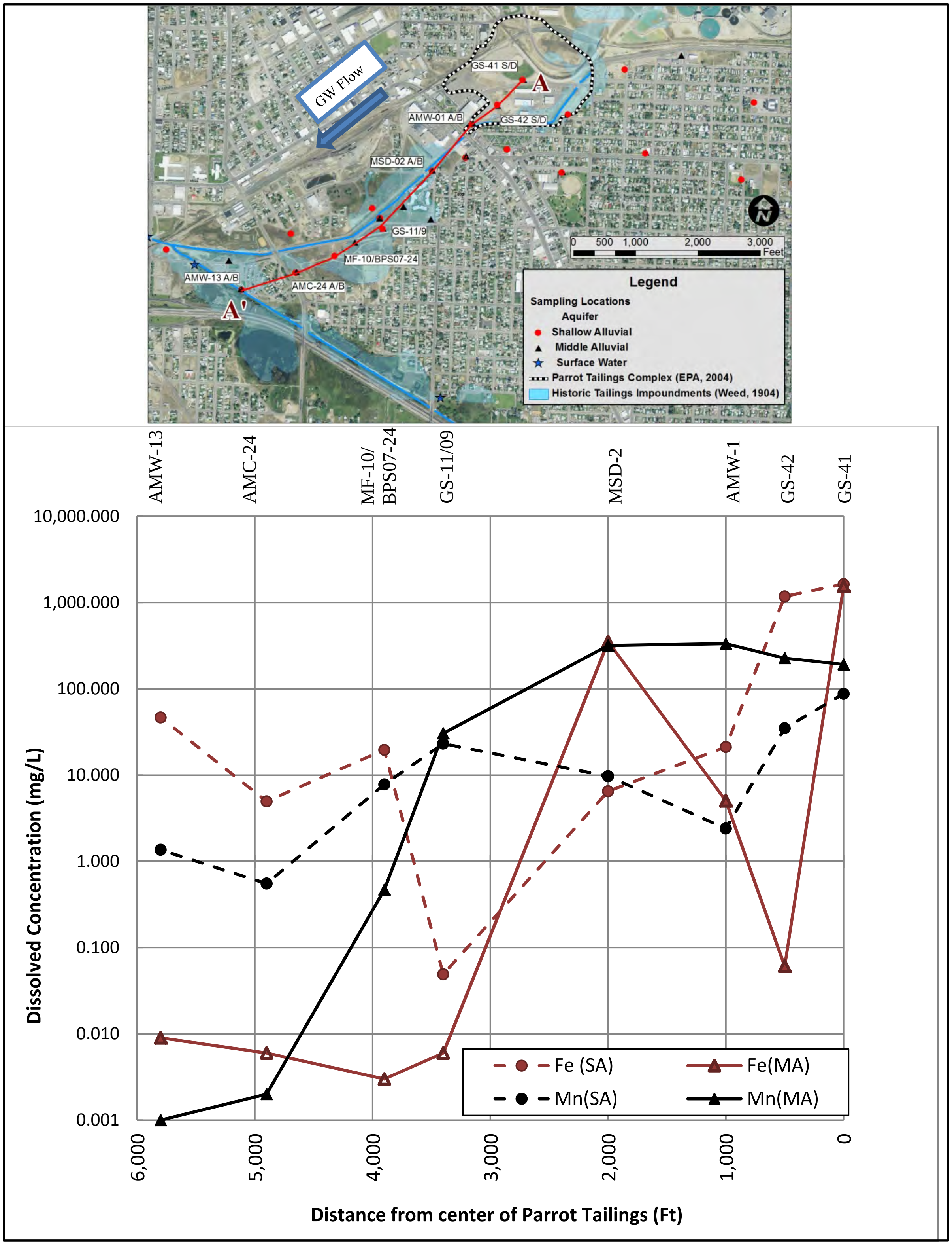

Figure 9. Fe and Mn concentrations in water from SA (dashed lines)/MA (solid lines) wells along a northeast–southwest transect section (A–A') in the direction of groundwater flow. An open symbol represents a result that was below detection (detection limit plotted for graphical purposes).

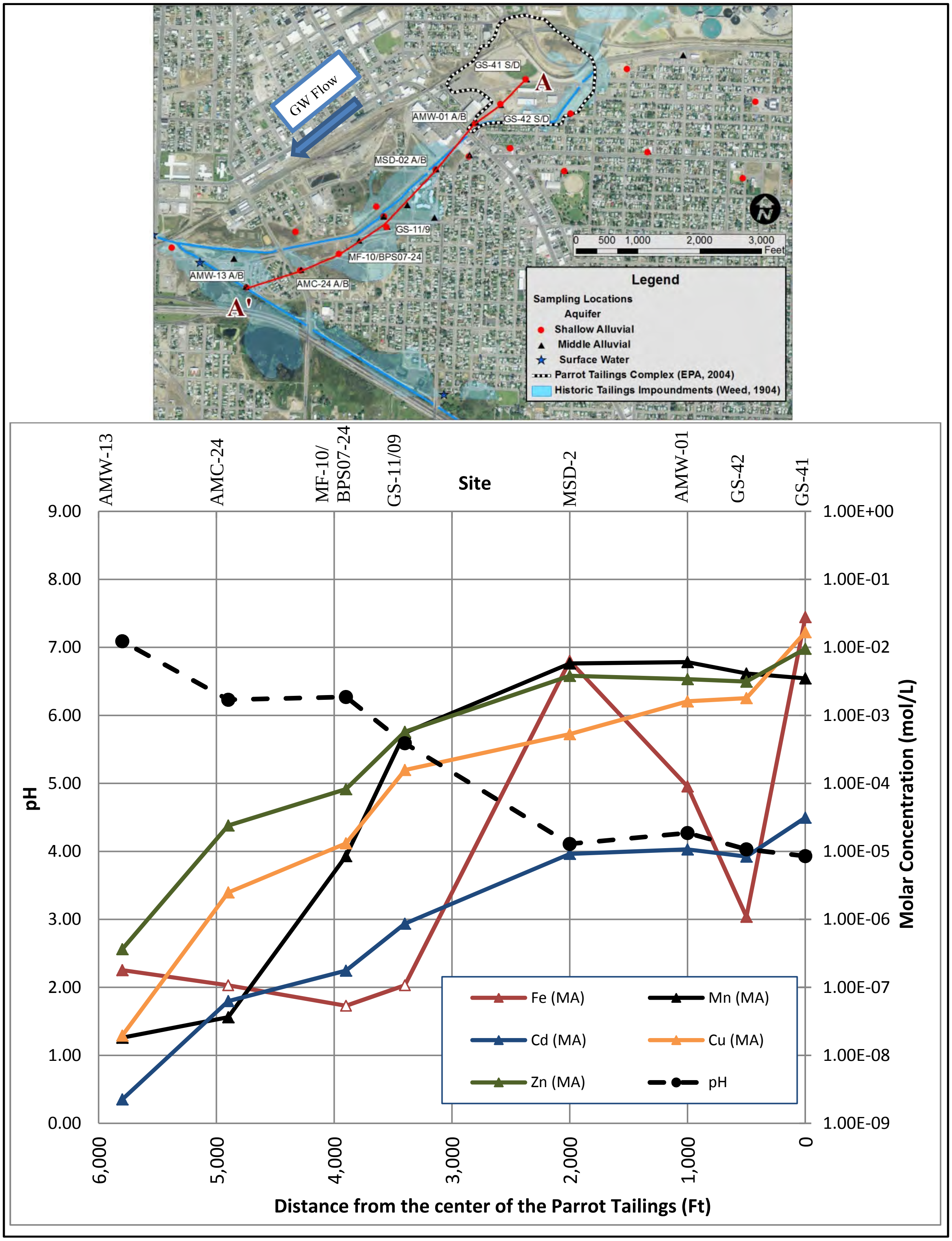

Figure 10. Relationships of pH to Cd, Cu, Fe, Mn, and Zn in water from the MA unit along the northeast–southwest transect section (A–A'). An open symbol represents a result that was below detection (detection limit plotted for graphical purposes). Molar concentrations (mol/L) were presented for analytical comparison.

3.2.3.1 Spatial Groundwater Quality Distribution for Selected Contaminants of Concern

Concentrations of Cd, Cu, Zn, and specific conductance for all wells sampled as part of the current study are presented in plate I and in appendices B (surface water) and C (groundwater). Copper and zinc concentrations were selected to demonstrate the general spatial distribution of contaminants of concern in the SA and MA units because their highly elevated concentrations are more persistent than other COCs (As, Cd, Hg, and Pb).

Isopleth maps (figs. 11, 12) of Cu and Zn in SA water show multiple areas of elevated concentrations. The highest Cu concentrations (fig. 11) and Zn concentrations (fig. 12) occur below areas where mine wastes have been left in place (Parrot, Northside, and Diggings Tailings areas). Cu concentrations >1,000 µg/L, not associated with a known waste area, were also detected south of the SBC/MSD channel near Harrison Avenue.

MA unit Cu and Zn isopleth maps are presented in figures 13 and 14. The highest concentrations occur at the Parrot Tailings area and decrease downgradient toward the confluence of SBC/MSD and Blacktail Creek. West of Harrison Avenue to the south of the SBC/MSD channel, Cu and Zn concentrations decrease markedly. North of SBC/MSD, the extent of the plume is undefined due to a lack of data/wells. Similar to the SA aquifer, south of the Parrot Tailings area there are elevated Cu and Zn concentrations that do not underlie any known waste left in place and that are not downgradient of the Parrot Tailings area.

3.2.3.2 Temporal Groundwater-Quality Trends

All data used for this report can be found on the MBMG Groundwater Information Center projects webpage under project code BPSOU-2010GWQ (GWIC, http://mbmggwic.mtech.edu). Prior to the 2010 sampling event, the data were collected by multiple organizations, including the MBMG and BP/ARCO.

Eight wells in the study area have historical (prior to 1990) water-quality data (GS-41S, GS-41D, GS-44S, GS-44D, AMC-12, AMC-06, MF-10, and GS-09) and are shown on plate I. The water-quality trend from well GS-44S was not included in this analysis because COC concentrations could have been compromised as the result of well-completion issues. Prior to October 2008, well GS-44S had a flush mount completion, and was in a topographically low-lying area. The well was often covered under several inches of water and ice for significant periods of time. Sampling of this well during the winter and early spring months was often prevented by the freezing and bridging of surface water inside the two-inch casing. Analysis of unusually low SC values during sampling events (~100 µs/cm) supports the conclusion that a significant volume of surface-water contamination (i.e., snowmelt, rain events) may have influenced the well’s water chemistry. To prevent surface infiltration at this site, in October 2008, a protective outer surface casing was added and extended 2 ft above ground surface. For this reason, well GS-44S was not used in this report.

Concentration trends were not displayed for wells that do not have an adequate historical record (i.e., sites AMW-01, MSD-01, MSD-02, MSD-03, and MSD-05, and BPS-07 series wells). However, the limited data available (some with only three sampling points) for wells without historical data were consistent with data from wells with historical data. It should be noted that wells GS-08, 09, and 11 were included in this report though the EPA questions the well completion integrity of these wells. MBMG disagrees with this hypothesis, and references the aquifer test data available in the Phase I RI for SBC (MultiTech, 1987), which clearly demonstrates that a hydraulic connection among GS-08, 09, and 11 does not and never did exist. Wells GS-08, 09, and 11 represent the only historical nested site downgradient of the Parrot Tailings area with screened intervals completed in the MA aquifer. All other wells completed in the MA were installed after 2004; historical trends analysis is not available for the deeper aquifers. MBMG believes it would be irresponsible not to consider the only data set that provides historical trends in deeper aquifers downgradient of the Parrot Tailings.

Time series plots of Cu and Zn in the Parrot Tailings area (GS-41S and GS-41D) show increasing concentrations for both analytes (plate I). In the SA (well GS-41S), Cu and Zn concentrations increased by at least a factor of 3 between 2003 and 2008. After 2008, the concentrations of Cu and Zn decreased to approximately two to three times the 2003 concentrations. Similarly, in the MA (well GS-41D), Cu and Zn concentrations increased from 2003 with a peak in 2008; however, the concentrations did not decrease to the same extent in 2009 as those observed in the SA. Concentrations in GS-41D appear to be increasing again in 2010.

Temporal water-quality trends in the MA unit to the east and southeast of the Parrot Tailings area (AMC-06, AMC-12, and GS-44D) show decreasing concentrations for Cu and Zn between Farragut Avenue and Harrison Avenue (plate I). Between 1983 and 1993, Cu concentrations in well AMC-12 increased. The Zn concentrations in the early AMC-12 samples follow the same general decreasing trend as the rest of the Zn data for this well. Copper concentrations in wells AMC-06 and GS-44D have continually decreased since records began in 1983 and are below the drinking water standard. If Cu concentrations in AMC-12 water continue on the same downward trend, the Cu concentrations will be below the human health standards by 2021. These wells are not downgradient of the Parrot Tailings area and show steadily decreasing trends in both Cu and Zn concentrations since the 1980s.

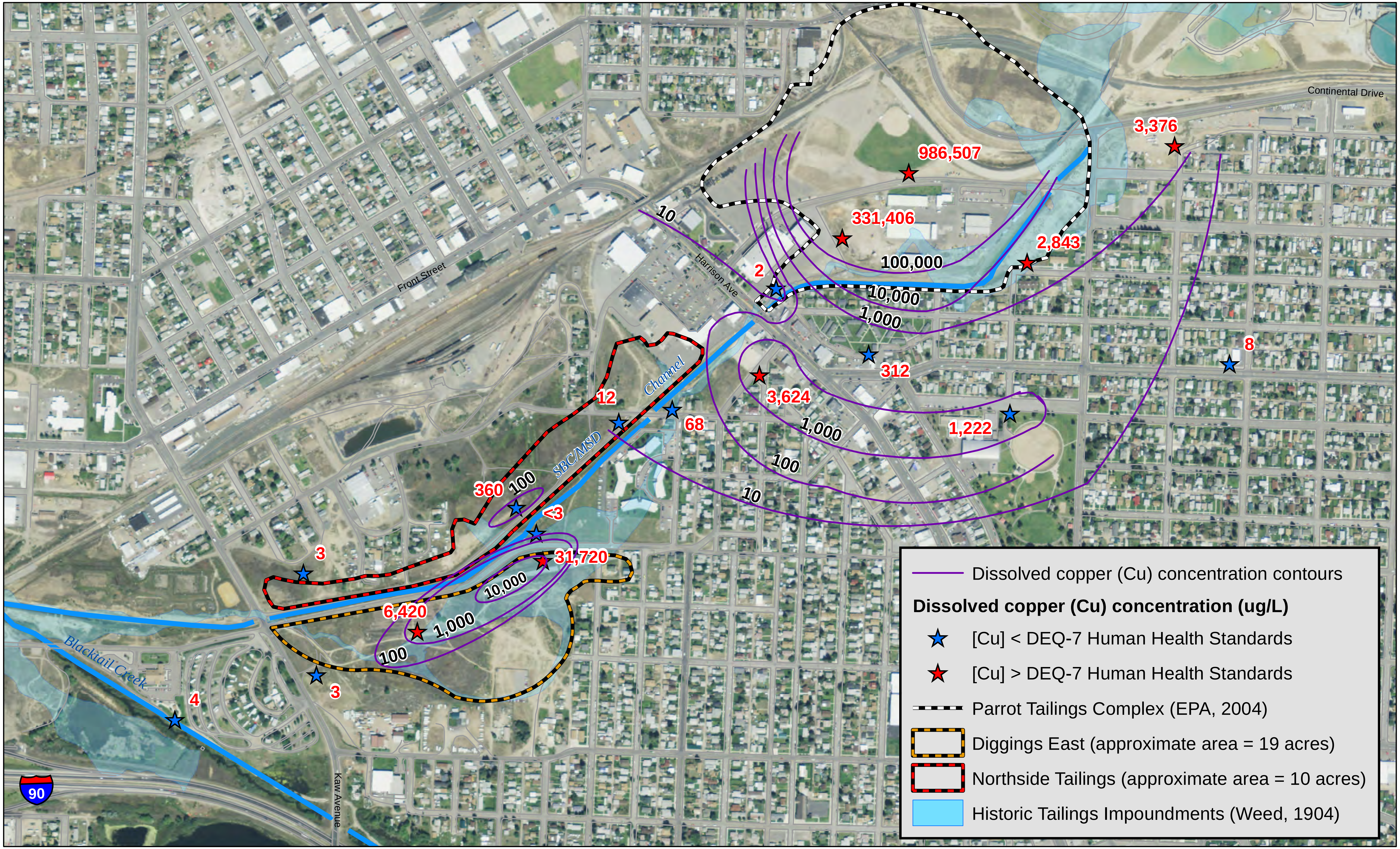

Figure 11. Dissolved copper concentrations in the shallow alluvial (SA) unit. Copper contour intervals are on a log scale.

Concentrations are compared to DEQ-7 human health standards for Cu (1,300 ug/L)

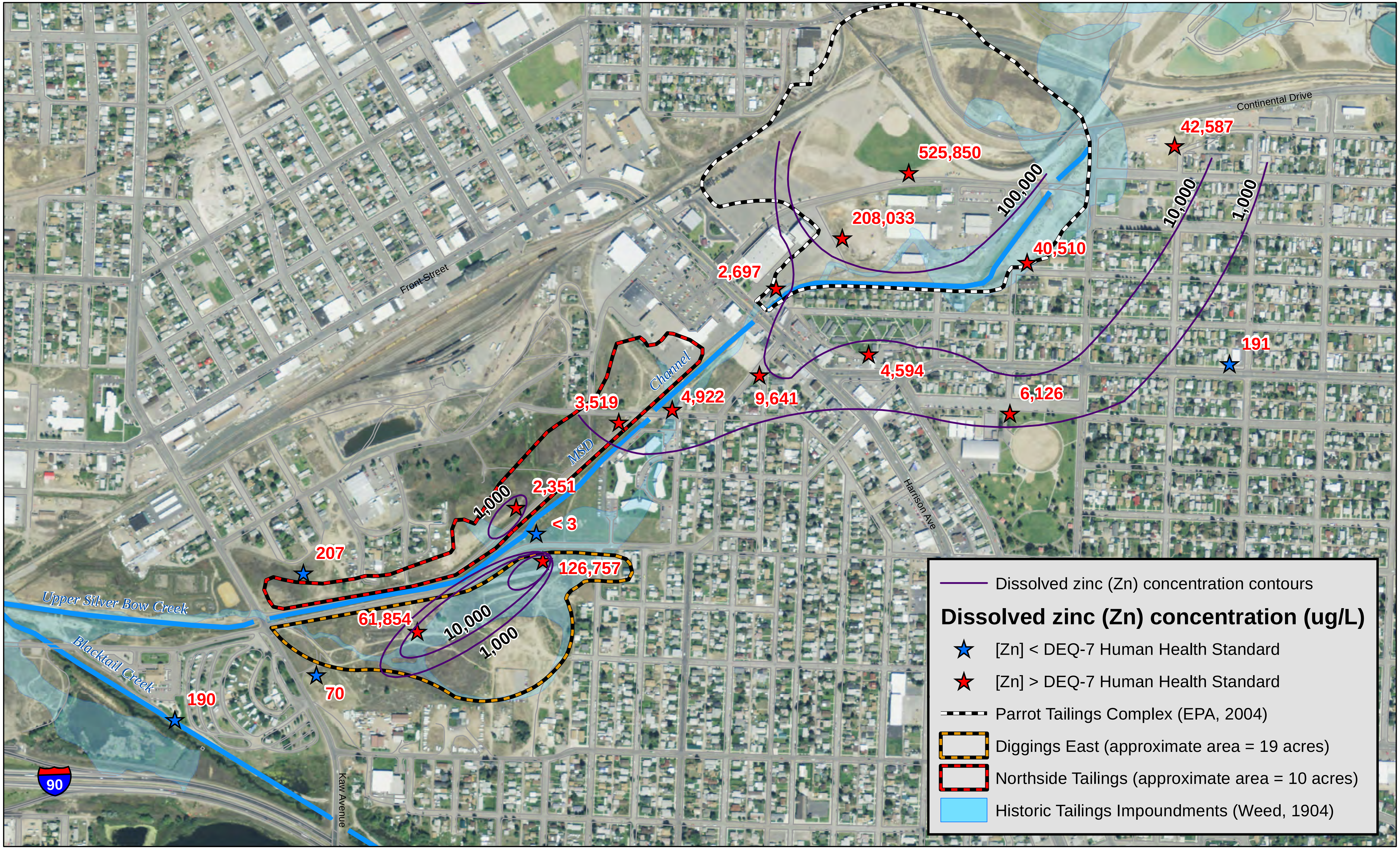

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Figure 12. Dissolved zinc concentrations in the shallow alluvial (SA) unit. Zinc contours are on a log scale.

Concentrations are compared to DEQ-7 Human Health Standards for Zn (2,000 ug/L)

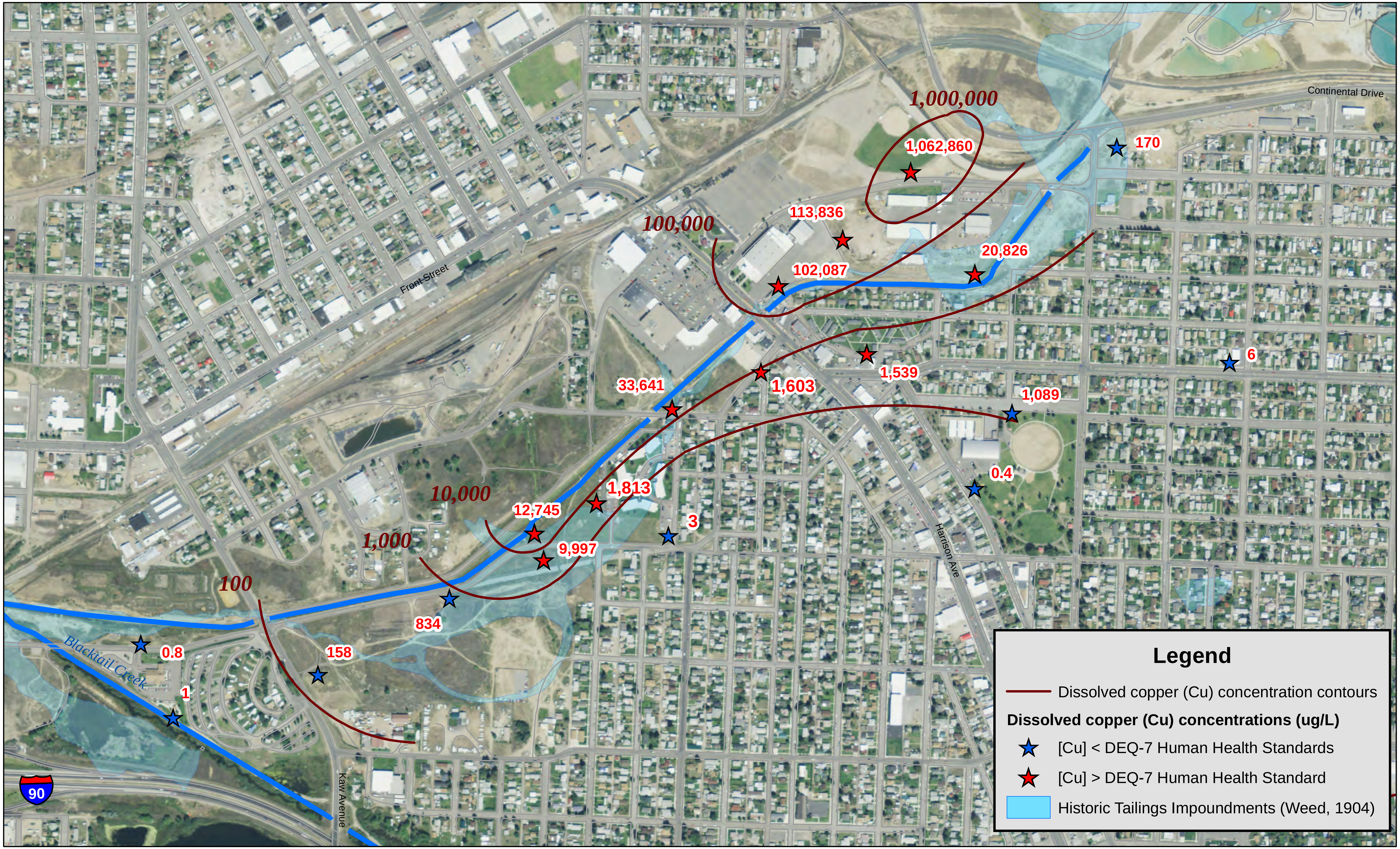

Figure 13 . Dissolved copper concentrations (ug/L) in the middle alluvial (MA) unit. Copper contours are on a log scale.

Concentrations compared to DEQ-7 human health standards for Cu (1,300 ug/L)

0 0.125 0.25 0.5 Miles

Figure 14. Dissolved zinc concentrations (ug/L) in the middle alluvial (MA) unit. Zinc contours are on a log scale.

Concentrations compared to DEQ-7 human health standards for Zn (2,000 ug/L)

In general, concentrations of COCs in water beneath the Diggings East have increased during the period of record (plate I, GS-09, MF-10). Concentrations of Cu and Zn in MA water from well GS-09 appeared to peak in 2004, but the only earlier sample was collected in 1989; since 2007, Cu and Zn concentrations have increased. Data from well MF-10 show Cu and Zn concentrations in water have increased by 2 orders of magnitude between 2007 and 2010 (plate I, MF-10). Zn has been increasing since 2007, but the greatest change in Cu occurred between the 2009 and 2010 sampling events. Well MF-10 is a low-yield well. In 2010 the sample was collected after the well was redeveloped, which may have influenced the observed concentrations in Cu, but not Zn, which has been increasing since 2007. However, the results from subsequent sampling of MF-10 are consistent with those observed in 2010, suggesting that the 2010 samples are not anomalous. Unfortunately, other wells in the Northside and Diggings East areas were not sampled with sufficient frequency to support time series analysis.

3.3 Geochemical Calculations and Modeling

The water chemistries of both the SA and MA aquifers along the transect A–A' were modeled using PHREEQC to evaluate the potential for mineral formation. Geochemical modeling of SA unit water samples downgradient from the Parrot Tailings area indicates that the primary Fe and Mn species are Fe^{2+} and Mn^{2+} (tables 6, 7). In water from well MF-10, the model predicted that Fe^{3+} (relative to Fe^{2+}) was the predominant species; however, the sample evaluated had an anomalously high Eh measurement, which may be erroneous (appendix C). Even though the model predicted Fe^{2+} would be the dominant Fe species in most waters, it also predicted the formation of iron oxides and hydroxides (supersaturated ($SI>0$) values for ferrihydrite, lepidocrocite, magnetite, and cupricferrite) in the SA. The Fe^{3+}-sulfate mineral K-jarosite also was at or near saturation in the SA water. Na-jarosite was supersaturated in water at AMW-01 and MF-10. With the exception of water from GS-11, green rust, a mixed Fe^{2+}/Fe^{3+} hydroxide, was supersaturated in all water downgradient of GS-42S. No Mn oxide or hydroxide minerals were predicted to be supersaturated in SA waters.

The modeling indicated that carbonate minerals for most metals of interest are undersaturated in most SA waters (table 8). Exceptions were siderite, which was supersaturated at AMW-13A, and malachite, which was supersaturated in water from well GS-11. Rhodochrosite and smithsonite were predicted to be undersaturated in all SA waters. Gypsum was undersaturated in most SA waters (table 8); however, the gypsum was also near equilibrium in water from wells GS-41S, GS-42S, GS-11, and AMW-13. The pattern of waters near equilibrium with gypsum roughly coincides with the high sulfate concentrations along the transect.

Modeling of the MA waters downgradient from the Parrot Tailings area indicates that aqueous Fe exists primarily as Fe^{2+} and Mn solely as Mn^{2+} (tables 6, 7). Detectable Mn concentrations were observed in all wells, which suggests that reducing conditions exist throughout the aquifer along the A–A' transect. Iron was not present in detectable concentrations in water from wells GS-09, BPS07-24, or AMC-24B, and the Fe concentration at AMW-13B was near the detection limit of 0.001 mg/L. Ferrihydrite was predicted to be undersaturated in all wells with measurable iron concentrations. Lepidocrocite, magnetite, cupricferrite, and K-jarosite were predicted to be supersaturated in water from wells GS-41D, AMW-01B, and MSD-02B. Na-jarosite was slightly supersaturated in water at AMW-01B and essentially in equilibrium at MSD-02B. Green rust was undersaturated in all MA water, but was near saturation (normalized to iron) with water from MSD-02B. All Mn minerals were undersaturated in water from MA wells.

The modeling showed that carbonate minerals for most metals of interest are undersaturated in most MA waters (table 8). Siderite was not predicted to be supersaturated with any of these waters; however, only one well had both dissolved Fe and HCO_3^-. Malachite was predicted to be supersaturated in water from wells GS-09 and BPS07-24. Rhodochrosite and smithsonite were predicted to be undersaturated in all MA waters. Gypsum was near equilibrium in most MA waters (table 8) and undersaturated in water from wells AMC-24B and AMW-13B, located the farthest downgradient. This may indicate that gypsum may have been precipitating in the aquifer but only to a limited extent, as both Li and SO_4^{2-} downgradient trends are quite similar.

Eh–pH diagrams are a common geochemical tool used to visualize the thermodynamic stability fields for specific aqueous species or mineral phases. This type of analysis typically uses 4 to 6 chemical variables from one sample to construct the stability fields in X–Y space. Additional samples are plotted on the diagram by using the Eh and pH values. Eh–pH diagrams showing iron oxide and carbonate (Mn, Cu, and Zn) stability relationships were plotted for MA waters along the transect downgradient from the Parrot area and generally agreed with the PHREEQC modeling predictions for the sample that was used to create the Eh–pH diagram. Both methods used the same thermodynamic database, so this was a valuable confirmation of the two methods. However, the results did not compare favorably when multiple water chemistries were plotted on a single Eh–pH diagram. The additional water chemistries consistently plotted in stability fields that were not predicted by the PHREEQC modeling. Eh–pH diagrams are most useful in areas of consistent water chemistry, because the shape of the stability fields is dependent on the concentrations of the elements used to create the diagram. Accurate representations of these water chemistries would require individual Eh–pH diagrams for each sample. For these reasons, Eh–pH diagrams were not presented in this report.

Table 6. Summary of calculated Fe speciation concentrations and geochemical modeling output data. Saturation indices for common Fe minerals listed with Fe normalized saturation indices in parentheses for minerals with more than one Fe.

Site	Distance from Parrot (ft)	$\mathrm{Fe(II)}_{\mathrm{Total}}$ (mol/L)*	$\mathrm{Fe(III)}_{\mathrm{Total}}$ (mol/L)*	SI Ferrihydrite $Fe(OH)_3$	SI Lepido-crocite FeOOH	SI Magnetite Fe_3O_4	SI Cupricferrite $CuFe_2O_4$	SI K-Jarosite $KFe_3(SO_4)_2(OH)_6$	SI Na-Jarosite $NaFe_3(SO_4)_2(OH)_6$	SI Sulfate Green Rust** $Fe_6(OH)_{12}(SO_4)$
	SA Unit Wells									
GS-41S	0	2.97E-02	9.76E-07	-1.45 (-0.36)	1.10 (0.37)	4.99 (0.71)	2.37 (0.34)	1.53 (0.13)	-1.34 (-0.11)	-1.90 (-0.10)
GS-42S	500	2.13E-02	3.02E-06	-1.17 (-0.29)	1.36 (0.45)	4.77 (0.68)	2.21 (0.32)	2.00 (0.17)	-0.85 (-0.07)	-4.80 (-0.25)
AMW-1A	1,000	3.36E-04	4.36E-05	2.72 (0.68)	5.24 (1.75)	16.97 (2.42)	10.20 (1.46)	3.62 (0.30)	0.79 (0.07)	14.43 (0.76)
MSD-2A	2,000	1.14E-04	2.53E-06	0.31 (0.08)	2.91 (0.97)	9.38 (1.34)	4.78 (0.68)	0.57 (0.05)	-2.19 (-0.18)	1.90 (0.10)
GS-11	3,400	5.32E-08	8.26E-07	0.83 (0.02)	3.25 (1.08)	8.68 (1.24)	10.08 (1.44)	1.13 (0.09)	-1.78 (-0.15)	-6.84 (-0.35)
MF-10	3,900	1.43E-04	2.09E-04	2.17 (0.54)	4.38 (1.46)	12.53 (1.79)	9.82 (1.40)	8.09 (0.67)	4.84 (0.40)	0.95 (0.05)
AMC-24	4,900	8.79E-05	9.93E-07	1.19 (0.30)	3.55 (1.18)	13.36 (1.91)	NA	-0.75 (-0.06)	-3.69 (-0.31)	8.10 (0.43)
AMW-13	5,800	8.36E-04	8.00E-07	1.12 (0.28)	3.52 (1.17)	14.07 (2.01)	6.76 (0.97)	1.00 (0.08)	-2.48 (-0.21)	12.12 (0.64)
	MA Unit Wells									
GS-41D	0	2.82E-02	3.57E-07	-2.01 (-0.50)	0.54 (0.17)	3.62 (0.52)	1.06 (0.15)	0.26 (0.02)	-2.62 (-0.22)	-3.84 (-0.20)
GS-42D	500	1.09E-06	3.38E-09	-3.85 (-0.96)	-1.33 (-0.44)	-3.92 (-0.56)	-3.19 (-0.46)	-5.92 (-0.49)	-8.97 (-0.75)	-23.72 (-1.25)
AMW-1B	1,000	8.69E-05	3.57E-06	-0.43 (-0.11)	1.94 (0.65)	5.41 (0.77)	4.20 (0.60)	3.44 (0.29)	0.41 (0.03)	-8.78 (-0.46)
MSD-2B	2,000	6.34E-03	2.43E-06	-0.89 (-0.22)	1.60 (0.53)	5.85 (0.84)	2.33 (0.33)	2.72 (0.23)	-0.04 (-0.003)	-2.68 (-0.14)
GS-09	3,400	BD	BD	NA	NA	NA	NA	NA	NA	NA
BPS07-24	3,900	BD	BD	NA	NA	NA	NA	NA	NA	NA
AMC-24B	4,900	BD	BD	NA	NA	NA	NA	NA	NA	NA
AMW-13B	5,800	5.44E-08	1.07E-07	0.80	3.31 (1.10)	10.75 (3.58)	7.10 (1.01)	-4.51 (-0.38)	-7.16 (-0.60)	-0.41 (-0.02)

*Total (before aqueous speciation) concentrations calculated by the model.

**Green rust thermodynamic data were added to the database using data from Genin and others (1998) and Maziena and others (2008).

SI, Saturation Index: negative values indicate the water is undersaturated with respect to the mineral. Positive values indicate the water is supersaturated with respect to the mineral.

NA, not applicable due to a lack of one of the aqueous species required for mineral formation.

BD, the analyte was below detection.

Table 7. Summary of geochemical output for Manganese (Mn) and saturation indices for several common Mn-oxide minerals.

Site	Distance from Parrot (ft)	$Mn(II)_{Total}$ (mol/L)	SI Manganite MnOOH	SI Pyrochroite $Mn(OH)_2$	SI Pyrolusite MnO_2	SI Birnessite MnO_2	SI Bixbyite Mn_2O_3
SA Unit Wells							
GS-41S	0	1.61E-03	-10.64	-11.86	-18.99	-19.42	-24.05
GS-42S	500	6.43E-04	-10.68	-12.92	-17.90	-18.38	-24.03
AMW-1A	1,000	4.37E-05	-6.17	-7.87	-13.89	-14.38	-14.96
MSD-2A	2,000	1.76E-04	-7.37	-9.57	-14.97	-15.29	-17.72
GS-11	3,400	4.23E-04	-3.40	-7.52	-8.19	-8.91	-8.95
MF-10	3,900	1.42E-04	-6.30	-10.15	-10.30	-11.49	-13.78
AMC-24	4,900	1.01E-05	-8.00	-8.38	-16.27	-17.10	-17.91
AMW-13	5,800	2.48E-05	-8.59	-8.13	-17.87	-18.63	-19.25
MA Unit Wells							
GS-41D	0	3.54E-03	-10.84	-11.75	-19.49	-19.92	-24.43
GS-42D	500	4.15E-03	-8.24	-11.12	-14.77	-15.27	-19.09
AMW-1B	1,000	6.09E-03	-6.79	-10.29	-11.94	-12.78	-15.50
MSD-2B	2,000	5.82E-03	-8.94	-10.86	-16.31	-16.86	-20.38
GS-09	3,400	5.57E-04	-5.17	-8.68	-10.60	-11.30	-12.52
BPS07-24	3,900	8.54E-06	-9.25	-9.15	-18.66	-19.20	-21.03
AMC-24B	4,900	3.65E-08	-8.30	-11.44	-14.28	-14.90	-18.95
AMW-13B	5,800	1.82E-08	-7.70	-9.83	-14.93	-15.45	-17.97

SI, Saturation Index: negative values indicate the water is undersaturated with respect to the mineral. Positive values indicate the water is supersaturated with respect to the mineral.

NA, not applicable due to a lack of one of the aqueous species required for mineral formation.

BD, the analyte was below detection.

Table 8. Summary of geochemical modeling output data. Saturation indices for common carbonate minerals.

Site	Distance from Parrot (ft)	HCO_3 (mol/L)	SI Calcite $Ca(CO)_3$	SI Siderite $Fe(CO)_3$	SI Rhodo-chrosite $Mn(CO)_3$	SI Mala-chite $Cu_2CO_3(OH)_2$	SI Smith-sonite $Zn(CO)_3$	SI Gypsum $CaSO_4 \bullet 2H_2O$
SA Unit Wells								
GS-41S	0	BD	NA	NA	NA	NA	NA	0.04
GS-42S	500	BD	NA	NA	NA	NA	NA	-0.33
AMW-1A	1,000	1.65E-03	-1.51	-0.50	-0.92	-3.76	-1.64	-1.76
MSD-2A	2,000	9.43E-05	-3.98	-3.36	-2.66	-4.89	-3.76	-1.43
GS-11	3,400	1.25E-03	-1.41	-4.98	-0.58	3.37	-0.59	-0.26
MF-10	3,900	8.66E-04	-2.96	-2.74	-2.30	-1.89	-2.12	-0.69
AMC-24	4,900	1.15E-03	-1.76	-1.19	-1.68	NA	-3.33	-1.68
AMW-13	5,800	1.03E-02	-0.09	0.48	-0.58	-3.81	-2.18	-0.33
MA Unit Wells								
GS-41D	0	BD	NA	NA	NA	NA	NA	0.02
GS-42D	500	BD	NA	NA	NA	NA	NA	-0.01
AMW-1B	1,000	BD	NA	NA	NA	NA	NA	-0.05
MSD-2B	2,000	BD	NA	NA	NA	NA	NA	-0.03
GS-09	3,400	9.84E-04	-2.01	NA	-1.25	0.43	-1.90	-0.04
BPS07-24	3,900	2.30E-03	-1.00	NA	-1.95	0.42	-1.65	-0.19
AMC-24B	4,900	1.13E-03	-1.57	NA	-4.53	-0.94	-2.41	-0.58
AMW-13B	5,800	1.76E-03	-1.09	-3.50	-3.50	-2.91	-2.92	-2.08

SI, Saturation Index: negative values indicate the water is undersaturated with respect to the mineral. Positive values indicate the water is supersaturated with respect to the mineral.

NA, not applicable due to a lack of one of the aqueous species required for mineral formation.

BD, the analyte was below detection.

3.4 Acid-Neutralization Experiments

The acid-neutralization experiments performed on water from MA well MSD-2B produced a green particulate that precipitated from solution (fig. 15). Prior to acid neutralization (pH=4.16, fig. 15A), the MSD-02B water sample was clear and colorless. A green particulate (green rust) began forming immediately upon addition of sodium hydroxide and continued to form as the pH was increased (fig. 15B). After neutralization to a pH >6.0, the precipitates from the sample bottle were poured into a beaker and left to equilibrate with atmospheric oxygen for 1 hour (fig. 15C). After 24 hours approximately half of the green rust precipitate altered to a reddish-orange precipitate, and after 3 days the precipitate was completely replaced with reddish-orange precipitate.

Figure 15. Acid-neutralization experiments of well MSD-02B. Water samples were clear and free of observable precipitate prior to acid neutralization (A). Green rust precipitate formed immediately after the pH was adjusted (>6) (B), and remained in solution 1 hour post-acid neutralization (C).

4.0 DISCUSSION

4.1 Surface Water

The synoptic metal-loading analysis (Section 3, tables 2 and 3) suggests that a source of copper and zinc loading to Blacktail Creek exists between Oregon Avenue (BTC @ Oregon) and George Street (SS-04). Although metals concentrations in groundwater are reported in the dissolved form, the Cu load in the creek is predominately a particulate (tables 2, 3). Influent groundwater containing dissolved Cu may form copper-complexes as a result of changing geochemical conditions upon mixing. Several possible sources of the Cu in waters entering Blacktail Creek include:

- Clark and Colorado Tailings via Grove Gulch (fig. 1), a tributary of Blacktail Creek just downstream of the sampling location at Oregon. The Colorado Tailings were placed with the Clark Tailings in an unlined repository in the upper reaches of Grove Gulch in the 1990s, approximately 1 mile southwest of Blacktail Creek. Prior to being capped with soil and vegetation in the 1990s, the Clark Tailings were exposed and located adjacent to the Grove Gulch Channel.
- Blacktail Berm (fig. 1), located adjacent to the south bank of the creek near the Butte Visitor's center between Kaw Avenue and George Street. This berm was constructed of mining-related waste at the beginning of the 20th century as an impoundment dike. Loading from this potential source could be in the form of groundwater or sediment.
- Waste left in place along the MSD corridor (Parrot Tailings, Northside, and Diggings East areas). Concentrations of Cd, Cu, and Zn in MA wells (AMC-24B and C) closer to the creek indicate that there may be significant contamination that is not being captured by the MSD Subdrain (discussed in detail below).

More detailed groundwater/surface-water studies might provide these answers. The data available at this time are insufficient to allow for a determination of the metals for source of loading to Blacktail Creek. Since the collection of the data used in this report, surface-water investigations designed to determine this source have been conducted by MBMG and BP/ARCO.

4.2 Groundwater

Samples from monitoring wells show that there are several different sources of metals contamination to the SA unit in the upper SBC/MSD area, primarily from areas where near-surface mining-related waste has been left in place. Concentrations of Cu and Zn in water from SA wells located in areas without near-surface waste were significantly lower than wells located in areas where waste was left in place. The tight spacing between the Parrot, Diggings East, and Northside Tailings areas and the substantial decreases observed in metals concentrations in SA groundwater between them shows that the plumes around each source may be geographically constrained in the SA unit. In addition, the temporal trends indicate that in the Parrot Tailings and Diggings East areas, the Cu and Zn concentrations have increased in recent years.

4.2.1 Spatial Distribution

The SA unit is a water-table aquifer throughout the study area. Groundwater levels in the SA were lowered in 2003/2004 as a result of the installation of the MSD Subdrain (appendix A; A6), which was installed to capture shallow contaminated groundwater and prevent it from discharging to SBC (EPA, 2006a). Although a quantitative analysis of the capture zone associated with the subdrain has not been performed by the MBMG, the subdrain appears to be capturing a significant amount of Cu and Zn (BP/ARCO, 2010b), and it is likely that the subdrain may be capturing much of its flow from SA unit groundwater. Above GS-11, there is greater confidence that the subdrain is capturing contamination in the SA unit, because the sources are near the subdrain and distant from Blacktail Creek. There is less confidence that the shallow groundwater in the Diggings East and to the southwest is being captured by the subdrain, because these areas are farther from the subdrain and closer to BTC. Also, hampering the assessment of capture in the Diggings East area is a lack of potentiometric-surface data (wells). This area has a relatively flat hydraulic gradient (0.002 ft/ft) that is likely to be influenced by seasonal fluctuations in stream stage. Data from the available wells near the SBC/MSD indicate that the greatest concentrations of COCs (Cd, Cu, and Zn) and more conservative ions (SO_4^{2-} and Li) are concentrated near source areas (Parrot, Northside, and Diggings areas; figs. 5–13). These source areas appear to be currently contributing COCs to groundwater in the SA unit. However, the elevated concentrations within the SA decrease downgradient from source areas, which may indicate that the subdrain is capturing these contaminated waters. A quantitative analysis of the capture zone is needed to estimate with any confidence the amount of SA contamination being captured by the subdrain. This type of capture analysis was beyond the scope of this project.

Elevated concentrations of COCs in the SA unit were also observed south of the Parrot Tailings area. Groundwater flow paths from the Parrot Tailings area is southwest (fig. 2), and under the current flow system it is unlikely that the elevated metals concentrations observed in water from the SA and MA units to the south of the Parrot Tailings area are coming from the Parrot. Historically, it is also unlikely that groundwater in the SA or MA units in the Parrot Tailings area would have flowed south of Silver Bow Creek, because SBC should have been a natural groundwater divide with groundwater discharging to or recharging from SBC. The downward vertical gradients near the Parrot Tailings area suggest that the SA may have been recharged by SBC in this area. The nearly 100 years of mine discharge to the creek is the most likely source for the contamination observed in the SA unit south of the Parrot Tailings area. This argument also implies that groundwater plumes emanating from the Parrot Tailings area have only been moving on their current flow paths since 1982, when mine discharges ceased.

Boundary and flow conditions in the MA unit are more complex than for the SA. In general, in the Parrot Tailings area (north and east of Harrison Avenue), there is a hydraulic connection between the SA/MA units and a downward vertical gradient (fig. 2). In the Parrot Tailings area, contamination from near-surface mining-related waste is observed in the SA and MA units (plate I). Similar concentration trends shown by samples from SA and MA wells in the Parrot Tailings area indicate that the contamination observed in the MA unit is coming from the Parrot Tailings. Further downgradient, southwest of Harrison Avenue, the vertical gradients are upward from the MA to the SA at all nested well locations except AMW-13 (furthest downgradient near BTC), where the vertical gradients fluctuate. The lack of downward vertical gradients implies that the only source of contamination to the MA unit throughout the upper SBC/MSD corridor must be from the Parrot Tailings area. The MA unit appears to be confined downgradient of the Parrot to at least GS-09 based on upward vertical gradients, geochemistry, and the pumping responses in the MA unit (Tucci and Icopini, 2010). Because there is no evidence of a connection between the SA and MA units between Harrison Avenue and GS-09, contamination entering the MA unit in the Parrot Tailings area can only discharge to the SA unit west of GS-09. West of well GS-09, water-quality differences between SA/MA nested wells suggest that contaminants in the MA have not discharged to the SA as far downgradient as AMC-24B (table 5). Once the plume reaches the SA unit it can discharge to surface water or the MSD Subdrain.

In general, the 2010 water-quality data collected from the MA unit shows steadily decreasing Cu and Zn concentrations along the SBC/MSD corridor from AMW-1B to AMW-13B; however, the concentration decrease between AMC-24B and AMW-13B was more pronounced than the rate of decrease elsewhere (fig. 6). The wells used for this analysis were located at a considerable distance downgradient from the Parrot Tailings area and are not likely to fall on a single groundwater flow path, but probably do lie along adjacent groundwater flow paths. Well AMW-13 may be intercepting a different part of the Parrot plume than other wells along the transect, there may be greater dilution of the plume in this area, or the well may not intercept the plume at all. Decreasing COC concentrations along the entire transect support the conclusion that the wells used in this evaluation lie along a similar flow path. This idea is supported by the nearly log-linear concentration trends observed for conservative parameters (SO_4^{2-} and Li; fig. 7) from near the Parrot Tailings area to AMC-24B downgradient of the Diggings East area. The available evidence for the MA unit suggests that the contamination plume originating at the Parrot Tailings can be traced to a least AMC-24B at Kaw Avenue.

The north–south width of the Parrot Tailings plume in the MA unit is unknown. The very high concentrations in the Parrot Tailings area form a plume extending to the southwest, with an apparently sharp concentration gradient to the south along the upper SBC/MSD corridor (figs. 10, 11). The dimensions of the plume to the north are unknown due to lack of data, but the abrupt southern boundary suggests that the Parrot Tailings plume may be relatively narrow.

The extent and fate of contamination in the DA aquifer remains undefined. Contamination to the DA is evidenced by elevated concentrations in water from wells AMW-01C, MSD-01C, GS-08, and AMC-24C. The source area for the DA unit is likely the Parrot Tailings.

4.2.2 Temporal Trends

Historical water-quality data from the SA unit show that Cu and Zn concentrations increased between 2004 and 2008 in the Parrot Tailings and Diggings East areas. The cause of the increase is not clear, but may be related to the construction and operation of the MSD Subdrain starting in 2004. The subdrain may have altered groundwater flow paths, drawing more highly concentrated parts of the plume toward the shallow wells. Another possibility is that Cu and Zn concentrations are increasing as a result of some other process such as artificial recharge related to irrigation and snow removal practices, or the shift of the local groundwater divide (Tucci, 2010).

Concentration trends in the MA unit appear to result from two different processes. In the Parrot Tailings area, the Cu and Zn concentration trends in MA water mimic those observed in the SA unit; concentrations increased starting in 2004 (plate I). This observation indicates that contaminated water is moving vertically downward from the SA to the MA. Also, Cu and Zn concentrations in water at GS-09, which is 0.5 miles downgradient from the Parrot Tailings area, have shown net increases since at least 2008. The estimated groundwater travel time from the Parrot Tailing area to GS-09 is 1 to 3 years (Tucci and Icopini, 2010). Therefore, it seems likely that the concentration increase observed in GS-09 is due to the downgradient movement of highly contaminated Parrot Tailings water. The parallel increases over time support the conclusion that the increasing metal concentrations observed in water near the Parrot Tailings area are actual increases in MA plume concentrations and not the result of possible altered groundwater flow directions caused by the installation of the MSD Subdrain.

Concentration trends in the MA water in wells to the south and east (not downgradient) of the Parrot Tailings area suggest a different contaminant source (plate I). These wells have long sampling histories dating back to 1983 for wells AMC-12 and AMC-06 and to 1989 for GS-44D. Water from all of these wells show a steady decrease in Cu and Zn concentrations beginning in 1992. For almost a century, ACM discharged wastewater from its mining practices into upper SBC, loading the creek with elevated concentrations of Cu (>4,000 ppb) and Zn (>4,000 ppb). Prior to 1982, SBC between Continental Drive and Harrison Avenue was a losing stream, and effluent discharged by ACM recharged the aquifer in the immediate area of the streambed (MultiTech, 1987; Hydrometrics, 1983). In the fall of 1982, ACM discontinued the discharge when it implemented a zero-point discharge system. The decreasing metals concentrations in water from wells AMC-06, AMC-12, and GS-44D (plate I) appear to be a response to the implementation of the zero-point discharge system and the cessation of the historic loading source.

4.2.3 Geochemical Modeling and Possible Attenuation Mechanisms in the MA Unit

The processes controlling the observed metal concentration decreases in MA water downgradient from the Parrot Tailings area are difficult to determine from the available data. Possible attenuation mechanisms include: precipitation, co-precipitation, sorption onto aquifer material, and dilution with adjacent waters. In many mining-impacted systems, ferric iron (Fe^{3+}) oxides and hydroxides (hereafter referred to as Fe oxides) dominate metal attenuation. Iron oxides typically form red to yellow precipitates with large surface areas that can cause metal attenuation by sorption onto their surfaces or through co-precipitation during Fe oxide formation and precipitation (McBride, 1994).

The geochemical model evaluated the potential for mineral precipitation to cause decreases in metals concentrations in the MA downgradient of the Parrot Tailings area.

PHREEQC geochemical modeling assumes thermodynamic equilibrium; kinetic limitations are not considered. Thermodynamic modeling is used to predict potential mineral formation based on the saturation state calculated by the program. A positive saturation index (supersaturation) indicates that mineral formation is thermodynamically possible. However, the mineral may not form due to disequilibrium conditions or kinetic limitations. The saturation state is also not an indication of the volume of the mineral that may form, which is controlled by the concentration of the least abundant mineral component. On the other hand, a mineral that is predicted to be undersaturated is very unlikely to form and may dissolve in the system. Modeling results are not definitive, but they provide valuable insights regarding mineral precipitation or dissolution, which requires interpretation.

The modeling predicted that waters from MA wells GS-09 and BPS07-24 were supersaturated with respect to malachite (table 6), indicating the potential for malachite to form in the MA unit. However, the downgradient concentration trends for Cu and Zn are quite similar (fig. 6), which suggests a similar attenuation mechanism for both metals. PHREEQC modeling did not predict the formation of any other Cd, Cu, Mn, or Zn mineral phases. It is possible that amorphous or mineral phases not in the MINTEQ database could be important for metal attenuation in the aquifer, but it is unlikely that this would be true for all the elements that behave similarly (Cd, Cu, Mn, and Zn). Therefore, it is unlikely that formation of malachite is impacting Cu concentrations.

PHREEQC modeling also indicated that iron oxides are supersaturated in the MA aquifer, suggesting that they may be precipitating. This is the result of the model predicting small amounts of aqueous Fe^{3+} relative to Fe^{2+}(table 6). In instances where the model predicted aqueous Fe^{3+}(model predicted very low concentrations of Fe^{3+} <0.2 mg/L), Fe^{2+} was always the dominant Fe species in solution. However, the presence of any aqueous Fe^{3+} forces the model to predict that Fe oxides are supersaturated at these pH values. The iron speciation predictions are sensitive to the field Eh measurements, which can be difficult to measure accurately. Eh measurement errors could arise from calibration issues or if the electrode is responding to multiple redox couples. Although the modeling indicates that iron oxides may be forming, reliance on these results to understand MA unit geochemistry will require additional evidence.

Iron oxides are often visually apparent when present because of their bright coloration. It is common for acid-mine drainage at the surface or in the vadose zone to produce widespread orange or red Fe-oxide staining (fig. 3A). Widespread iron staining was not observed in core samples from MA unit sediments downgradient from the Parrot Tailings. Some discrete clasts (sand to gravel) within the MA unit appear to have an orange stain or coating indicative of Fe oxides, but the majority of clasts are not stained (fig. 3B). SBC historically included tributaries from the Butte Hill where natural weathering of sulfide minerals would have produced orange-stained rocks, and it seems likely that the stained clasts observed in the MA unit were eroded and transported from nearby sources or were the result of historic loading of high-Fe, high-oxygen waters to the aquifer from the SBC channel. Furthermore, historic mine discharges to the SBC Channel may have created a halo zone of Fe-stained clasts (near Kaw Avenue) from loading to the aquifer. The presence of Fe oxides in contact with water that contains aqueous Fe^{2+} (between AMW-1B and GS-09) is an apparent contradiction. However, microbial activity is generally required to reduce iron oxides in the environment. The presence of these Fe-oxide-stained clasts suggests that while Fe^{2+} may be the dominant aqueous Fe species in the MA unit, there is insufficient microbial activity to drive active Fe^{3+} reduction. The presence of aqueous Fe^{2+} (between AMW-1B and GS-09) in contact with solids that contain Fe oxides does not necessarily imply either the biological reduction or precipitation of iron oxides.

The active formation of iron oxides is controlled by the presence of Fe^{2+} and dissolved O_2 (Drever, 1997). Oxygen concentrations in the MA well water between the Parrot Tailings and BTC are less than 1 mg/L, except at AMC-24B (2.27 mg/L; table 5). The oxygen concentration at AMC-24 was not collected using a flow-through cell and may have been compromised. The concentration of dissolved oxygen in the MA unit water is likely a rate-limiting factor in the production of Fe oxides. Without a source of dissolved oxygen to the MA unit there is no oxidative driver for Fe oxide generation even though there may be abundant Fe^{2+} (between AMW-1B and GS-09).

There are few ways oxygen can reach the MA unit downgradient from Harrison Avenue. One potential oxygen source is the migration from the land surface; however, this seems unlikely for two reasons. First, the SA unit throughout the area contains both soluble Fe and Mn, which indicates reducing conditions are present. Second, once water enters the MA unit under the Parrot Tailings area and progresses downgradient from Harrison Avenue, there is a consistent upward vertical gradient between the SA and MA units. The only other potential source of oxygen would be the dilution of Parrot plume water with oxygenated groundwater from the east.

The question of dilution of Parrot plume water with groundwater from the east to form iron oxides can be assessed by examining the geochemistry between MSD-2B and GS-09, which is a well-confined section of the MA unit. Water at MSD-2B contains 352 mg/L (6.3 mmol/L) Fe (likely Fe^{2+}), but the water downgradient at GS-09 contains no measurable iron. It takes 1 mole of O_2 to oxidize 4 moles of Fe^{2+}. If oxygenated Whittier School water (7.08 mg/L or 0.22 mmol/L O_2) “mixes” with the Parrot plume water at MSD-2B, the water at GS-09 would have to be diluted to the approximate extent of one part MSD-2B water to seven parts Whittier School water (86 percent dilution) in order to provide enough oxygen to oxidize and precipitate all of the Fe from solution. This level of dilution is much greater than the apparent dilution of SO_4^{2-} (42 percent) or Li (29 percent) between MSD-2B and GS-09. The precipitation of Fe oxides is also often accompanied by the liberation of H^+, causing the pH to decrease (Drever, 1997); however, the pH is higher at GS-09 than at MSD-2B. In addition, if Fe oxides were precipitating in the unit between MSD-2B and GS-09, they would create an abundance of sorption sites and/or co-precipitate with other metals, and the other divalent cation concentrations (Cd, Cu, and Zn) would be expected to decrease to a much greater extent than the observed concentrations between the two wells. This is not the case here, especially for Cu and Zn (fig. 10). The concentrations of Cu and Zn decrease considerably between GS-09 and AMC-24B and there is no measurable dissolved iron.

Another indication of the lack of oxidative potential in the MA is the presence of measurable dissolved Mn throughout the unit, which is likely to exist as reduced Mn^{2+} (table 6), because Mn^{4+} is very insoluble. Given the nature of groundwater mixing and the lack of sufficient oxidation potential, it seems apparent that some mechanism other than Fe oxide precipitation is responsible for the removal of Fe between MSD-2B and GS-09. These observations suggest that the Fe oxide formation is not the main attenuation mechanism for metals in the MA unit.

The cause for the decreasing iron concentrations between MSD-2B and GS-09 is difficult to determine with the available data. The thermodynamic modeling suggests that iron oxides or K-jarosite are capable of precipitating from waters at MSD-2B. However, the formation of these minerals requires the oxidation of most or all of the dissolved iron, which is unlikely for the reasons discussed above. Green rust was added to the thermodynamic database because the iron in this mineral is primarily Fe^{2+}. Green rust is near equilibrium (relative to iron) with the water from MSD-2B, and it is possible this mineral could be forming in the MA between MSD-2B and GS-09. The formation of a green precipitate during the MSD-2B acid-neutralization experiments (fig. 15) strongly supports the hypothesis that the formation of green rust is causing the decrease in iron concentrations in the MA between AMW-01B and GS-09.

Dilution of the plume migrating within the MA unit is another possible mechanism for decreasing metals concentrations. Dilution of groundwater is quite unlike mixing and dilution of two surface waters because groundwater flow is laminar; groundwater flows in smooth lines. Dilution of groundwater is caused by hydrodynamic dispersion, which includes mechanical mixing (dispersion) and molecular diffusion (Freeze and Cherry, 1979). Dispersion occurs during groundwater advection as a result of the continual division of flow around sand grains or clasts. Molecular diffusion is important only at very slow groundwater velocities, which are not likely in the MA unit. Dispersion is probably the dominant mechanism by which the plume water is diluted into adjacent waters. Dispersion of groundwater is facilitated by the broadening or narrowing of flow paths as the water moves through materials with different hydraulic conductivities. Mixing and dilution in the sense of two flows intermingling completely, as with surface-water flows, does not occur in groundwater in the absence of large subterranean void spaces such as caverns or fractures, which do not exist in the MA unit.

Evidence for dilution of the MA unit plume includes the decreasing concentrations of the more conservative analytes (fig. 7), but decreasing COC concentration rates along the transect (fig. 6) are about 2 orders of magnitude greater than for the conservative analytes. Nordstrom (2011) evaluated dilution of an acid-mine plume migrating in an aquifer by plotting the weight ratios of various metal concentrations against the concentration of sulfate. If dilution is the primary cause for the decline in metal concentrations, the metal weight ratios will remain constant (form a flat line) relative to the concentrations of sulfate, which was the case for the groundwater Nordstrom evaluated. However, a similar evaluation of metal weight ratios plotted against sulfate for the MA waters along the SBC/MSD corridor did not plot along a flat line (fig. 8). In the region with the greatest metal declines (3,000 to 60 mg/L sulfate), there was a significant decline in the metal weight ratios as the sulfate concentrations approached zero. Although dilution is occurring, this analysis indicates that there is at least one other dominant mechanism causing metals concentrations in the MA aquifer to decrease between MSD-2B and AMC-24B.

Because carbonate precipitation, dilution by dispersion, and Fe oxide precipitation do not appear to account for the observed declines in metals concentrations, by process of elimination, sorption of metals onto the alluvial sediments appears to be the dominant attenuation mechanism in MA groundwater. The sorption process is consistent with the observed downgradient pH and divalent metal concentration trends along the SBC/MSD. Concentrations of Cd, Cu, Fe, Mn, and Zn (fig. 10) decrease by up to 4 orders of magnitude within the plume, while conservative analytes (fig. 7) decrease by only 2 orders of magnitude across the same distance. The decrease in divalent metals concentrations is concurrent with the increase observed in pH along the transect. The increase in pH most likely results from weathering of carbonate minerals or granitic sediments within the aquifer. Under low pH conditions, sorption sites will be dominated by protons (H^+), and as the pH increases, divalent metals will begin to out-compete the protons for adsorption sites (Langmuir, 1997). Above pH 5, divalent metals readily adsorb on to many solids including iron oxides, organic material, clays, and silicate minerals that may exist within the MA aquifer (Langmuir, 1997). Iron oxides and organic material typically have higher adsorption site densities and bind metals more strongly than do clay and silicate minerals (McBride, 1994). Copper has a particularly strong affinity for organic matter. However, alluvial sediments below the original soil horizon typically contain little organic matter (Meinzer, 1914). Due to the limited amount of organic matter in the MA unit, much of the metal sorption likely occurs on the iron oxides coating the clasts (fig. 3B), clay minerals, and silicate minerals. The sorption of COCs onto alluvial sediments is not an infinite attenuation mechanism because there are a finite number of sorption sites. In time, continual metals loading to the MA unit is likely to overwhelm this attenuation mechanism.

The decreasing metals concentrations in water from wells AMC-06, AMC-12, and GS-44D located south of the Parrot Tailings area (plate I) appear to be a response to cessation of aquifer loading in 1982 from mine operation discharges. This concentration decrease is consistent with an adsorption attenuation mechanism in the MA unit because adsorption is a reversible thermodynamic process. Adsorption is generally a fast reaction; desorption of divalent cations is thought to take longer than adsorption (McBride, 1994). For example, during a Cu adsorption/desorption batch reaction experiment conducted at pH 5.5 using Fe-oxide/kaolinite (Al silicate) and Fe-oxide/gibbsite (Al hydroxide) soils, over 80 percent of the observed Cu adsorption occurred within 24 hours (Guilherme and Anderson, 1998). Within 450 hours, approximately 10 to 20 percent of the adsorbed Cu desorbed, and the trends indicated that Cu desorption would have continued with time (Guilherme and Anderson, 1998). The rate of copper desorption was most rapid immediately after the initiation of the desorption experiment and rate of desorption decreased over time with concentrations gradually increasing. The Guilherme and Anderson experiment is of significance here because the batch reaction conditions were very similar to the conditions in the MA unit south of the Parrot.

The environment within an aquifer is not directly comparable to a batch reaction experiment, where metal-laden fluid can be replaced with a metal-free solution. In an aquifer that is flushed with clean water, the concentrations would be expected to gradually decrease with time similar to the Guilherme and Anderson experiment. That may be occurring in the MA wells south of the Parrot, but decreasing concentrations could also come from the flushing of the MA unit with relatively clean groundwater after mine-water discharges ended. At GS-44D, using an approximate hydrologic gradient of 0.003 ft/ft (fig. 2; assuming similar SA and MA gradients), hydraulic conductivity values of 120–640 ft/day (Tucci and Icopini, 2010), and a porosity of 30 percent (EPA, 2004) for the MA unit, Darcy's Law (Fetter, 1980) can be used to calculate a linear groundwater velocity between 448 and 2,390 ft per year through this area. If a conservative assumption is made that uncontaminated water must travel at least 3,000 ft (approximate distance between GS-44D and BMF-05-03), it would take 1.3 to 6.7 years for uncontaminated water to reach GS-44D. This implies that the area around GS-44D has been flushed with clean water for 21 to 27 years. It should be noted that this is a conservative estimate due to the high porosity value used, and a more realistic (lower) porosity value would yield faster linear velocities.

Non-adsorbing solutes in porous-media column experiments typically reach effluent concentrations consistent with influent concentrations within 2 pore volumes of flushing (e.g., Matocha and Hossner, 1999). Although dispersion and diffusion will retard movement of dissolved constituents relative to the groundwater velocity, it is unlikely that much of the original dissolved metals would have been retained within the aquifer after being flushed with clean water for more than a few years. Continued decreasing trends in metals concentrations (AMC-06, AMC-12, GS-44D,plate I) indicate desorption is also occurring within an aquifer where a metals loading source has been removed. The rate of decreasing concentrations (plate I: Cu, Zn) in wells contaminated by the SBC plume suggest that this desorption process is much faster than previously assumed (centuries; EPA, 2006a). The trends indicate that cessation of loading to the aquifer in other areas would likely result in similar decreases in metals concentrations.

5.0 CONCLUSIONS

- There is a source of copper (Cu) and zinc (Zn) loading to Blacktail Creek in its reach between Oregon Avenue and George Street. Currently, data are insufficient to determine the source for the Cu and Zn observed in this reach of the creek.
- Multiple source areas appear to be loading the shallow alluvial (SA) unit in the SBC/MSD corridor. These sources can be traced to the Parrot, Diggings East, and Northside Tailings. These sites are known to contain mining-related waste that has been left in place. Concentrations of contaminants in SA plumes originating from these sources decrease substantially downgradient of their source areas, which may be an indication that the MSD Subdrain is effectively capturing the SA plumes. However, determining the overall effectiveness of the MSD Subdrain collection system was beyond the scope of this investigation.

- The middle alluvial (MA) unit hosts a plume that contains the highest concentrations of contaminants measured in the study area; this plume is the farthest-reaching and most expansive in the SBC/MSD area. The Parrot Tailings appears to be the primary source for arsenic (As), cadmium (Cd), copper (Cu), and zinc (Zn) in the plume. The MA plume can be traced from the Parrot Tailings area to Kaw Avenue (AMC-24), which more than doubles the previously documented extent of the Parrot plume (MSD-02B; Metesh and Madison, 2004).
- The maximum downgradient extent of the Parrot Plume beyond AMC-24 (MA unit) remains undefined but is likely controlled by three possible scenarios, or combinations thereof:
    4) The plume's contaminants naturally attenuate within the aquifer;
    5) The MSD Subdrain effectively captures the plume west of Kaw Avenue; or
    6) The plume is, or will be, discharging to Blacktail Creek or Silver Bow Creek.
- Within the MA unit, sorption of metals onto alluvial sediments and, to a lesser extent, dilution appear to be the attenuation mechanisms responsible for reducing contaminants of concern (COCs; Cu, Zn, As, and Cd) as the water moves downgradient. Sorption of COCs onto existing alluvial sediments is a finite attenuation mechanism, as dissolved COCs will be progressively less attenuated as the available sorption sites on alluvial sediments are exhausted. Although dilution reduces COC concentrations, COCs are only dispersed and not removed from solution.
- Green rust precipitation appears to be the most likely mechanism for the attenuation of iron (Fe) observed in the MA unit between wells MSD-01B and GS-09.
- In some SA and MA unit wells near the Diggings East and Parrot Tailings areas, the COC concentrations have increased markedly since 2003.
- The MA unit south and upgradient of the Parrot Tailings area appears to have been contaminated from historic discharges of contaminated mine water to Silver Bow Creek that ended in 1982. Since 1983, aqueous metals concentrations have steadily declined in this area, which is the expected concentration trend for metal desorption and dilution of a contaminated aquifer continually flushed with relatively clean groundwater. However, dilution alone is not sufficient to explain the concentration trends. The rates of decreasing metals concentrations suggest a flushing/desorption process that is much faster than previously assumed (EPA, 2006b).
- Some COCs (Cd, Cu, and Zn) have penetrated to the deep alluvial (DA) unit, and water samples show concentrations above background levels. However, concentrations are 1 to 2 orders of magnitude lower than in the MA unit. The source area for the COCs in the DA unit is most likely the Parrot Tailings. Elevated metals in the DA unit are present as far downgradient as well GS-08.

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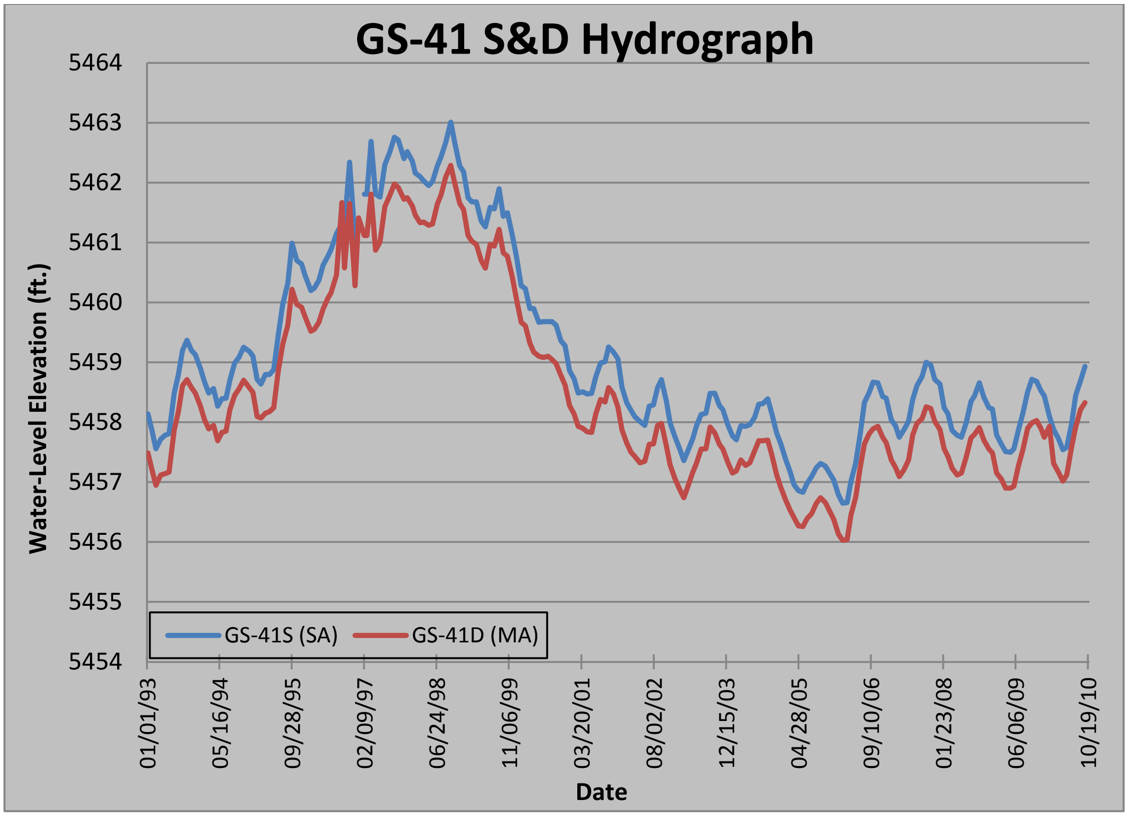
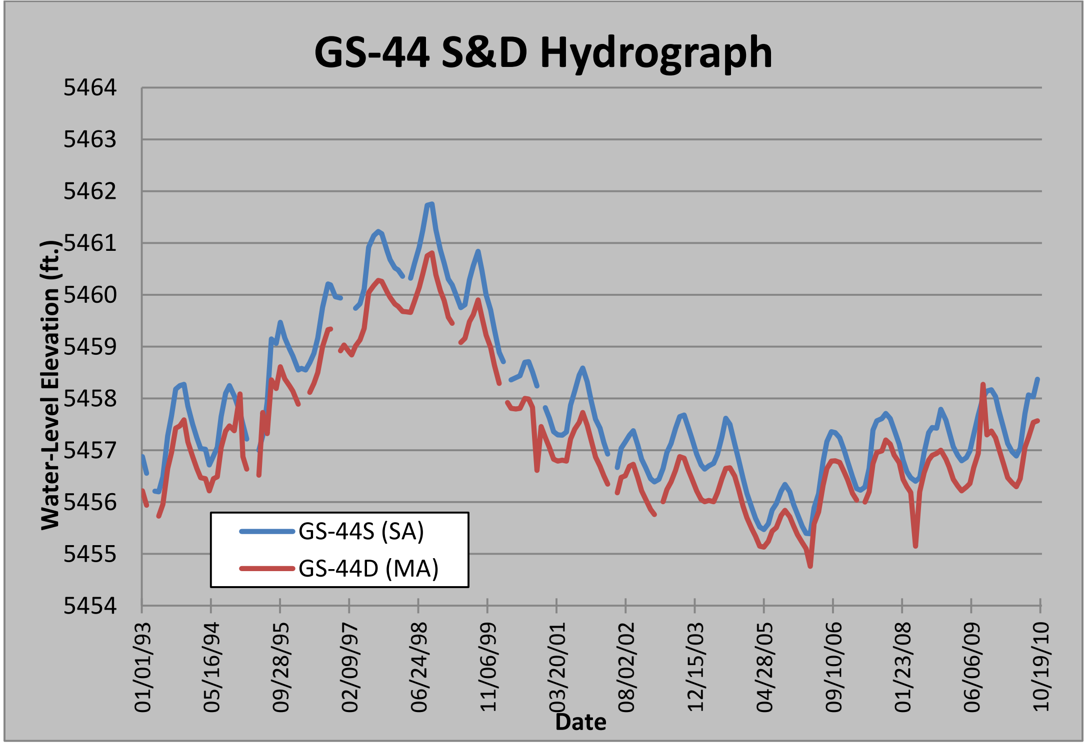
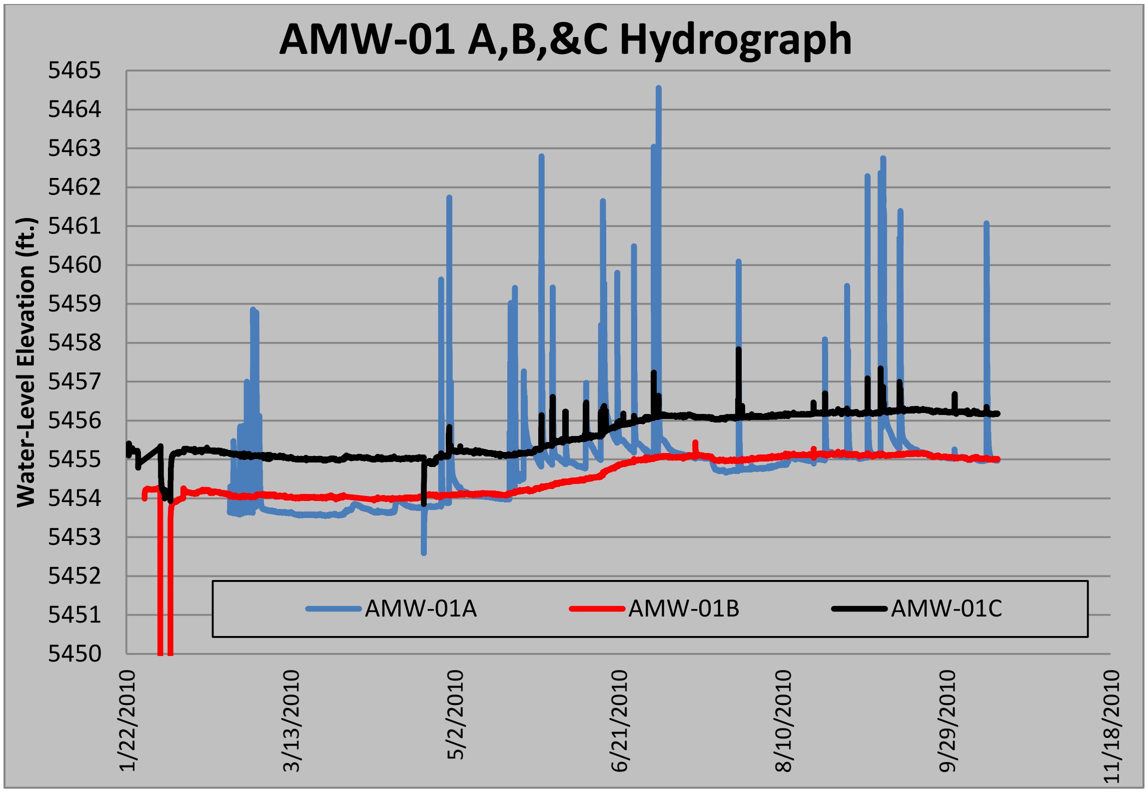
APPENDIX A GROUNDWATER HYDROGRAPHS

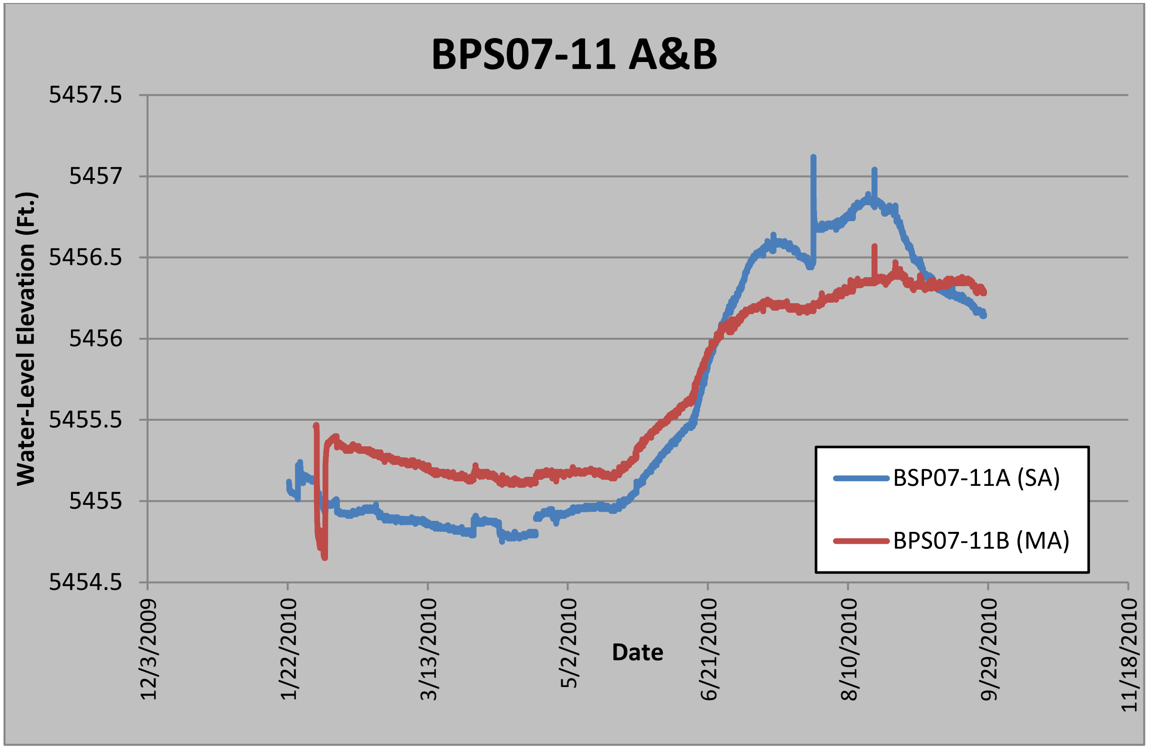


A.1. Long term water-level trends in SA/MA nested alluvial wells located in the Parrot Tailings area.

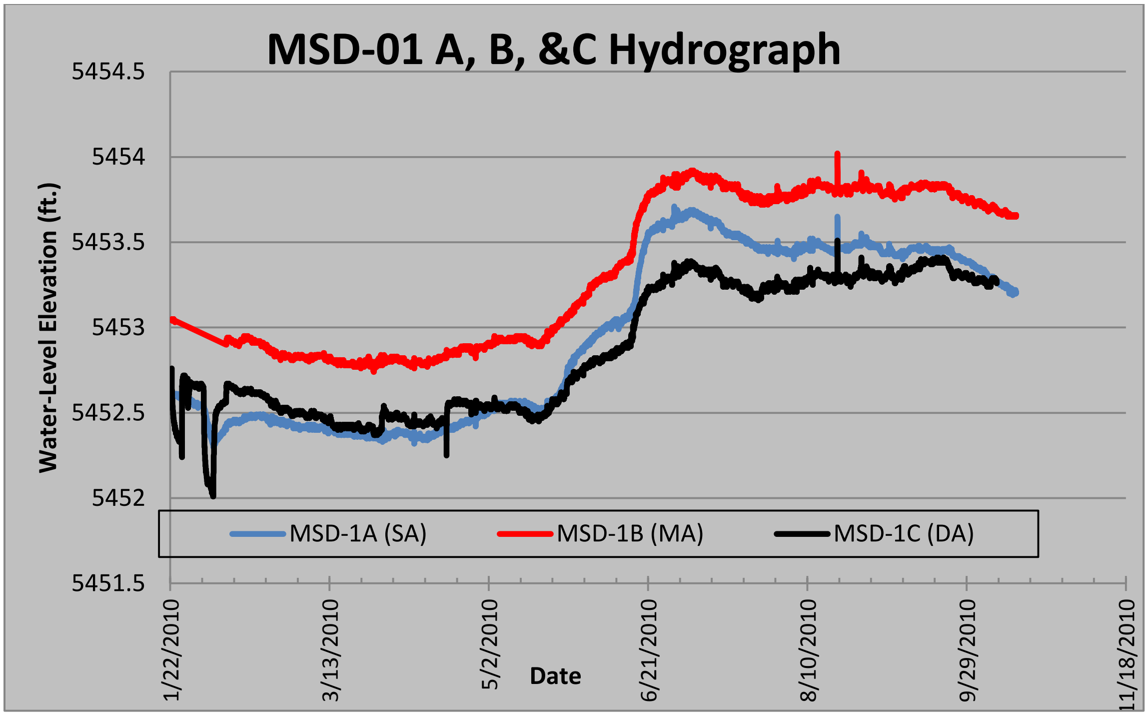


A.2. Long term water-level trends in SA/MA nested alluvial wells located to the southeast of the Parrot Tailings area.

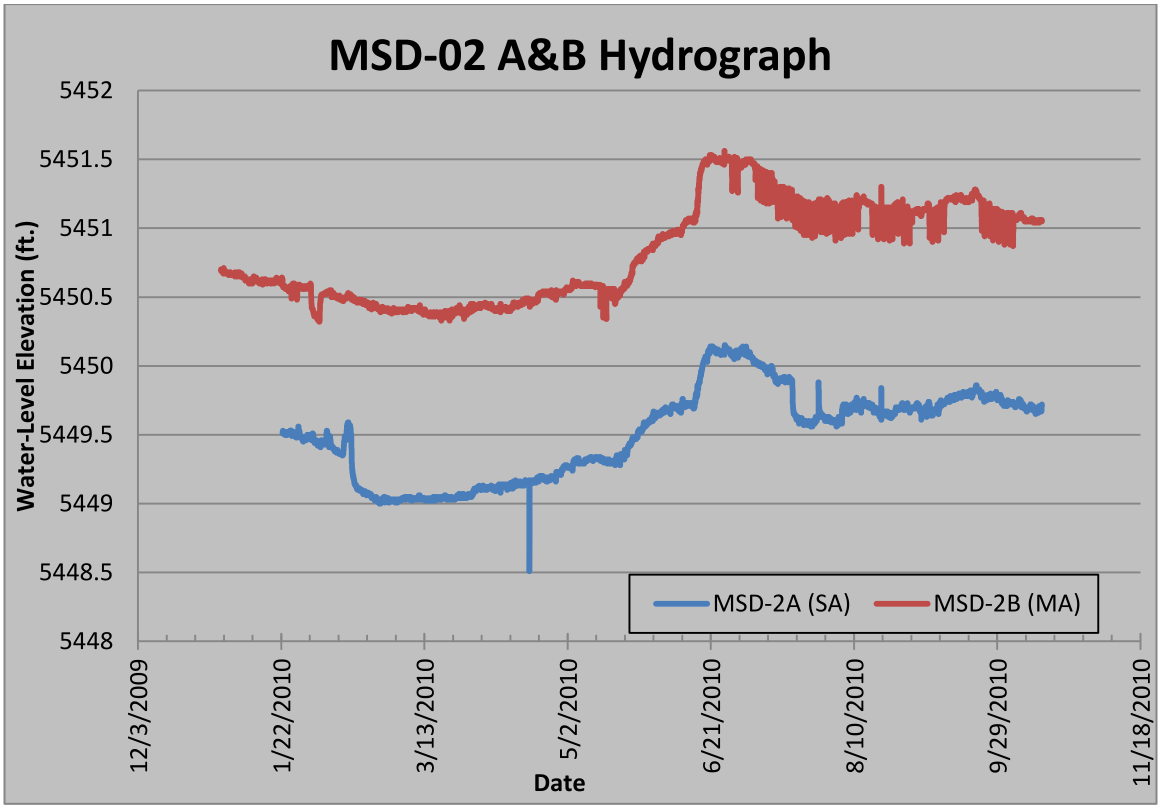




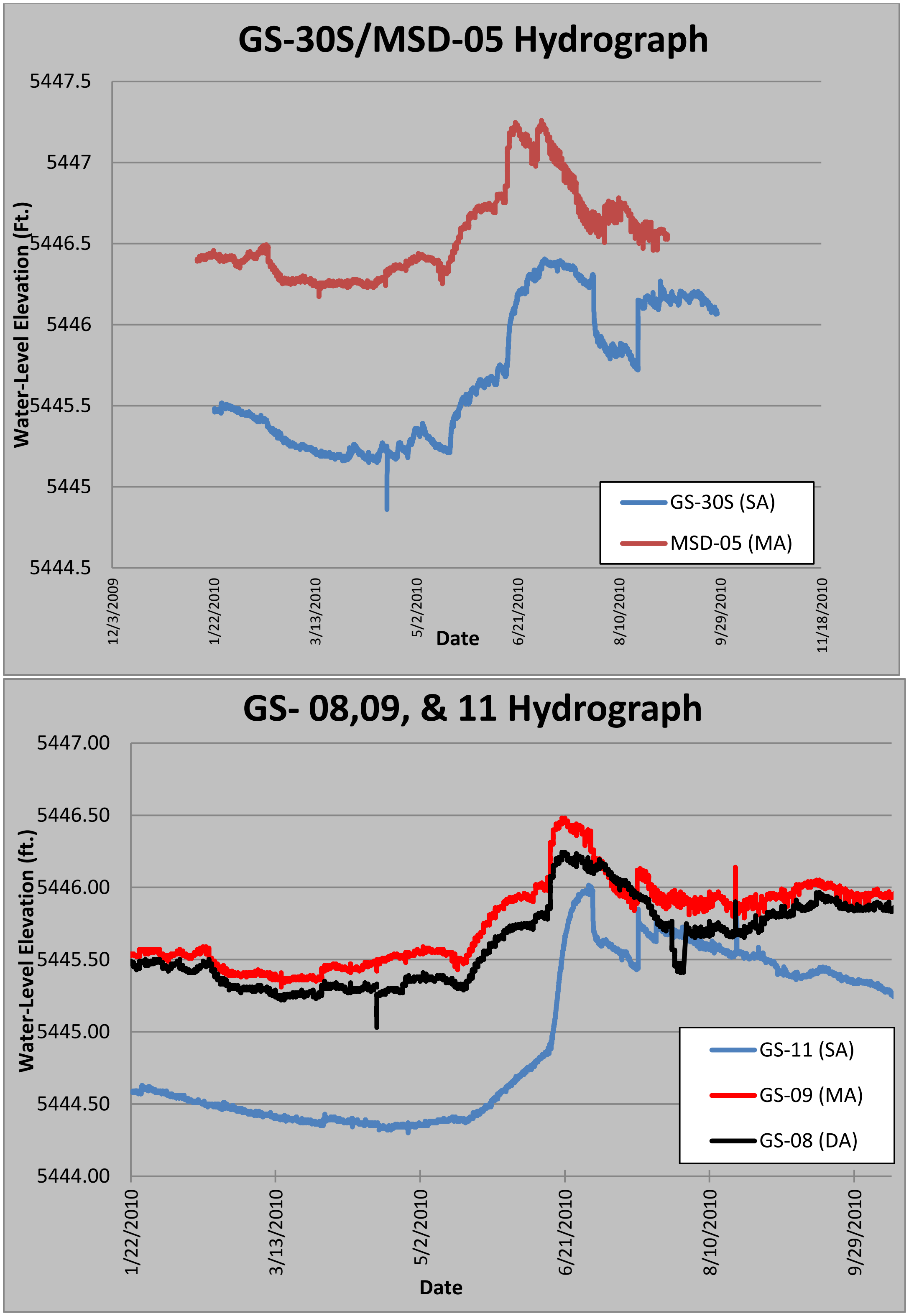
A.3. Short term water-level trends in SA/MA nested alluvial wells located to the southwest of the Parrot Tailings area.



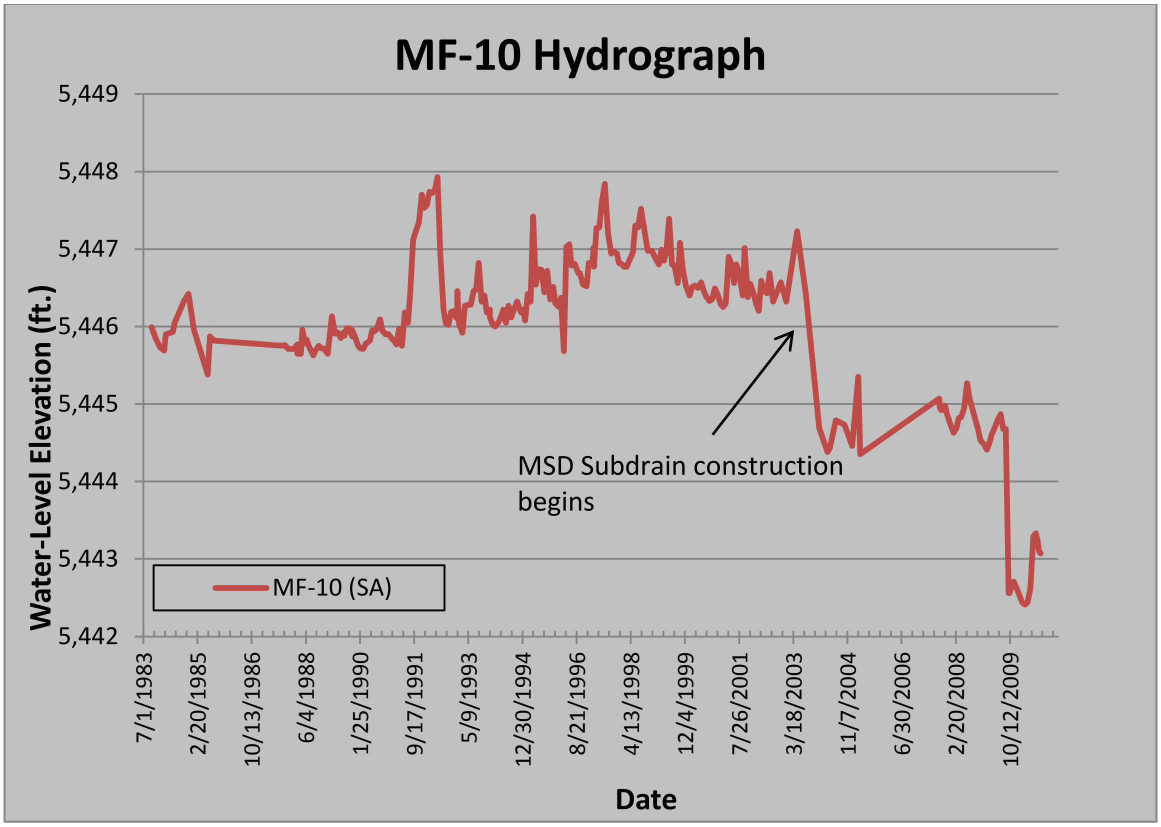
A.4. Short term water-level trends in nested (SA/MA/DA) groundwater wells located downgradient of the Parrot Tailings.



A.5. Short term water-level trends in a nested SA/MA alluvial pair in the Northside Tailings area



A.6.Water-level trends in nested SA/MA/DA alluvial wells located in the Diggings East area



A.7. Long term water-level trends in the SA in the Diggings East area showing impacts to the SA by the subdrain.

APPENDIX B SURFACE-WATER QUALITY

Montana Bureau of Mines and Geology
Butte Priority Soils Surface-Water-Quality Data

		PHYSICAL AND CALIBRATED PARAMETERS																
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS									
													PERCENT MEQ/L					
	DATE (MM/DD/YR)	TIME (HRS)	SWL (FT)	FLOW (cfs)	pH	SC (UMHOS)	TEMP (C)	REDOX (mv)	pH	SC (UMHOS)	HARDNESS (MG/L)	ALKALINITY (MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4
Blacktail Cr @ Harrison Ave **M#:226754**																		
	06/26/06	13:10		9.79	7.12	215	18.7	362	7.22	250	103	86	57.6	22.9	16.1	71.7	0.0	19.7
	05/04/07	15:00		13.20	6.99	130	8.3	205	7.16	210	87	67	54.2	21.9	18.6	63.6	0.0	22.6
	05/20/08	10:50			6.84	195	12.2	307	7.18	220	88	80	56.8	22.6	16.5	72.1	0.0	15.8
Fingerprint	04/12/10	9:25		8.39	7.00	256	4.43	364	7.63	254	104	88	57.69	21.37	17.74	62.10	0.00	22.05
Mean					6.99	199	10.9	310	7.30	234	96	80	56.6	22.2	17.2	67.4	0.0	20.1
Max					7.12	256	18.7	364	7.63	254	104	88	57.7	22.9	18.6	72.1	0.0	22.6
Min					6.84	130	4.4	205	7.16	210	87	67	54.2	21.4	16.1	62.1	0.0	15.8
Blacktail Cr @ Oregon Ave **M#:191287**																		
	06/26/06	15:20		10.95	7.02	220	21.9	392	7.68	255	112	91	57.6	22.9	16.5	68.4	0.0	20.0
	05/04/07	14:30		17.10	7.15	130	9.4	224	7.19	225	93	70	54.4	22.0	19.3	62.5	0.0	22.4
	05/20/08	11:50			7.02	210	12.9	270	7.21	215	94	85	56.5	22.6	16.9	70.6	0.0	16.3
Fingerprint	04/12/10	10:20		8.39	7.36	269	5.23	345	7.40	270	111	94	58.26	21.37	17.35	61.86	0.00	21.68
Mean					7.14	207	12.4	308	7.37	241	102	85	56.7	22.2	17.5	65.8	0.0	20.1
Max					7.36	269	21.9	392	7.68	270	112	94	58.3	22.9	19.3	70.6	0.0	22.4
Min					7.02	130	5.2	224	7.19	215	93	70	54.4	21.4	16.5	61.9	0.0	16.3
Blacktail Creek USGS SS-04		**M# 127593**																
	08/30/00	13:30																
	11/08/01	15:30			7.44	387	8.2	232	7.48	375	150	116	56.4	23.4	17.5	60.2	0.0	29.9
	12/06/05	10:10			7.69	326			7.59	339	134	108	56.1	23.1	18.1	64.7	0.0	22.8
	05/22/06	16:40		17.00	6.51	257	15.0	394	6.91	284	113	95	57.3	21.5	16.7	67.3	0.0	21.7
	06/26/06	16:40		10.65	8.03	240	20.9	374	8.12	285	117	96	56.5	22.8	17.6	67.0	0.0	21.5
	05/04/07	12:45		10.10	7.17	130	8.4	154	7.16	255	104	82	53.4	22.3	20.1	63.1	0.0	22.2
	05/20/08	13:10			7.56	220	14.8	259	7.76	375	102	92	56.5	22.4	17.4	69.6	0.0	17.3
Fingerprint	04/12/10	12:36		13.65	7.82	282	6.81	336	7.76	296	115	94	57.47	21.08	18.47	60.50	0.00	23.17
Mean					7.46	263	12.4	292	7.54	316	119	98	56.2	22.4	18.0	64.6	0.0	22.7
Max					8.03	387	20.9	394	8.12	375	150	116	57.5	23.4	20.1	69.6	0.0	29.9
Min					6.51	130	6.8	154	6.91	255	102	82	53.4	21.1	16.7	60.2	0.0	17.3

Montana Bureau of Mines and Geology
Butte Priority Soils Surface-Water-Quality Data

			MAJOR CATIONS AND ANIONS																		NON-METALS					
			CATIONS												ANIONS						Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot. Organic	Diss. Organic
	DATE	TIME	Ca	Ca, TR	Mg	Mg, TR	Na	Na, TR	K	K, TR	Fe	Fe, TR	Mn	Mn, TR	HCO_3	CO_3	Cl	SO_4	F	SiO_2	NO_3-N	PO_4		Carbon	Carbon
	(MM/DD/YR)	(HRS)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Blacktail Cr @ Harrison Ave M#:226754																									
	06/26/06	13:10	29.6		7.1		9.5		2.3		0.415		0.038		104.7	0.0	6.8	22.6	<0.05	23.3	<0.05				
	05/04/07	15:00	24.8	25.0	6.1	5.8	10.4	10.6	3.0	2.8	0.216	0.720	0.036	0.052	81.5	0.0	9.0	22.8	0.24	23.9	0.30				
	05/20/08	10:50	25.3		6.1		8.4		2.7		0.285		0.034		96.6	0.0	7.9	16.7	0.29	15.4	0.38				
Fingerprint	04/12/10	9:25	30.3	31.7	6.8	7.9	10.7	11.1	2.6	2.80	0.18	0.500	0.05	0.067	107.4	0.0	13.1	30.0	0.22	21.6	0.97	<0.05	0.041	2.47	<0.25
Mean			27.5		6.5		9.8		2.6		0.274		0.040		97.6	0.0	9.2	23.0	0.25	21.1	0.55				
Max			30.3		7.1		10.7		3.0		0.415		0.050		107.4	0.0	13.1	30.0	0.29	23.9	0.97				
Min			24.8		6.1		8.4		2.3		0.181		0.034		81.5	0.0	6.8	16.7	0.22	15.4	0.30				
Blacktail Cr @ Oregon Ave M#:191287																									
	06/26/06	15:20	32.0		7.7		10.5		2.6		0.182		0.032		111.0	0.0	8.8	25.5	0.24	23.0	0.65				
	05/04/07	14:30	26.5	25.9	6.5	6.3	10.8	10.3	3.1	3.0	0.266	0.611	0.035	0.044	85.4	0.0	10.2	24.1	0.25	24.2	0.52				
	05/20/08	11:50	27.0		6.5		9.3		2.9		0.267		0.040		104.4	0.0	9.3	19.0	0.24	16.1	0.60				
Fingerprint	04/12/10	10:20	32.5	33.8	7.2	8.4	11.1	11.8	2.8	2.97	0.10	0.384	0.05	0.056	114.9	0.0	14.5	31.7	0.23	21.6	1.13	<0.05	0.038	3.45	<0.25
Mean			29.5		7.0		10.4		2.8		0.205		0.039		103.9	0.0	10.7	25.1	0.24	21.2	0.72				
Max			32.5		7.7		11.1		3.1		0.267		0.048		114.9	0.0	14.5	31.7	0.25	24.2	1.13				
Min			26.5		6.5		9.3		2.6		0.104		0.032		85.4	0.0	8.8	19.0	0.23	16.1	0.52				
Blacktail Creek USGS SS-04		**M# 12759**																							
	08/30/00	13:30									0.018		0.086					44.8							
	11/08/01	15:30	42.6	38.1	10.7	9.9	15.2	17.8	3.3	3.52	0.071	0.532	0.114	0.09	141.5	0.0	13.1	55.3	0.28	28.4	1.47				
	12/06/05	10:10	38.1		9.5		14.1		3.1		0.035		0.085		132.0	0.0	12.4	37.4	0.30	28.4	1.55				
	05/22/06	16:40	33.0		7.5		11.0		3.1		0.394		0.383		116.3	0.0	9.3	29.5	0.25	24.0	0.51				
	06/26/06	16:40	33.3		8.2		11.9		2.8		0.250		0.043		117.4	0.0	9.8	29.6	0.29	22.2	0.54				
	05/04/07	12:45	29.4	28.9	7.4	7.9	12.7	11.4	3.6	3.2	0.276	0.62	0.064	0.073	99.6	0.0	11.6	27.6	0.29	24.5	0.49				
	05/20/08	13:10	29.2		7.0		10.3		3.0		0.243		0.050		111.8	0.0	10.1	21.9	0.29	15.7	0.54				
Fingerprint	04/12/10	12:36	33.6	35.0	7.5	8.7	12.4	13.0	2.9	3.12	0.08	0.472	0.06	0.069	114.2	0.0	14.9	34.4	0.26	21.2	1.02	<0.05	0.03	2.27	<0.25
Mean			34.2		8.3		12.5		3.1		0.171		0.110		119.0	0.0	11.6	35.1	0.28	23.5	0.88				
Max			42.6		10.7		15.2		3.6		0.394		0.383		141.5	0.0	14.9	55.3	0.30	28.4	1.55				
Min			29.2		7.0		10.3		2.8		0.018		0.043		99.6	0.0	9.3	21.9	0.25	15.7	0.49				

Montana Bureau of Mines and Geology
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			MINOR AND TRACEMETALS																		
			Aluminum		Silver		Arsenic		Boron		Barium		Beryllium		Bromine	Cadmium		Cerium		Cobolt	
	DATE	TIME	Al	Al, TR	Ag	Ag, TR	As	As, TR	B	B, TR	Ba	Ba, TR	Be	Be, TR	Br	Cd	Cd, TR	Ce	Ce, TR	Co	Co, TR
	(MM/DD/YR)	(HRS)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Blacktail Cr @ Harrison Ave																					
M#:226754																					
	06/26/06	13:10	<10		<1		8.15		<30		34.3		<2			<1				<2	
	05/04/07	15:00	6.5		<0.5	<0.5	4.42	5.01	8.5		28.9	31.8	<0.1	<0.1		0.13	0.16			0.13	0.18
	05/20/08	10:50	2.3		<0.5		6.26		8.5		21.7		<0.1			<0.1				0.56	
Fingerprint	04/12/10	9:25	2.50		<0.1	0.944	2.57	3.52	12.40		41.70	48.3	<0.15	<0.5	64	<0.1	<0.5	<0.1	<0.5	1.06	<0.5
Mean			3.8		#DIV/0!		5.35		9.8		31.7		#DIV/0!			0.13				0.58	
Max			6.5		0.0		8.15		12.4		41.7		0.0			0.13				1.06	
Min			2.3		0.0		2.57		8.5		21.7		0.0			0.13				0.13	
Blacktail Cr @ Oregon Ave																					
M#:191287																					
	06/26/06	15:20	<10		<1		6.52		<30		35.4		<2			<1				<2	
	05/04/07	14:30	8.7		<0.5	<0.5	4.38	4.86	10.0		31.5	34.9	<0.1	<0.1		<0.1	0.23			0.80	0.18
	05/20/08	11:50	3.5		<0.5		5.96		9.9		25.0		<0.1			<0.1				0.68	
Fingerprint	04/12/10	10:20	<1.08		<0.1	<0.5	2.44	3.24	13.20		42.40	47.7	<0.15	<0.5	66	<0.1	<0.5	<0.1	<0.5	0.78	<0.5
Mean			6.1		#DIV/0!		4.83		11.0		33.6		#DIV/0!			#####				0.75	
Max			8.7		0.0		6.52		13.2		42.4		0.0			0.00				0.80	
Min			3.5		0.0		2.44		9.9		25.0		0.0			0.00				0.68	
Blacktail Creek		**M# 12759**																			
USGS SS-04																					
	08/30/00	13:30	<30				10.90									<2					
	11/08/01	15:30	<30	222	<1	<1	4.72	3.91	<30		59.9	61.3	<2	<2		<2	<1			<2	<2
	12/06/05	10:10	<10		<1		2.77		<30		55.6		<2			<1				<2	
	05/22/06	16:40	19.3		<1		8.97		<30		35.7		<2			1.44				<2	
	06/26/06	16:40	<10		<1		8.87		<30		36.3		<2			<1				<2	
	05/04/07	12:45	6.08	2.76	<0.5	<0.5	5.93	39.7	13.10	12.6	32.3	33	<0.1	38.1		<0.1	37.6			1.05	37.9
	05/20/08	13:10	2.76		<0.5		6.59		12.60		23.1		<0.1			<0.1				0.43	
Fingerprint	04/12/10	12:36	<1.08		<0.1	<0.5	3.25	4.58	15.60		39.50	46.5	<0.15	<0.5	70	<0.1	<0.5	<0.1	<0.5	1.24	<0.5
Mean			9		#DIV/0!		6.50		13.77		40.3		#DIV/0!			1.44				0.91	
Max			19		0.0		10.90		15.60		59.9		0.0			1.44				1.24	
Min			2.8		0.0		2.77		12.60		23.1		0.0			1.44				0.43	

			MINOR AND TRACE METALS															
			Chromium		Cesium		Copper		Gallium		Mercury		Lanthanum		Lithium		Molybdenum	
	DATE	TIME	Cr	Cr, TR	Cs	Cs, TR	Cu	Cu, TR	Ga	Ga,TR	Hg	Hg, TR	La	La, TR	Li	Li, TR	Mo	Mo, TR
	(MM/DD/YR)	(HRS)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Blacktail Cr @ Harrison Ave																		
M#:226754																		
	06/26/06	13:10	<2				3.79				NA				7.1		<10	
	05/04/07	15:00	0.13	0.32			7.08	10.00			NA	NA			8.5	8.0	5.18	5.01
	05/20/08	10:50	<0.1				4.41				NA				6.7		3.61	
Fingerprint	04/12/10	9:25	0.11	0.682	<0.1	<0.5	1.60	3.5	<0.1	<0.5	NR		<0.1	<0.5	4.4	4.95	4.59	5.04
Mean			0.12				4.22				#DIV/0!				6.7		4.46	
Max			0.13				7.08				0.00				8.5		5.18	
Min			0.11				1.60				0.00				4.4		3.61	
Blacktail Cr @ Oregon Ave																		
M#:191287																		
	06/26/06	15:20	<2				10.20				NA				7.9		<10	
	05/04/07	14:30	0.19	0.43			6.42	10.40			NA	NA			8.6	8.1	5.59	5.64
	05/20/08	11:50	<0.1				5.53				NA				7.1		3.91	
Fingerprint	04/12/10	10:20	0.13	<0.5	<0.1	<0.5	1.73	3.47	<0.1	<0.5	NR		<0.1	<0.5	4.4	6.23	5.20	5.74
Mean			0.16				5.97				#DIV/0!				7.0		4.90	
Max			0.19				10.20				0.00				8.6		5.59	
Min			0.13				1.73				0.00				4.4		3.91	
Blacktail Creek		**M# 12759**																
USGS SS-04																		
	08/30/00	13:30	<2				2.41				<1							
	11/08/01	15:30	<2	<2			<2	9.18							9.9	18.2	<10	<10
	12/06/05	10:10	<2				<2								8.3		<10	
	05/22/06	16:40	<2				71.0								8.6		<10	
	06/26/06	16:40	<2				3.71				NA				8.6		<10	
	05/04/07	12:45	0.13	38.1			6.37	39.2			NA				9.4	8.5	5.98	39.2
	05/20/08	13:10	<0.1				3.7				NA				7.2		4.24	
Fingerprint	04/12/10	12:36	<0.1	0.535	<0.1	<0.5	3.42	7.00	<0.1	<0.5	NR		<0.1	<0.5	4.8	5.91	5.90	6.55
Mean			0.13				15.11				#DIV/0!				8.1		5.37	
Max			0.13				71.00				0.00				9.9		5.98	
Min			0.13				2.41				0.00				4.8		4.24	

			MINOR AND TRACE METALS													
			Niobium		Neodymium		Nickel		Lead		Palladium		Praseodymium		Rubidium	
	DATE (MM/DD/YR)	TIME (HRS)	Nb (ug/L)	Nb, TR (ug/L)	Nd (ug/L)	Nd, TR (ug/L)	Ni (ug/L)	Ni, TR (ug/L)	Pb (ug/L)	Pb, TR (ug/L)	Pd (ug/L)	Pd, TR (ug/L)	Pr (ug/L)	Pr, TR (ug/L)	Rb (ug/L)	Rb, TR (ug/L)
Blacktail Cr @ Harrison Ave																
M#:226754																
	06/26/06	13:10					<2		<2							
	05/04/07	15:00					0.86	0.73	0.74	1.24						
	05/20/08	10:50					0.30		<0.2							
Fingerprint	04/12/10	9:25	<0.1	<1.5	<0.1	<0.5	0.2		0.12	0.879	<0.1	<1.0	<0.1	<0.5	0.6	0.944
Mean							0.46		0.43							
Max							0.86		0.74							
Min							0.21		0.12							
Blacktail Cr @ Oregon Ave																
M#:191287																
	06/26/06	15:20					<2		<2							
	05/04/07	14:30					0.74	1.53	<0.2	0.98						
	05/20/08	11:50					0.73		<0.2							
Fingerprint	04/12/10	10:20	<0.1	<1.5	<0.46	<0.5	0.3		<0.1	0.747	0.10	<1.0	<0.1	<0.5	0.6	0.677
Mean							0.57		#DIV/0!							
Max							0.74		0.00							
Min							0.25		0.00							
Blacktail Creek		**M# 12759**														
USGS SS-04																
	08/30/00	13:30							<2							
	11/08/01	15:30					2.55	<2	<2	2.93						
	12/06/05	10:10					<2		<2							
	05/22/06	16:40					<2		<2							
	06/26/06	16:40					<2		<2							
	05/04/07	12:45					0.64	39.2	2.00	38.5						
	05/20/08	13:10					0.26		1.16							
Fingerprint	04/12/10	12:36	<0.1	<1.5	<0.46	<0.5	0.3		0.14	1.58	0.11	<1.0	<0.1	<0.5	0.5	0.858
Mean							0.93		1.10							
Max							2.55		2.00							
Min							0.26		0.14							

			MINOR AND TRACE METALS																	
			Selenium		Tin		Strontium		Thorium		Titanium		Thallium		Uranium		Tungsten		Zinc	
	DATE (MM/DD/YR)	TIME (HRS)	Se (ug/L)	Se, TR (ug/L)	Sn (ug/L)	Sn, TR (ug/L)	Sr (ug/L)	Sr, TR (ug/L)	Th (ug/L)	Th, TR (ug/L)	Ti (ug/L)	Ti, TR (ug/L)	Tl (ug/L)	Tl, TR (ug/L)	U (ug/L)	U, TR (ug/L)	W (ug/L)	W, TR (ug/L)	Zn (ug/L)	Zn, TR (ug/L)
Blacktail Cr @ Harrison Ave																				
M#:226754																				
	06/26/06	13:10	<1				214								2.88				3.6	
	05/04/07	15:00	<0.5	<0.5			182	180							1.59	1.52			5.2	23
	05/20/08	10:50	<0.5				191								1.26				12	
Fingerprint	04/12/10	9:25	<0.37	<1.0	<0.1		194	209	<0.39	<0.5	0.4	6.52	<0.1	<0.5	3.4		<0.3	<1.5	3.1	6.13
Mean			#DIV/0!				195								2.29				6.0	
Max			0.00				214								3.44				12.1	
Min			0.00				182								1.26				3.1	
Blacktail Cr @ Oregon Ave																				
M#:191287																				
	06/26/06	15:20	<1				230								3.59				19.3	
	05/04/07	14:30	<0.5	<0.5			195	192							2.10	1.97			6.2	23.9
	05/20/08	11:50	<0.5				200								1.58				13.6	
Fingerprint	04/12/10	10:20	<0.37	<1.0	<0.1		207	221	<0.39	<0.5	0.3	2.76	<0.1	<0.5	3.82		<0.3	<1.5	3.4	6.39
Mean			#DIV/0!				208								2.77				10.6	
Max			0.00				230								3.82				19.3	
Min			0.00				195								1.58				3.4	
Blacktail Creek		**M# 12759**																		
USGS SS-04																				
	08/30/00	13:30																	<2	
	11/08/01	15:30	<1	1.25			316	273							5.72	5.03			10	45
	12/06/05	10:10	1.88				267								5.03				16	
	05/22/06	16:40	<1				220								3.70				229	
	06/26/06	16:40	<1				244								3.99				3.2	
	05/04/07	12:45	<0.5	39.1			215	210							2.74	<0.05			11.0	38.8
	05/20/08	13:10	<0.5				215								2.07				3.7	
Fingerprint	04/12/10	12:36	<0.37	<1.0	<0.1		199	227	<0.39	<0.5	0.3	7.68	<0.1	<0.5	4.4		0.32	<1.5	8.0	14.2
Mean			1.88				239								3.94				40	
Max			1.88				316								5.72				229	
Min			1.88				199								2.07				3	

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	PHYSICAL AND CALIBRATED PARAMETERS																
	FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS									
DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L					
(MM/DD/YR)	(HRS)	(FT)	(cfs)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4
MSD @ Kaw Ave																	
M#:226756																	
06/26/06	11:20		0.25	5.79	185	18.3	343	6.89	210	95	69	65.0	22.3	9.8	66.3	0.0	26.5
05/04/07	11:05		0.20	7.37		6.6	-22.6	6.71	208	88	68	60.6	23.0	11.9	66.8	0.0	21.8
Mean				6.58	185	12.5	160	6.80	209	92	69	62.8	22.7	10.8	66.6	0.0	24.1
Max				7.37	185	18.3	343	6.89	210	95	69	65.0	23.0	11.9	66.8	0.0	26.5
Min				5.79	185	6.6	-23	6.71	208	88	68	60.6	22.3	9.8	66.3	0.0	21.8
MSD French Drain	**M# 216477**																
01/20/05	14:20			6.60	1,440	6.5	290	6.59	1,410	560	79	51.5	21.1	20.6	10.1	0.0	70.6
02/02/05	8:30			5.95	1,340	6.6		6.24	1,540	736	68	53.0	21.4	14.9	6.8	0.0	83.0
05/23/06	9:30			6.11	1,288	9.4	336	6.01	1,290	592	80	52.2	21.9	16.6	10.4	0.0	80.4
04/16/07	10:45			5.48	1,380	10.2	102	5.84	1,435	633	72	52.5	23.2	15.9	8.6	0.0	81.2
08/26/08	14:00			6.75	1,240	11.4	308	6.69	1,260	578	80	49.4	23.1	17.5	10.1	0.0	79.1
Mean				6.18	1,338	8.8	259	6.27	1,387	620	76	51.7	22.1	17.1	9.2	0.0	78.9
Max				6.75	1,440	11.4	336	6.69	1,540	736	80	53.0	23.2	20.6	10.4	0.0	83.0
Min				5.48	1,240	6.5	102	5.84	1,260	560	68	49.4	21.1	14.9	6.8	0.0	70.6

		MAJOR CATIONS AND ANIONS																	NON-METALS					
		CATIONS												ANIONS					Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot. Organic	Diss. Organic
DATE	TIME	Ca	Ca, TR	Mg	Mg, TR	Na	Na, TR	K	K, TR	Fe	Fe, TR	Mn	Mn, TR	HCO_3	CO_3	Cl	SO_4	F	SiO_2	NO_3-N	PO_4		Carbon	Carbon
(MM/DD/YR)	(HRS)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
MSD @ Kaw Ave **M#:226756**																								
06/26/06	11:20	28.4		5.9		4.9		1.4		0.018		0.199		84.1	0.0	4.3	26.4	0.50	10.4	<0.5				
05/04/07	11:05	25.5	24.8	5.9	5.7	5.7	5.7	1.7	1.7	0.472	1.060	0.009	0.091	83.0	0.0	7.2	21.3	0.44	10.1	0.08				
Mean		27.0		5.9		5.3		1.6		0.245		0.104		83.6	0.0	5.7	23.9	0.47	10.3	0.08				
Max		28.4		5.9		5.7		1.7		0.472		0.199		84.1	0.0	7.2	26.4	0.50	10.4	0.08				
Min		25.5		5.9		4.9		1.4		0.018		0.009		83.0	0.0	4.3	21.3	0.44	10.1	0.08				
MSD French Drain	**M# 216477**																							
01/20/05	14:20	159		39.5		73.1		8.1		7.3		5.5		96.9	0.0	104.0	533	<0.5	26.7	1.38				
02/02/05	8:30	210		51.5		67.9		10.3		18.4		11.2		82.4	0.0	68.6	794	<1	30.8	1.29				
05/23/06	9:30	167		42.4		60.8		9.3		11.0		9.2		97.3	0.0	45.4	590	<1	28.6	1.56				
04/16/07	10:45	176		47.1		61.0		9.9		8.3		10.7		87.8	0.0	55.3	656	0.95	30.1	1.47				
08/26/08	14:00	158		44.5		64.9		9.7		12.7		9.7		96.8	0.0	54.9	598	0.84	28.2	2.05				
Mean		174		45.0		65.5		9.5		11.5		9.2		92.2	0.0	65.6	634	0.90	28.9	1.55				
Max		210		51.5		73.1		10.3		18.4		11.2		97.3	0.0	104.0	794	0.95	30.8	2.05				
Min		158		39.5		60.8		8.1		7.3		5.5		82.4	0.0	45.4	533	0.84	26.7	1.29				

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			MINOR AND TRACEMETALS																		
			Aluminum		Silver		Arsenic		Boron		Barium		Beryllium		Bromine	Cadmium		Cerium		Cobolt	
	DATE	TIME	Al	Al, TR	Ag	Ag, TR	As	As, TR	B	B, TR	Ba	Ba, TR	Be	Be, TR	Br	Cd	Cd, TR	Ce	Ce, TR	Co	Co, TR
	(MM/DD/YR)	(HRS)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
MSD @ Kaw Ave **M#:226756**																					
	06/26/06	11:20	26.7		<1		<1		<30		23.7		<2			2.00				<2	
	05/04/07	11:05	48.8		<0.5	<0.5	2.13	3.16	11.50		23.1	23.9	<0.1	<0.1		1.95	2.02			2.10	0.65
Mean			38		#DIV/0!		2.13		11.50		23.4		#DIV/0!			1.98				2.10	
Max			49		0.0		2.13		11.50		23.7		0.0			2.00				2.10	
Min			26.7		0.0		2.13		11.50		23.1		0.0			1.95				2.10	
MSD French Drain	**M# 216477**																				
	01/20/05	14:20	309		<1		2.39		160		29.1		<2			22.10				16.50	
	02/02/05	8:30	113		<1		3.76		167		26.7		<2			36.70				35.80	
	05/23/06	9:30	117		<1		3.87		176		27.0		<2			37.80				32.60	
	04/16/07	10:45	<30		<1		2.34		159		26.8		<0.1			33.60				34.00	
	08/26/08	14:00	84.6		<0.36		3.62		284		22.2		0.78			36.40				39.40	
Mean			156		#DIV/0!		3.20		189		26.4		0.8			33.32				31.66	
Max			309		0.0		3.87		284		29.1		0.8			37.80				39.40	
Min			84.6		0.0		2.34		159		22.2		0.8			22.10				16.50	

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			MINOR AND TRACE METALS															
			Chromium		Cesium		Copper		Gallium		Mercury		Lanthanum		Lithium		Molybdenum	
	DATE	TIME	Cr	Cr, TR	Cs	Cs, TR	Cu	Cu, TR	Ga	Ga,TR	Hg	Hg, TR	La	La, TR	Li	Li, TR	Mo	Mo, TR
	(MM/DD/YR)	(HRS)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
MSD @ Kaw Ave **M#:226756**																		
	06/26/06	11:20	<2				44.60				NA				7.6		<10	
	05/04/07	11:05	0.15	0.24			132.10	230.00			NA				8.2	8.2	4.21	4.16
Mean			0.15				88.35				#DIV/0!				7.9		4.21	
Max			0.15				132.10				0.00				8.2		4.21	
Min			0.15				44.60				0.00				7.6		4.21	
MSD French Drain		**M# 216477**																
	01/20/05	14:20	<2				1,017				NA				150.0		<10	
	02/02/05	8:30	<2				2,615				NA				194.0		<10	
	05/23/06	9:30	<2				1,066				NA				160.0		<10	
	04/16/07	10:45	<0.1				954				NA				183.0		3.36	
	08/26/08	14:00	<0.34				1,631				NA				132.0		4.28	
Mean			#DIV/0!				1,457				#DIV/0!				163.8		3.82	
Max			0.00				2,615				0.00				194.0		4.28	
Min			0.00				954				0.00				132.0		3.36	

		MINOR AND TRACE METALS													
		Niobium		Neodymium		Nickel		Lead		Palladium		Praseodymium		Rubidium	
DATE	TIME	Nb	Nb, TR	Nd	Nd, TR	Ni	Ni, TR	Pb	Pb, TR	Pd	Pd, TR	Pr	Pr, TR	Rb	Rb, TR
(MM/DD/YR)	(HRS)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
MSD @ Kaw Ave															
M#:226756															
06/26/06	11:20					<2		<2							
05/04/07	11:05					2.27	2.14	0.38	1.42						
Mean						2.27		0.38							
Max						2.27		0.38							
Min						2.27		0.38							
MSD French Drain	**M# 216477**														
01/20/05	14:20					26.40		<2							
02/02/05	8:30					37.40		<2							
05/23/06	9:30					20.60		<2							
04/16/07	10:45					18.80		<0.2							
08/26/08	14:00					21.70		<2.81							
Mean						24.98		#DIV/0!							
Max						37.40		0.00							
Min						18.80		0.00							

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			MINOR AND TRACE METALS																		
			Selenium		Tin		Strontium		Thorium		Titanium		Thallium		Uranium		Tungsten		Zinc	
	DATE	TIME	Se	Se, TR	Sn	Sn, TR	Sr	Sr, TR	Th	Th, TR	Ti	Ti, TR	Tl	Tl, TR	U	U, TR	W	W, TR	Zn	Zn, TR
	(MM/DD/YR)	(HRS)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
MSD @ Kaw Ave M#:226756																				
	06/26/06	11:20	<1				97								1.40				291	
	05/04/07	11:05	<0.5	<0.5			90	91							1.03	1.05			370	410
																			21	
Mean			#DIV/0!				94								1.22				227	
Max			0.00				97								1.40				370	
Min			0.00				90								1.03				21	
MSD French Drain		**M# 216477**																		
	01/20/05	14:20	2.15				1,238								11.40				4,380	
	02/02/05	8:30	1.58				1,618								7.42				9,569	
	05/23/06	9:30	1.71				1,321								9.60				7,658	
	04/16/07	10:45	0.65				1,460								9.83				7,870	
	08/26/08	14:00	<1.9				1,370								11.10				8,171	
Mean			1.52				1401								9.87				7,530	
Max			2.15				1618								11.40				9,569	
Min			0.65				1238								7.42				4,380	

		PHYSICAL AND CALIBRATED PARAMETERS																
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS									
	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L					
	(MM/DD/YR)	(HRS)	(FT)	(cfs)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4
SBC Below Blacktail, MT St SS-05																		
M#127536																		
	05/08/07	8:55		7.80	7.23	195	8.1	8.3	7.18	250	102	82	54.4	22.4	19.4	62.4	0.0	23.0
	05/20/08	13:45			7.74	225	15.3	276	7.75	250	100	87	56.4	22.6	17.2	68.3	0.0	18.0
Fingerprint	04/12/10	13:15		13.85	8.21	284	8.86	333	7.93	292	113	95	57.38	21.16	18.52	60.76	0.00	23.05
Mean					7.73	235	10.7	206	7.62	264	105	88	56.0	22.0	18.4	63.8	0.0	21.3
Max					8.21	284	15.3	333	7.93	292	113	95	57.4	22.6	19.4	68.3	0.0	23.1
Min					7.23	195	8.1	8	7.18	250	100	82	54.4	21.2	17.2	60.8	0.0	18.0
SBC, SS-05A	04/12/10	15:25		12.65	8.50	292	11.26	304	8.13	291	117	96	56.97	20.90	19.21	59.36	0.00	23.48
M#249187																		
Fingerprint	04/12/10	16:33			8.61	292	11.41	307	8.12	300	119	97	57.19	20.68	19.14	59.53	0.00	23.54
SBC, SS-06G																		
M#249189																		
Fingerprint	04/19/10	10:35			7.71	282	5.98	320	7.31	301	111	71	53.70	22.45	19.73	47.63	0.00	35.89
SBC @USGS Temp gauge above SS-07																		
	05/07/07	1615		14.00	7.94	290	17.1	480	6.12	345	133	74	49.2	20.6	26.0	40.8	0.0	38.7
Fingerpring	04/19/10	11:00			7.16	375	8.45	331	7.12	586	108	89	46.85	19.39	28.59	51.84	0.00	18.29
Mean					7.55	333	12.8	406	6.62	466	120	81	48.0	20.0	27.3	46.3	0.0	28.5
Max					7.94	375	17.1	480	7.12	586	133	89	49.2	20.6	28.6	51.8	0.0	38.7
Min					7.16	290	8.5	331	6.12	345	108	74	46.9	19.4	26.0	40.8	0.0	18.3
SBC, SS-07B																		
	05/07/07	14:47		19.30	7.39	265	18.4	213	7.09	390	149	81	55.2	22.2	19.4	43.2	0.0	41.8
Mean					7.39	265	18.4	213	7.09	390	149	81	55.2	22.2	19.4	43.2	0.0	41.8
Max					7.39	265	18.4	213	7.09	390	149	81	55.2	22.2	19.4	43.2	0.0	41.8
Min					7.39	265	18.4	213	7.09	390	149	81	55.2	22.2	19.4	43.2	0.0	41.8
SBC, SS-08																		
M#196457																		
	05/07/07	11:13		21.50	7.34	285	12.0	-41.4	6.62	400	141	76	49.2	20.5	26.0	40.4	0.0	39.4
Mean					7.34	285	12.0	-41	6.62	400	141	76	49.2	20.5	26.0	40.4	0.0	39.4
Max					7.34	285	12.0	-41	6.62	400	141	76	49.2	20.5	26.0	40.4	0.0	39.4
Min					7.34	285	12.0	-41	6.62	400	141	76	49.2	20.5	26.0	40.4	0.0	39.4

Montana Bureau of Mines and Geology
Butte Priority Soils Surface-Water-Quality Data

			MAJOR CATIONS AND ANIONS																	NON-METALS					
			CATIONS												ANIONS					Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot. Organic	Diss. Organic
	DATE	TIME	Ca	Ca, TR	Mg	Mg, TR	Na	Na, TR	K	K, TR	Fe	Fe, TR	Mn	Mn, TR	HCO_3	CO_3	Cl	SO_4	F	SiO_2	NO_3-N	PO_4		Carbon	Carbon
	(MM/DD/YR)	(HRS)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
SBC Below Blacktail, MT St SS-05																									
M#127536																									
	05/08/07	8:55	28.8	29.7	7.2	7.1	11.8	11.0	3.1	3.3	0.179	0.5	0.081	0.1	99.8	0.0	11.2	28.9	0.28	24.0	0.73				
	05/20/08	13:45	28.5		6.9		10.0		2.9		0.245		0.048		105.7	0.0	10.2	21.9	0.34	15.4	0.53				
Fingerprint	04/12/10	13:15	33.2	34.1	7.4	8.5	12.3	12.9	2.9	3.04	0.08	0.357	0.05	0.058	116.1	0.0	15.0	34.7	0.27	20.9	0.97	<0.05	0.04	2.62	<0.25
Mean			30.2		7.2		11.4		3.0		0.167		0.059		107.2	0.0	12.1	28.5	0.29	20.1	0.74				
Max			33.2		7.4		12.3		3.1		0.245		0.081		116.1	0.0	15.0	34.7	0.34	24.0	0.97				
Min			28.5		6.9		10.0		2.9		0.077		0.048		99.8	0.0	10.2	21.9	0.27	15.4	0.53				
SBC, SS-05A	04/12/10	15:25	34.4	35.3	7.7	8.8	13.3	13.8	3.0	3.21	0.04	0.446	0.07	0.080	117.4	0.0	16.8	36.6	0.29	20.6	0.92	<0.05	0.034	2.39	<0.25
M#249187																									
Fingerprint	04/12/10	16:33	34.9	34.6	7.7	8.6	13.4	13.4	3.0	3.15	0.09	0.512	0.08	0.106	117.6	0.0	16.6	36.6	0.28	20.6	0.89	<0.05	0.03	2.54	<0.25
SBC, SS-06G																									
M#249189																									
Fingerprint	04/19/10	10:35	31.3	29.0	7.9	7.2	13.2	11.7	3.6	3.40	0.38	0.745	0.08	0.101	86.9	0.0	15.4	51.5	0.27	17.7	0.63	<0.05	<0.03	2.81	<0.25
SBC @USGS Temp gauge above SS-07																									
	05/07/07	1615	37.5	38.3	9.5	9.4	22.7	217.0	5.3	5.0	0.121	0.4	0.100	0.1	90.0	0.0	23.4	67.1	0.32	23.5	0.73				
Fingerpring	04/19/10	11:00	30.7	32.1	7.7	8.1	21.5	19.2	5.4	5.05	0.30	0.643	0.08	0.100	109.3	0.0	22.4	46.8	0.29	18.7	0.46	0.24	<0.03	5.57	1.47
Mean			34.1		8.6		22.1		5.3		0.209		0.090		99.7	0.0	22.9	57.0	0.31	21.1	0.60				
Max			37.5		9.5		22.7		5.4		0.296		0.100		109.3	0.0	23.4	67.1	0.32	23.5	0.73				
Min			30.7		7.7		21.5		5.3		0.121		0.080		90.0	0.0	22.4	46.8	0.29	18.7	0.46				
SBC, SS-07B																									
	05/07/07	14:47	42.6	43	10.4	10.7	17.2	17.5	3.9	3.4	0.135	0.387	0.082	0.09	99.3	0.0	17.1	75.6	0.33	23.3	0.92				
Mean			42.6		10.4		17.2		3.9		0.135		0.082		99.3	0.0	17.1	75.6	0.33	23.3	0.92				
Max			42.6		10.4		17.2		3.9		0.135		0.082		99.3	0.0	17.1	75.6	0.33	23.3	0.92				
Min			42.6		10.4		17.2		3.9		0.135		0.082		99.3	0.0	17.1	75.6	0.33	23.3	0.92				
SBC, SS-08																									
M#196457																									
	05/07/07	11:13	40.0	39.9	10.1	9.6	24.3	22.5	5.7	5.7	0.135	0.4	0.173	0.2	93.0	0.0	23.0	74.4	0.34	23.6	1.21				
Mean			40.0		10.1		24.3		5.7		0.135		0.173		93.0	0.0	23.0	74.4	0.34	23.6	1.21				
Max			40.0		10.1		24.3		5.7		0.135		0.173		93.0	0.0	23.0	74.4	0.34	23.6	1.21				
Min			40.0		10.1		24.3		5.7		0.135		0.173		93.0	0.0	23.0	74.4	0.34	23.6	1.21				

			MINOR AND TRACEMETALS																	
			Aluminum			Silver	Arsenic			Boron		Barium		Beryllium	Bromine		Cadmium	Cerium		Cobolt
	DATE	TIME	Al	Al, TR	Ag	Ag, TR	As	As, TR	B	B, TR	Ba	Ba, TR	Be	Be, TR	Br	Cd	Cd, TR	Ce	Ce, TR	Co	Co, TR
	(MM/DD/YR)	(HRS)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
SBC Below Blacktail, MT St SS-05 **M#127536**																					
	05/08/07	8:55	3		<0.5	<0.5	5.02	5.26	15.60		36.6	38.6	<0.1	<0.1		<0.1	<0.1			3.54	0.13
	05/20/08	13:45	<2		<0.5		6.86		13.60		23.0		<0.1			<0.1				0.17	
Fingerprint	04/12/10	13:15	<1.08		<0.1	<0.5	3.42	4.72	15.60		37.00	42.8	<0.15	<0.5	69	<0.1	<0.5	<0.1	<0.5	0.98	<0.5
Mean			3		#DIV/0!		5.10		14.93		32.2		#DIV/0!			#####				1.56	
Max			3		0.0		6.86		15.60		37.0		0.0			0.00				3.54	
Min			3.0		0.0		3.42		13.60		23.0		0.0			0.00				0.17	
SBC, SS-05A **M#249187**	04/12/10	15:25	<1.08		<0.1	<0.5	4.73	6.47	19.50		37.80	43.6	<0.15	<0.5	83	0.11	<0.5	<0.1	<0.5	0.66	<0.5
Fingerprint	04/12/10	16:33	1.52		<0.1	<0.5	4.69	6.4	18.80		35.00	41.8	<0.15	<0.5	75	<0.1	<0.5	<0.1	<0.5	0.80	<0.5
SBC, SS-06G **M#249189**																					
Fingerprint	04/19/10	10:35	<4.2		<0.5	<0.5	4.97	6.52	<27.0		29.90	31.9	<0.6	<0.5	59	<0.5	<0.5	<0.5	<0.5	1.33	<0.5
SBC @USGS Temp gauge above SS-07																					
	05/07/07	1615	5.71		<0.5	<0.5	5.10	5.37	61.50		27.8	31.6	<0.1	<0.1		0.11	0.18			3.27	0.21
Fingerpring	04/19/10	11:00	7.41		<0.1	<0.5	4.36	6.01	60.60		28.30	31.9	<0.1	<0.5	70	<0.1	<0.5	<0.1	<0.5	0.39	<0.5
Mean			7		#DIV/0!		4.73		61.05		28.1		#DIV/0!			0.11				1.83	
Max			7		0.0		5.10		61.50		28.3		0.0			0.11				3.27	
Min			5.7		0.0		4.36		60.60		27.8		0.0			0.11				0.39	
SBC, SS-07B																					
	05/07/07	14:47	3.78		<0.5	<0.5	5.58	5.92	30.50		31.2	33.5	<0.1	<0.1		<0.1	0.16			0.24	0.16
Mean			4		#DIV/0!		5.58		30.50		31.2		#DIV/0!			#####				0.24	
Max			4		0.0		5.58		30.50		31.2		0.0			0.00				0.24	
Min			3.8		0.0		5.58		30.50		31.2		0.0			0.00				0.24	
SBC, SS-08 **M#196457**																					
	05/07/07	11:13	4.94		<0.5	<0.5	5.08	5.34	66.50		28.0	31.4	<0.1	<0.1		0.17	0.31			5.48	0.25
Mean			5		#DIV/0!		5.08		66.50		28.0		#DIV/0!			0.17				5.48	
Max			5		0.0		5.08		66.50		28.0		0.0			0.17				5.48	
Min			4.9		0.0		5.08		66.50		28.0		0.0			0.17				5.48	

			MINOR AND TRACE METALS															
				Chromium	Cesium		Copper		Gallium		Mercury		Lanthanum		Lithium		Molybdenum	
	DATE	TIME	Cr	Cr, TR	Cs	Cs, TR	Cu	Cu, TR	Ga	Ga,TR	Hg	Hg, TR	La	La, TR	Li	Li, TR	Mo	Mo, TR
	(MM/DD/YR)	(HRS)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
SBC Below Blacktail, MT St SS-05																		
M#127536																		
	05/08/07	8:55	<0.1	0.25			4.10	7.67			NA				8.5	8.7	6.01	5.92
	05/20/08	13:45	0.13				3.88				NA				7.0		4.29	
Fingerprint	04/12/10	13:15	<0.1	<0.5	<0.1	<0.5	1.88	3.84	<0.1	<0.5	NR		<0.1	<0.5	5.0	6.66	5.80	6.65
Mean			0.13				3.29				#DIV/0!				6.8		5.37	
Max			0.13				4.10				0.00				8.5		6.01	
Min			0.13				1.88				0.00				5.0		4.29	
SBC, SS-05A	04/12/10	15:25	0.20	<0.5	<0.1	<0.5	5.66	10.5	<0.1	<0.5	NR		<0.1	<0.5	4.9	5.00	6.57	6.86
M#249187																		
Fingerprint	04/12/10	16:33	0.12	0.646	<0.1	<0.5	5.52	14.1	<0.1	<0.5	NR		<0.1	<0.5	5.3	4.09	6.18	6.72
SBC, SS-06G																		
M#249189																		
Fingerprint	04/19/10	10:35	<0.5	<0.5	<0.5	<0.5	<3.0	12.4	<0.5	<0.5	NR		<0.5	<0.5	11	10.60	4.87	4.34
SBC @USGS Temp gauge above SS-07																		
	05/07/07	1615	0.10	0.31			12.20	19.7			NA				17.4	16.6	4.96	5.12
Fingerpring	04/19/10	11:00	0.12	0.561	<0.1	<0.5	8.98	14.6	<0.1	<0.5	NR		<0.1	<0.5	8.9	10.00	4.36	4.36
Mean			0.11				10.59				#DIV/0!				13.1		4.66	
Max			0.12				12.20				0.00				17.4		4.96	
Min			0.10				8.98				0.00				8.9		4.36	
SBC, SS-07B																		
	05/07/07	14:47	0.12	0.29			9.54	14.1			NA				19.6	18	5.84	5.86
Mean			0.12				9.54				#DIV/0!				19.6		5.84	
Max			0.12				9.54				0.00				19.6		5.84	
Min			0.12				9.54				0.00				19.6		5.84	
SBC, SS-08																		
M#196457																		
	05/07/07	11:13	0.19	0.26			13.20	21.2			NA				21.6	19.4	4.78	5
Mean			0.19				13.20				#DIV/0!				21.6		4.78	
Max			0.19				13.20				0.00				21.6		4.78	
Min			0.19				13.20				0.00				21.6		4.78	

			MINOR AND TRACE METALS													
			Niobium		Neodymium		Nickel		Lead		Palladium		Praseodymium		Rubidium	
	DATE (MM/DD/YR)	TIME (HRS)	Nb (ug/L)	Nb, TR (ug/L)	Nd (ug/L)	Nd, TR (ug/L)	Ni (ug/L)	Ni, TR (ug/L)	Pb (ug/L)	Pb, TR (ug/L)	Pd (ug/L)	Pd, TR (ug/L)	Pr (ug/L)	Pr, TR (ug/L)	Rb (ug/L)	Rb, TR (ug/L)
SBC Below Blacktail, MT St SS-05 **M#127536**																
	05/08/07	8:55					0.81	0.2	<0.2	0.84						
	05/20/08	13:45					0.36		0.21							
Fingerprint	04/12/10	13:15	<0.1	<1.5	<0.46	<0.5	0.3		<0.1	1.03	<0.1	<1.0	<0.1	<0.5	0.53	0.616
Mean							0.47		0.21							
Max							0.81		0.21							
Min							0.25		0.21							
SBC, SS-05A	04/12/10	15:25	<0.1	<1.5	<0.46	<0.5	0.3		0.16	1.83	<0.1	<1.0	<0.1	<0.5	0.6	0.853
M#249187																
Fingerprint	04/12/10	16:33	<0.1	<1.5	<0.46	<0.5	0.2		0.16	2.23	0.11	<1.0	<0.1	<0.5	0.62	0.970
SBC, SS-06G **M#249189**																
Fingerprint	04/19/10	10:35	<0.7	<1.5	<0.4	<0.5	<0.6		<2.5	2.51	<0.6	<1.0	<0.5	<0.5	0.98	1.190
SBC @USGS Temp gauge above SS-07																
	05/07/07	1615					1.14	0.55	<0.2	1.41						
Fingerpring	04/19/10	11:00	<0.1	<1.5	<0.1	<0.5	0.4		<0.5	2.22	<0.1	<1.0	<0.1	<0.5	2.87	2.680
Mean							0.78		#DIV/0!							
Max							1.14		0.00							
Min							0.42		0.00							
SBC, SS-07B																
	05/07/07	14:47					0.65	0.23	<0.2	3.61						
Mean							0.65		#DIV/0!							
Max							0.65		0.00							
Min							0.65		0.00							
SBC, SS-08 **M#196457**																
	05/07/07	11:13					1.44	0.53	<0.2	1.5						
Mean							1.44		#DIV/0!							
Max							1.44		0.00							
Min							1.44		0.00							

			MINOR AND TRACE METALS																	
			Selenium		Tin		Strontium		Thorium		Titanium		Thallium		Uranium		Tungsten		Zinc	
	DATE (MM/DD/YR)	TIME (HRS)	Se (ug/L)	Se, TR (ug/L)	Sn (ug/L)	Sn, TR (ug/L)	Sr (ug/L)	Sr, TR (ug/L)	Th (ug/L)	Th, TR (ug/L)	Ti (ug/L)	Ti, TR (ug/L)	Tl (ug/L)	Tl, TR (ug/L)	U (ug/L)	U, TR (ug/L)	W (ug/L)	W, TR (ug/L)	Zn (ug/L)	Zn, TR (ug/L)
SBC Below Blacktail, MT St SS-05																				
M#127536																				
	05/08/07	8:55	<0.5	<0.5			215	220							2.99	2.96			13	31
	05/20/08	13:45	<0.5				212								2.09				3	
Fingerprint	04/12/10	13:15	<0.37	<1.0	<0.1		207	222	<0.39	<0.5	0.4	<1.5	<0.1	<0.5	4.4		0.33	<1.5	6.4	10.1
Mean			#DIV/0!				211								3.16				7	
Max			0.00				215								4.39				13	
Min			0.00				207								2.09				3	
SBC, SS-05A	04/12/10	15:25	0.40	<1.0	<0.1		207	231	<0.39	<0.5	0.4	3.26	<0.1	<0.5	4.5		0.42	<1.5	5.3	21.5
M#249187																				
Fingerprint	04/12/10	16:33	<0.37	<1.0	<0.1		206	227	<0.39	<0.5	0.4	8.39	<0.1	<0.5	4.72		0.49	<1.5	10.7	28.7
SBC, SS-06G																				
M#249189																				
Fingerprint	04/19/10	10:35	<1.0	<1.0	<3.0		187	187	<2.5	<0.5	<0.8	3.21	<2.5	<0.5	<3.0		<0.6	<1.5	6.9	29.4
SBC @USGS Temp gauge above SS-07																				
	05/07/07	1615	<0.5	<0.5			283	292							3.26	3.31			36	63
Fingerpring	04/19/10	11:00	0.23	<1.0	<0.6		193	197	<0.5	<0.5	0.7	2.51	<0.5	<0.5	2.0		0.25	<1.5	27.6	36.7
Mean			0.23				238								2.64				32	
Max			0.23				283								3.26				36	
Min			0.23				193								2.01				28	
SBC, SS-07B																				
	05/07/07	14:47	<0.5	<0.5			321	309							4.10	3.62			20	41
Mean			#DIV/0!				321								4.10				20	
Max			0.00				321								4.10				20	
Min			0.00				321								4.10				20	
SBC, SS-08																				
M#196457																				
	05/07/07	11:13	<0.5	<0.5			315	310							3.48	3.47			57	86
Mean			#DIV/0!				315								3.48				57	
Max			0.00				315								3.48				57	
Min			0.00				315								3.48				57	

APPENDIX C GROUNDWATER QUALITY

Montana Bureau of Mines and Geology
Butte Priority Soils Groundwater-Quality Data

		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
AMC-6	**M#4604**																													
	07/27/83	10:20	29.00	1.0	5.75	1,800	9.5		5.54	1,700	901	9	68.0	24.3	6.7	0.8	0.0	97.1					16.20	30.70			15.6	1,010		
	07/29/87	15:40	33.30	0.9	6.13	980	9.3		6.12	1,255	595	33	65.7	24.3	9.0	4.9	0.0	91.9					4.15	14.20			15.3	598		
	07/26/88	15:40	33.10	8.0	6.21	1,440	10.8		6.03	1,400	700	21	63.4	24.2	8.0	2.5	0.0	95.3					6.92	20.60			13.3	765		
	08/03/89	14:00	34.20	7.0	5.88	1,460	10.5		6.89	1,510	741	21	64.7	24.2	7.5	2.2	0.0	95.9					4.30	19.20			12.7	859		
	11/06/89	14:35	34.45	7.0	5.95	1,460	9.8		6.18	1,470	793	22	64.9	24.3	7.4	2.5	0.0	95.6					3.15	19.11			12.7	830		
	07/24/90	14:30	34.50	7.5	5.86	1,380	10.1		6.01	1,500	790	28	65.8	25.2	7.7	3.1	0.0	94.9					4.43	18.43			13.3	840		
	08/20/91	12:40	34.20	7.0	6.25	1,335	10.6		6.35	1,385	724	36	65.9	25.2	8.0	4.4	0.0	92.4					3.98	12.89			18.4	727		
	10/22/92	14:15	34.00	6.6	6.21	1,230	9.9		6.26	1,290	700	40	65.7	26.0	7.4	5.2	0.0	92.4					2.76	10.85			13.5	695		
	12/22/93	14:36	33.30	4.0	6.01		8.0		6.10	1,166	592	41	63.8	26.2	8.9	6.0	0.0	91.2					3.61	9.66			13.9	604		
ESE	08/18/94				5.99	1045	9.3	57			589	42							172				3.67	9.47				500	0.5	
ESE	03/13/95				6.25	990	9.1	-14			565	42							163	38.2			3.8	9				491	0.5	
	10/03/95	09:40	32.03	6.0	5.61		9.2		6.60	1,035	500	40	64.2	25.7	9.1	6.9	0.0	90.1					2.30	7.60			12.0	500		
	04/04/96	14:08	32.42	5.1	6.19	870	10.2		6.54	925	457	44	63.9	25.4	9.5	8.3	0.0	87.4					1.60	6.90			15.8	440		
	11/14/96	15:50	31.27	5.0	5.91	955	9.1		6.90	930	499	45	63.3	26.5	9.0								2.00	7.50			<10	500		
ESE	06/11/97				6.22	830	9.2	9			390	59							114	27.8	20.5	4.76	1.58	6.03	59.4	<10	15	299	0.5	
	01/06/98	10:10	29.82		5.96	845	9.1		6.54	900	379	50	83.8	3.0	11.4	11.1	0.0	83.6	146	3.2	22.8	6.3	1.61	7.40	61	0.0	17.1	363		
ESE	06/22/98				6.20	628	9.2	-31			319	73							86	23.1	23	5.7	1.99	4.49	73	<10	19	309	0.5	
	01/07/99	11:15	29.60		6.08	740	9.1		6.40	756	311	62							89.6	21.2	19.7	4.9	0.88	4.78	75	0.0	19.7	246	<0.5	
	07/06/99	14:34	29.60		5.90	760	9.1		6.20	750	325	64							93.3	22.4	20.8	5.4	0.61	4.76	78	0.0	19.8	247	0.10	
	01/10/00	15:10	31.59	3.8	6.12	770	9.0	195	6.16	745	328	56	59.3	23.7	11.2	13.6	0.0	71.1	93.7	22.8	20.2	4.6	0.59	5.19	68	0.0	18.9	282	<0.5	
	06/12/00	13:00							6.42	706	307	61	60.4	23.3	10.9	17.3	0.0	65.3	88.7	20.8	18.4	4.2	0.68	4.46	75	0.0	17.7	221	<0.5	
	06/18/01	16:00	35.50	6.0	5.93	805	9.3	107	6.23	770	339	72	60.9	23.3	10.3	16.5	0.0	68.4	98.1	22.8	19.0	4.4	0.59	5.05	88	0.0	20.1	289	0.01	
	12/06/01	14:55	34.75		5.94	835	9.2	57	6.36	800	346	55	53.0	22.0	9.2	12.4	0.0	73.3	97.7	24.7	19.5	4.6	18.40	5.15	67	0.0	19.5	313	<0.5	
ESE	08/09/02	12:50			6.05	800	9.4	77			359	51							103	24.7	22.2	5.0	0.55	5.08	51	<10	24.0	283	<0.5	
	04/09/03	14.:20	34.20		5.93	760	9.9		6.17	805	359	54	60.2	23.8	10.5	11.8	0.0	74.1	103	24.7	20.7	4.4	0.61	5.18	66	0.0	18.4	325	<0.25	
	11/07/03	11:00	34.58		5.98	725	9.8	72	6.45	720	336	56	57.8	23.9	12.9	13.8	0.0	68.8	95.3	23.9	24.4	4.2	1.38	4.28	68	0.0	20.7	267	<0.5	
	04/27/04	15:05	32.94		6.22	540	11.3	311	6.48	610	247	70	57.5	24.5	12.7	22.5	0.0	57.4	69.4	17.9	17.6	3.9	0.58	3.44	85	0.0	21.5	172	<0.5	
	06/03/05	11:30	31.43	3.0	6.20	565	10.2	446	6.25	645	275	52	58.9	22.7	12.3	16.0	0.0	67.3	79.6	18.6	19.1	4.2	0.82	4.16	64	0.0	20.8	212	<0.1	
	12/13/05	11:35	31.53		6.16	565	10.7	269	6.66	595	262	53	58.1	23.3	12.1	16.7	0.0	57.7	74.8	18.2	17.9	4.1	1.21	4.02	65	0.0	20.9	200	0.14	
	04/25/06	15:00	31.30	5.0	6.18	635	10.5	293	5.83	675	261	0	57.9	23.5	12.4	14.7	0.0	64.4	74.2	18.3	18.2	4.2	1.01	4.07	60	0.0	20.2	207	0.11	
	10/25/06	11:30	30.08	4.0	6.19	600	10.6	237	6.26	655	276	60	58.7	23.7	11.7	16.4	0.0	68.2	79.0	19.3	18.0	4.2	0.91	4.08	73	0.0	19.8	239	<0.5	
	04/23/07	16:00	30.50	5.0	6.29	605	10.3	322	6.02	675	289	56	58.7	23.8	11.2	15.5	0.0	69.9	82.4	20.3	18.1	4.4	0.94	4.57	68	0.0	19.1	241	<0.5	
	11/08/07	14:45	29.66		6.17	676	10.5	211	6.20	686	288	62	57.3	24.5	11.3	17.1	0.0	69.6	80.8	21.0	18.2	4.8	1.79	4.69	76	0.0	17.7	242	<0.5	
	06/02/08	11:45		8.0	6.19	670	10.9	286	6.30	770	306	64	58.5	22.1	10.5	16.9	0.0	69.9	89.0	20.4	18.4	7.4	4.65	4.61	78	0.0	20.9	252	<0.5	
	11/19/08	12:30		8.5	6.66	635	10.2	287	6.46	655	294	62	59.2	23.9	11.3	15.6	0.0	70.1	83.4	20.9	18.4	2.6	1.59	4.30	76	0.0	19.4	261	<0.5	
	06/09/09	17:36	30.59		6.31	721	10.8	246	6.62	747	282	59	56.5	24.2	12.5	15.8	0.0	69.5	79.1	20.5	20.1	5.1	1.66	4.39	72	0.0	21.5	249	<0.5	
	12/04/09	14:00	20.75		6.05	665	10.4	60	6.42	674	298	57	57.9	23.3	12.6	16.0	0.0	68.7	85.2	20.8	21.3	4.6	1.70	4.19	70	0.0	18.4	236	<0.5	
Fingerprint	06/22/10	13:49	30.62	6.0	5.76	651	11.5	270	6.74	651	308	55	58.6	24.8	12.9	16.0	0.0	64.6	86.6	22.2	21.8	4.7	1.39	<0.2	67	0.0	20.6	213	0.12	

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanum
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMC-6	**M#4604**																					
	07/27/83		1.30					60		0.70				130			8.0	210				
	07/29/87		6.05					<30		0.50				56			<2	160				
	07/26/88		3.13					<30		<.1				78			5.0	240				
	08/03/89		2.77					<30		0.60				72			<2	194				
	11/06/89		3.04					40		0.80				60			<5	183				
	07/24/90		2.84					<40		0.50				28			<5	119				
	08/20/91		4.75					<100		0.26				45			<6	69.0				
	10/22/92		3.76					<30		<1				39			<2	60.4				
	12/22/93		2.68					30		1.00				31			2.0	58.0				
ESE	08/18/94		2.5							1				32				54				
ESE	03/13/95		1.93							1				23.3				41				
	10/03/95		2.00					<80		<1				27			<2	42.9				
	04/04/96		3.30					<30		<1				2.4			<2	<2				
	11/14/96		3.90					<30		<1				25			<2	46.3				
ESE	06/11/97		4.46					18.5		<1.1				20.7				44				
	01/06/98	51.2	5.96					<30	<1	1.15	<30	24.8	<2	23		3.2	4.4	36.6			NA	
ESE	06/22/98		5.01					16.6		2.6				11.8				16.5				
	01/07/99	41.0	9.27					<30	<1	1.52	32	24.9	<2	17		2.4	2.7	33.4			<100	
	07/06/99	50.1	10.34					<30	<1	<1	<150	25.4	<2	19		2.3	<2	42.9			NA	
	01/10/00	49.7	10.32					<30	<1	1.00	41	29.0	<2	23		2.6	<2	53.5			NA	
	06/12/00	43.8	10.00					71	<1	<1	<30	27.0	<2	18		5.0	<2	33.4			NA	
	06/18/01	44.5	10.66					<30	<1	<1	31	25.8	<2	22		2.8	<2	55.5			NA	
	12/06/01	52.9	10.10					177	<1	1.20	31	30.3	<2	25		2.7	<2	94.5			NA	
ESE	08/09/02		11.60					47		3.40				26				78.1				
	04/09/03	37.4	10.89					<30	<1	<1	<30	22.1	<2	27		2.5	<2	52.7				
	11/07/03	43.0	11.50					<30	<1	<1	34.9	23.3	<2	19.8		2.2	<2	8.2			NA	
	04/27/04	47.3	9.03					<30	<1	<1	52.6	22.8	<2	18.3		2.3	<2	35.7			NA	
	06/03/05	50.4	7.15					<10	<1	<1	<30	29.7	<2	18.3		<2	<2	22.1			NA	
	12/13/05	46.3	8.06					<10	<1	2.38	31.0	25.0	<2	10.0		<2	<2	3.5			NA	
	04/25/06	43.9	11.50					<10	<1	1.09	35.0	25.1	<2	16.8		<2	<2	16.0			NA	
	10/25/06	45.2	7.88					<10	<1	<1	35.0	26.2	<2	16.5		<2	<2	32.6			NA	
	04/23/07	43.2	7.17					4.4	<1	0.63	27.1	24.7	<0.1	17.7		1.6	<0.1	14.3			NA	
	11/08/07	31.7	6.58					<2	<0.5	0.52	23.4	29.6	<0.1	14.9		1.7	<0.1	1.4			NA	
	06/02/08	42.6	5.59					<2	<0.5	<0.2	29.3	22.6	<0.1	5.1	<0.1	1.4	<0.1	13.4	<0.1	<0.1	NA	<0.1
	11/19/08	44.7	6.16					<8.8	<0.5	<2.3	39.6	24.9	<1.96	15.8	<0.37	<1.38	<0.37	<4.98	<0.26	<1.63	NA	<0.27
	06/09/09	50.0	6.82					1.5	<0.06	0.46	33.0	31.4	<0.15	15.1	0.10	1.8	<0.12	2.2	<0.04	<0.07	NA	0.04
	12/04/09	45.9	8.04					<8.0	<0.2	0.40	29.9	31.0	<0.2	14.3	<0.9	1.7	<0.1	2.2	<0.1	<0.2	NA	<0.9
Fingerprint	06/22/10	<0.2	10.46					<2.0	<0.2	1.24	29.1	31.1	<0.2	10.1	<0.2	1.7	<0.2	1.8	<0.5	<0.2	NA	<0.2

			MINOR AND TRACE METALS																
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	alladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMC-6	**M#4604**																		
	07/27/83						50.00												21,400
	07/29/87																		9,330
	07/26/88						<40				0.7								16,400
	08/03/89						<40												13,510
	11/06/89						<40												13,000
	07/24/90						<50												863
	08/20/91						90.00												6,640
	10/22/92						<2				<1								5,910
	12/22/93						2.00				2.2								5,610
ESE	08/18/94					60	1												5210
ESE	03/13/95					70	1												4630
	10/03/95						<2				1.3								4,131
	04/04/96						<2				<1								377
	11/14/96						<2				1.2								4,000
ESE	06/11/97	41.3	7.5			32.4	0.68				4.8								3330
	01/06/98	<50	<10				<2				1.9		696						3,942
ESE	06/22/98	47.6	5.4			36.6	2.6				1.3								2010
	01/07/99	60.5	<2				<10				510		2,720						
	07/06/99	<250	<10				<2				1.1		542						2,860
	01/10/00	46.0	<10				<2				1.6		567						3,480
	06/12/00	32.5	<10				<2				<1		532						2,600
	06/18/01	40.9	<10				<2				1.1		654				0.55		3,340
	12/06/01	44.6	<10				<2				1.2		703				0.53		3,930
ESE	08/09/02	44.9	<10				1.18				3.2								3,770
	04/09/03	41.2	<10				<2				1.3		690				<0.5		3,730
	11/07/03	41.1	<10				<2				<1		597				<0.5		3,036
	04/27/04	43.7	<10				<2				1.7		469				0.56		1,500
	06/03/05	52.4	<10			33.7	<2				2.3		500				0.55		3,108
	12/13/05	47.5	<10			31.9	<2				3.0		531				<0.5		2,571
	04/25/06	47.5	<10			31.0	<2				1.3		523				0.61		2,338
	10/25/06	43.5	<10			28.6	<2				<1		530				0.65		2,541
	04/23/07	44.6	1.7			28.4	<0.2				0.9		609				0.70		2,910
	11/08/07	48.5	2.3			30.7	<0.2				1.3		617				0.44		2,721
	06/02/08	46.9	<1	<0.1	<0.1	25.9	<0.2	0.74	<0.1	0.51	0.7	<0.1	534	<0.05	1.36	<0.1	0.22	<0.5	1,632
	11/19/08	13.4	3.0	<0.51	<0.73	33.0	<2.6	1.03	<0.38	0.65	<3.22	<0.55	508	<8.99	3.30	<0.34	<3.3	<0.45	2,586
	06/09/09	28.3	2.4	<0.03	<0.07	28.4	0.07	0.12	<0.02	0.64	0.7	<0.05	542	<0.02	1.80	<0.03	0.49	<0.07	2,653
	12/04/09	24.1	2.3	<0.1	<0.8	27.0	<0.6	<0.2	<0.8	0.60	0.6	<0.1	514	<0.3	1.88	<0.2	0.46	<0.2	2,500
Fingerprint	06/22/10	23.0	2.3	<0.2	<0.2	24.8	<0.2	<0.5	<0.2	0.62	0.6	<0.2	514	<0.2	1.40	<0.2	0.43	<0.2	2,045

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		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
AMC-8	**M#4611**																													
	04/26/83	15:10	52.40	0.6	5.95	345	9.0		6.44	340	143	45	59.4	24.6	13.5	28.7	0.0	62.3					0.85	0.19			10.0	93		
	07/26/83	15:11	54.15	1.0	6.46	370	11.0		6.60	340	137	46	58.3	25.0	14.0	29.0	0.0	62.1					0.37	0.10			9.9	94		
	07/29/87	16:30	61.70	0.7	6.70	350	8.8		6.48	415	162	50	58.3	24.4	15.1	28.8	0.0	61.5					0.24	0.08			11.8	102		
	07/26/88	16:40	61.10	0.5	6.54	355	11.3		6.57	430	173	47	58.2	25.2	14.3	25.2	0.0	63.1					0.19	0.06			15.6	112		
	08/03/89	14:45	62.20	0.5	6.17	460	10.0		6.59	450	174	47	59.5	25.1	13.2	22.8	0.0	63.1					0.09	0.04			20.7	124		
	10/30/89	15:20	61.97	0.6	6.35	425	10.2		6.98	475	185	46	59.3	25.2	13.0	22.4	0.0	65.1					0.10	0.03			18.6	129		
	07/24/90	13:35	62.40	0.5	6.48	410	10.0		6.20	445	179	43	59.0	25.4	13.2	21.6	0.0	67.2					0.14	0.03			15.9	128		
	08/20/91	11:45	62.00	4.0	6.44	430	10.8		6.48	450	178	43	60.2	24.3	13.4	21.9	0.0	66.6					0.18	0.04			15.8	124		
	10/22/92	13:05	60.70	4.0	6.45	440	10.1		6.54	490	184	49	59.3	25.7	13.1	24.6	0.0	63.0					0.17	0.03			17.6	121		
ESE	08/18/94				6.15	195	9.1	119			204	50							57.2				0.14	0.022				130	0.5	
	12/22/94	13:20	58.90	3.0	6.23		8.8		6.33	460	181	52	58.2	25.0	14.4	24.5	0.0	63.8					0.15	0.02			17.7	130		
ESE	03/13/95				6.29	474	8.6	99			218	58							61.6	15.6			0.154	0.019				136	0.5	
ESE	10/03/95				5.77	551	8.7	92			233	54							67.6				0.159	0.022				142	0.5	
	04/04/96	12:45	58.37	5.6	6.41	505	10.6		7.47	583	247	58	60.0	25.4	12.7	21.8	0.0	61.7					0.18	0.03			31.3	159		
ESE	11/13/96				6.11	622	8.8	236			276	56							68.9	18	17.5	4.28	0.181	0.0149	56	<10	34	160	0.5	
ESE	06/11/97				6.18	618	8.9	119			248	62							71.8	18.5	18.8	4.5	0.138	0.0194	62	<10	33	122	0.5	
ESE	01/06/98				6.06	667	8.7	369			289	60							79.6	21.8			0.0729	0.013	59.8	<10	40	197	0.5	
ESE	06/23/98				5.82	902	8.8	264			444	63							118	33.4	34.6	7.01	0.14	0.0245	63.4	<10	44	394	0.5	
	01/07/99	13:00	52.78		6.11	1,125	8.7		6.36	1,085	539	63							153	38.1	33.0	6.4	0.06	0.02	77	0.0	38.8	462	<.5	
ESE	07/06/99	15:15			5.94	1108	8.9	358			471	59							132	34.2	<31	6.04	0.0484	0.012	59.2	<10	39	453.33	0.5	
	08/24/99	15:35	52.78		5.94	1,110	8.7		6.26	1,115	529	58							149	38.2	36.4	7.6	0.05	0.01	71	0.0	30.8	503	<.5	
	01/11/00	13:35	55.31	4.4	6.25	825	8.7	346	6.31	800	331	50	57.7	24.3	16.0	12.1	0.0	69.8	93.1	23.9	29.6	5.3	0.05	0.007	61	0.0	39.7	278	<.5	
	06/16/00	10:31							6.81	740	298	62	58.4	23.3	16.2	16.9	0.0	65.2	85.4	20.7	27.1	4.5	0.11	0.008	76	0.0	35.0	231	<.5	
	12/20/00	12:10			6.01		8.5		6.66	742	305	63	56.3	23.4	18.3	15.9	0.0	67.8	86.4	21.8	32.2	4.8	0.12	0.008	77	0.0	34.5	258	<.5	
	06/18/01	16:30	61.06	2.0	6.07	800	9.1	286	6.40	770	321	66	57.1	22.9	18.0		0.0	69.5	91.6	22.3	33.2	4.8	0.08	0.029	81	0.0	32.4	275	0.07	
	12/07/01	10:55	62.17		6.27	800	8.5	342	6.43	805	308	64	54.9	24.0	19.0	14.9	0.0	71.2	85.8	22.8	34.0	4.9	0.15	0.12	78	0.0	33.5	294	<.5	
ESE	08/09/02	13:30			6.27	885	9.0	273			382	56							109	26.7	40.0	5.7	0.11	0.036	56	<10	36.0	366	<.5	
	05/05/03	14:05			6.31	938	12.1		6.39	1,030	434	52	59.1	23.8	15.1	9.1	0.0	80.7	124	30.3	36.2	6.0	0.22	0.046	63	0.0	25.9	440	<0.5	
	11/07/03	11:50	63.52		6.18	1,000	11.6	70	6.58	990	487	52	57.1	24.3	17.1	8.9	0.0	83.1	137	35.4	47.1	5.3	0.16	0.032	63	0.0	22.1	466	0.69	
	04/19/04	16:40	61.87		5.81	960	11.8	369	6.36	1,020	510	50	58.1	24.8	15.5	8.5	0.0	83.5	143	37.1	43.8	5.8	0.25	0.096	61	0.0	22.7	472	<0.25	
	05/18/05	13:30	61.99		6.39	880		261	6.50	985	444	51	58.1	24.6	15.6	9.5	0.0	80.5	125	32.1	38.4	5.9	0.23	0.035	62	0.0	27.8	413	<0.1	
	12/13/05	13:30	62.16		6.33	800	9.9	284	6.84	865	395	52	59.0	24.2	14.8	10.2	0.0	79.3	124	27.9	32.2	5.4	0.29	0.035	63	0.0	28.9	386	0.11	
	04/18/06	14:40	61.82	8.0	5.99	817	9.7	347	5.93	903	414	49	63.9	34.7	14.7	9.6	0.0	81.1	117	29.6	33.4	5.6	0.24	0.023	60	0.0	25.6	400	<0.5	
	11/06/06	16:00	59.89	3.2	6.32	905	10.4	289	6.31	955	438	53	58.6	25.0	14.5	10.9	0.0	80.0	123	31.8	34.8	5.5	0.60	0.058	65	0.0	23.0	372	<0.5	
	04/23/07	14:45	59.24	3.0	6.38	935	10.3	385	6.42	1,010	507	55	60.5	24.9	13.0	8.7	0.0	83.8	144	35.9	35.5	6.0	0.15	0.021	67	0.0	24.4	506	<0.5	
	12/18/07	15:40	58.39		6.25	1,052	11.7	274	6.32	1,162	499	58	59.7	24.3	14.2	9.4	0	84.5	142	35	38.7	6.4	0.35	0.060	71	0.0	20.0	501	<0.5	
	06/02/08	14:20	58.85	5.0	5.96	1,100	11.0	334	6.29	1,150	556	54	59.2	24.2	14.9	8.1	0	85.6	158	39.2	45.5	6.5	0.18	0.025	66	0.0	22.8	545	<0.5	
Dup	06/02/08	14:25	58.85	5.0	6.01	1,105	11.0	340	6.33	1,145	543	56	60.0	23.6	14.6	8.3	0	85.3	156	37.2	43.4	6.9	0.20	0.026	68	0.0	23.4	548	<0.5	
	12/08/08	17:00	58.08		6.71	1,095	9.1	380	6.47	1,110	597	55	57.8	23.1	17.7	8.1	0	84.4	170	41.8	59.7	4.1	<0.018	<0.003	67	0.0	25.9	549	<0.5	
	06/10/09	16:00	57.75		6.37	1,349	9.9		6.70	1,301	599	51	57.7	23.7	17.1	6.1	0	86.8	170	42.4	57.7	7.0	0.30	0.027	62	0.0	33.2	686	<0.5	
	12/01/09	16:36	NR		NR	NR	NR	NR	6.45	1,671	821	38	61.1	25.1	12.5	3.9	0	89.2	233	58	4.7	7.3	0.37	0.04	46	0.0	39.5	837	<0.5	
Fingerprint	06/08/10	14:32	NR		5.65	1,593	10.9	303	7.54	1,580	853	54	62.1	26.3	10.2	5.8	0	85.8	240	61.7	45.1	7.7	0.42	0.043	66	0.0	46.1	767	0.10	

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanun
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMC-8	**M#4611**																					
	04/26/83		3.10					<30		0.50				2.0			<2	22.0				
	07/26/83		2.74					<30		0.30				<2			<2	13.0				
	07/29/87		6.35					<30		0.40				<2			<2	7.0				
	07/26/88		4.45					<30		0.20				3.0			<2	8.0				
	08/03/89		4.35					<30		0.40				<2			<2	12.0				
	10/30/89		6.10					<40		0.70				<5			<5	21.0				
	07/24/90		4.64					<40		1.00				<5			<5	4.0				
	08/20/91		5.51					585		0.37				10.0			<6	15.0				
	10/22/92		4.73					<30		<1				2.1			<2	13.0				
ESE	08/18/94		5.5							1				1.7				12				
	12/22/94		0.35					<30		<1				<2			<2	9.5				
ESE	03/13/95		4.61							1				<1				11				
ESE	10/03/95		5.73							1				<1.8				16				
	04/04/96		6.50					<30		<1				<2			<2	<2				
ESE	11/13/96		5.88					24.6		2.6				2.1				9.9				
ESE	06/11/97		6.16					18.5		1.1				<1.9				10.1				
ESE	01/06/98		4.88					34.3	3.3	2.1				2.2				13.1				
ESE	06/23/98		5.78					16.6		2.5				3.2				20				
	01/07/99	31.9	6.43					<30	<1	1.16	<30	60.1	<2	3.9		<2	2.3	16.1			<100	
ESE	07/06/99		5.18					9.7		<0.79				4.4				17.9				
	08/24/99	37.5	4.94					<30	<1	<1	<150	52.4	<2	4.1		<2	<2	18.9			<250	
	01/11/00	36.2	5.28					<30	<1	<1	<30	36.4	<2	3.0		<2	<2	11.8			NA	
	06/16/00	32.3	4.66					52	<1	<1	<30	33.3	<2	2.2		2.9	<2	12.4			NA	
	12/20/00	34.7	4.40					<30	<1	<1	<30	32.2	<2	2.3		<2	<2	13.2			NA	
	06/18/01	33.2	3.84					<30	<1	<1	<30	35.7	<2	2.4		<2	<2	11.7			NA	
	12/07/01	33.6	3.56					<30	<1	<1	<30	32.8	<2	2.5		<2	<2	13.7			NA	
ESE	08/09/02		4.9					47		3.40				3.1				18.1				
	05/05/03	32.1	6.03					38	<1	1.73	<30	43.6	<2	3.2		<2	<2	37.3			NA	
	11/07/03	34.2	3.82					<30	<1	<1	<30	40.3	<2	3.9		<2	<2	16.8			NA	
	04/19/04	34.4	4.38					<30	<1	<1	<30	40.8	<2	21.3		<2	<2	22.6			NA	
	05/18/05	35.3	3.92					<100	<10	<10	<300	24.9	<20	<10		<20	<20	<20			NA	
	12/13/05	33.9	3.38					<10	<1	2.31	<30	31.8	<2	2.1		<2	<2	4.9			NA	
	04/18/06	32.6	3.32					<10	<1	<1	<30	33.5	<2	3.5		<2	<2	14.6			NA	
	11/06/06	32.4	3.16					<30	<1	<1	<30	35.6	<2	3.2		<2	<2	31.9			NA	
	04/23/07	32.6	3.65					<1	<1	0.41	7.3	36.0	<0.1	3.7		0.15	0.56	20.8			NA	
	12/18/07	23.0	2.64					<2	<0.5	0.50	7.3	39.8	<0.1	3.7		0.28	<.1	8.9			NA	
	06/02/08	33.1	2.73					<2	<0.5	0.35	8.3	29.0	<0.1	<0.1	<0.1	0.12	<0.1	21.7	<0.1	<0.1	NA	<0.1
Dup	06/02/08	34.0	2.70					<2	<0.5	0.29	5.7	28.4	<0.1	<0.1	<0.1	0.12	<0.1	20.7	<0.1	<0.1	NA	<0.1
	12/08/08	35.0	2.76					<8.8	<0.57	<2.34	11.8	36.0	<1.96	4.6	<0.37	<1.38	<0.37	27.6	<0.26	<1.6	NA	<0.27
	06/10/09	38.2	3.16					<1.73	<0.30	<0.64	15.0	36.6	<0.77	4.9	<0.24	<0.64	<.60	27.4	<0.19	<0.37	NA	<0.16
	12/01/09	34.0	3.39					<40.2	<1.2	<0.8	13.9	38.0	<0.9	6.5	<4.5	<0.5	<0.6	24.6	<0.3	<1.0	NA	<4.7
Fingerprint	06/08/10	35.0	3.49					<10.0	<1.00	<0.92	16.8	32.5	<1.0	6.7	<1.0	<0.9	<1.0	29.6	<2.5	<0.9	NA	<1.0

			MINOR AND TRACE METALS																
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	Palladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMC-8	**M#4611**																		
	04/26/83						<40				#N/A								160
	07/26/83						<40				#N/A								110
	07/29/87						#N/A				#N/A								160
	07/26/88						<40												180
	08/03/89						<40												155
	10/30/89						<50												187
	07/24/90						<50												<6
	08/20/91						90.00				#N/A								157
	10/22/92						<2				1.30								153
ESE	08/18/94					10	1												150
	12/22/94						<2				1.90								142
ESE	03/13/95					10	1												170
ESE	10/03/95					20	1												179
	04/04/96						<2				<1								18
ESE	11/13/96	<7.1	9.1			16.2	1.9				1.6								183
ESE	06/11/97	<6.3	7.5			16.6	0.68				5.2								180
ESE	01/06/98	6.9	7.1			15.8	1.6				1.6								219
ESE	06/23/98	1	5.4			14.9	2.6				1.3								318
	01/07/99	49.9	<2				<10				867		387						
ESE	07/06/99	<7.8	<6.7			10.3	0.69				0.76								342
	08/24/99	6.7	<2				<10				864		355						
	01/11/00	<25	<10				<2				2.30		564						221
	06/16/00	6.2	<10				<2				1.38		503						183
	12/20/00	7.7	<10				<2				1.97		499						198
	06/18/01	6.9	<10				<2				1.64		589				<0.5		242
	12/07/01	7.6	<10				<2				2.03		578				<0.5		245
ESE	08/09/02	7.7	<10				2.00				4.24								303
	05/05/03	8.7	<10				<2				<1		766				<0.5		559
	11/07/03	8.6	<10				<2				1.94		811				<0.5		422
	04/19/04	9.9	<10				<2				2.04		814				<1		420
	05/18/05	11.3	<100			<20	<20				<10		798				<5		431
	12/13/05	9.0	<10			3.1	<2				4.27		706				<0.5		371
	04/18/06	9.2	<10			2.9	<2				2.21		739				0.52		380
	11/06/06	7.7	<10			4.3	<2				1.47		730				<1		379
	04/23/07	9.6	2.67			2.6	<0.2				1.58		933				0.49		423
	12/18/07	9.1	3.86			4.4	<.2				1.98		911				0.24		364
	06/02/08	9.6	2.53	<0.1	<0.1	2.3	<0.2	1.39	<0.1	1.02	1.58	<0.1	105	0.43	2.99	<0.1	0.19	<0.5	563
Dup	06/02/08	10.1	2.46	<0.1	<0.1	2.1	<0.2	1.34	<0.1	1.04	1.45	<0.1	1,024	0.24	3.14	<0.1	0.13	<0.5	556
	12/08/08	<5.32	4	<0.5	<0.7	3.7	<2.6	1.50	<0.3	1.43	<3.2	<0.5	817	<8.9	6.25	<0.3	<3.3	<0.4	421
	06/10/09	8.6	3.77	<0.16	<0.35	3.6	<0.25	<0.48	<0.11	1.59	1.73	<0.24	9	<0.12	5.81	0.15	0.15	<0.35	456
	12/01/09	<7.4	2.94	<0.5	<4.0	4.0	<3.0	<1.0	<4.1	1.53	1.95	<0.7	1,207	<1.4	8.26	<1.2	<1.1	<0.8	595
Fingerprint	06/08/10	<10.0	2.79	<0.9	<1.0	3.5	<1.0	<2.5	<1.0	<2.5	1.54	<1.0	1,248	<1.0	7.16	<1.0	<1.0	<1.0	671

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		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
AMC-12	**M#4656**																													
	04/27/83																											2,180		
	10/12/83																											2,120		
	04/25/84																											2,100		
	07/24/84																											2,120		
	10/17/84																											2,100		
	07/30/86																											2,047		
	07/29/87																											1,950		
	07/26/88		21.10	8.0	5.69	2,930	10.30		5.24	2,760	1,528	0	59.3	26.3	5.9	0.4	0.0	98.2					12.6	137			21.3	1,938		
	08/02/89	17:15	21.50	10.0	4.86	2,960	10.00		5.32	2,910	1,605	8	61.0	24.6	5.1	0.4	0.0	98.2					11.3	158			21.5	2,060		
	10/22/92																											1,975		
	12/22/93	16:15	21.00	4.0	5.31		8.70		5.15	2,670	1,498	12	63.9	28.1	6.3	0.6	0.0	98.1					13.3	133			18.8	1,918		
ESE	08/19/94				5.10	2,660	9.14	149			1,690	10							510.0				12.8	146				1,840	2.00	
ESE	03/14/95				5.28	2,610	9.13	114			1,570	10							445.0				13.4	136				1,860	1.30	
ESE	10/03/95				4.90		9.00	195			1,680	10							422.0	111.0			11.9	127				1,740	1.00	
ESE	04/08/96				5.35	2,600	10.36	260			1,570	18							365.0				12.1	113				1,750	0.80	
ESE	12/11/96				5.03	2,670	8.98	143			1,220	18							397.0	106.0	43.3	19.4	12.3	121	18		22.0	1,870	0.80	
ESE	06/11/97				5.30	2,570	9.13	129			1,650	18							362.0	97.8	40.8	18.6	13.0	113	18	<10	19.0	1,590	0.80	
ESE	01/06/98				5.15	2,370	8.92	256			1,310	17							357.0	102.0			12.3	115	17	<10	21.0	1,540	7	
ESE	06/22/98				5.13	2,320	9.27	45			1,320	17							360.0	97.9	43.0	20.2	15.1	112	17	<10	24.0	1,290	1.10	
ESE	01/05/99	16:11			5.40	2,430	8.93	218			1,210	11							334.0	91.3	45.7	21.3	11.1	101	11	<10	24.8	1,400	0.50	
ESE	01/05/99	16:11			5.40	2,430	8.93	218			1,210	11							334.0	91.3	45.7	21.3	11.1	101	11.2	<10	25	1,400	0.5	
ESE	07/06/99	13:48			5.13	2,340	9.33	145			1,030	10							287.0	75.2	35.8	16.9	9.8	93.4	<10	<10	29	1,398	0.62	
ESE	01/11/00	15:35			5.37	2,320	9.01	298			1,210	10							341.0	86.5	38.4	18.5	11.9	106	<10	<10	31.46	1,404	0.6	
	02/07/00								5.37	2,320													11.9	106				1,404		
	06/08/00								6.13	2,250													11.4	95				1,360		
	01/02/01								5.19	1,744													10.7	97				1,388		
	06/19/01								5.23	2,220													9.7	94				1,155		
ESE	12/04/01								5.57	2,240													14.2	94				1,272		
	04/09/03	12:20	22.36		4.94	1,820	9.70		5.36	2,140	961	15	49.8	20.9	5.5	1.0	0.0	94.4	271.0	69.0	34.0	17.2	12.4	91	18	0	41.3	1,260	1.79	
	04/28/04	13:30	21.66		5.31	1,950	9.84	311	5.44	2,110	1,079	10	50.2	21.9	5.7	0.7	0.0	94.7	301.0	79.5	39.2	18.9	11.4	96	13	0	46.8	1,359	1.35	
	05/08/06	11:00	22.44	5.0	5.27	2,020	9.77	339	5.27	1,918	943	6	49.7	22.2	5.9	0.4	0.0	89.5	261.0	70.7	35.6	17.1	9.3	83	7	0	31.7	1,256	1.77	
	06/22/07	17:30	21.33	2.0	5.95	1,960	12.40	475	4.60	1,860	825	3	49.0	21.7	6.8	0.3	0.0	94.9	229.0	61.5	36.2	16.7	14.7	73	4	0	35.3	1,041	2.12	
	07/08/08	15:55	21.40	8.5	5.21	1,710	10.09	378	4.93	1,710	818	7	52.8	20.8	5.3	0.6	0.0	94.5	235.0	56.2	27.3	14.3	7.8	65	8	0	35.7	995	1.46	
	05/07/09	14:37	22.04	7.0	5.44	1,589	9.50	379	5.45	1,580	822	13	48.7	22.6	6.6	1.1	0.0	93.7	225.0	63.3	35.1	17.5	9.1	73	16	0	38.7	1,032	1.60	
	08/17/09	11:35	21.09		5.54	1,810	NR	332	4.78	1,810	804	4	50.4	22.0	6.8	0.4	0.0	98.1	224.0	59.4	34.5	15.4	8.0	64	5	0	44.7	1,062	1.37	
Fingerprint	06/14/10	15:10	NR		4.98	1,763	10.6	351	4.84	1,800	763	10	47.8	22.5	7.0	0.9	0.0	94.4	208	59.3	34.9	16.5	7.89	73	12	0	33.7	988	1.56	

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanun
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMC-12	**M#4656**																					
	04/27/83							1,720		0.20				400				2,550				
	10/12/83							1,560		5.00				290				2,000				
	04/25/84							1,150		0.60				240				1,830				
	07/24/84							1,050		0.70				250				1,720				
	10/17/84							1,250		0.40				265				2,000				
	07/30/86							1,600		0.20				230				1,800				
	07/29/87							560		0.60				220				2,120				
	07/26/88		0.06					640		1.00				240			14	2,410				
	08/02/89		<0.07					760		2.50				287			<2	2,800				
	10/22/92							907		5.70				308				4,540				
	12/22/93		0.25					1,032		0.70				305			2.0	4,904				
ESE	08/19/94		0.20							1.00				380				4,300				
ESE	03/14/95		0.09							1.00				328				4,580				
ESE	10/03/95		0.50							1.00				315				5,530				
ESE	04/08/96		0.05							1.00				239				3,340				
ESE	12/11/96		0.05					891		0.52				263				4,250				
ESE	06/11/97		0.05					851		1.10				244				3,930				
ESE	01/06/98		0.11					850		0.96				260				4,590				
ESE	06/22/98		0.05					958		3.00				240				4,010				
ESE	01/05/99		0.05					877		0.95				240				4,340				
ESE	01/05/99		0.05					877		0.95				240				4,340				
ESE	07/06/99		0.49					744		0.77				191				3,470				
ESE	01/11/00		0.05					835		1.9				244				4,190				
	02/07/00							835		1.90				244				4,190				
	06/08/00							784		1.30				196				3,200				
	01/02/01							840		1.14				222				3,810				
	06/19/01							927		<1.11				232				4,380				
ESE	12/04/01							823		<0.89				203				3,240				
	04/09/03	41.8	<1.0					978	<5	<5	<150	14.3	2.19	267		572.0	<10	2,520				
	04/28/04	52.4	<1.0					843	<5	<5	82	14.2	2.42	236		606.0	<10	3,098			NA	
	05/08/06	50.2	<.1					765	<1	3.33	82	14.0	<2	199		553.0	<2	3,498			NA	
	06/22/07	48.8	<1					412	<5	<1	102	14.3	1.16	132		448.0	<0.5	1,559			NA	
	07/08/08	45.4	<0.5					702	<0.5	0.38	100	12.0	1.07	179	149.00	436.0	<0.5	2,348	<0.5	0.48	NA	4.74
	05/07/09	53.2	<0.5					642	<0.2	0.80	110	14.8	1.35	166	18.30	451.0	0	2,878	<0.21	0.32	NA	5.30
	08/17/09	47.8	<0.5					706	0	0.59	109	15.2	1.28	176	20.70	455.0	1	3,101	<0.21	<0.25	NA	5.94
Fingerprint	06/14/10	49.4	<0.05					634	<1.0	<0.92	111	15.4	1.26	157	17.80	456	4	2,843	<2.5	<0.9	NA	5.21

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			MINOR AND TRACE METALS																
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	Palladiu	raseodymiu	Rubidium	Selenium	Tin	trontiu	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMC-12	**M#4656**																		
	04/27/83																		11,300
	10/12/83																		9,060
	04/25/84																		87,600
	07/24/84																		91,600
	10/17/84																		85,400
	07/30/86																		76,600
	07/29/87																		75,000
	07/26/88						<40												76,000
	08/02/89						110.00												89,400
	10/22/92																		88,260
	12/22/93						<2												79,060
ESE	08/19/94																		104,000
ESE	03/14/95																		86,200
ESE	10/03/95																		79,600
ESE	04/08/96																		70,700
ESE	12/11/96																		74,500
ESE	06/11/97																		68,200
ESE	01/06/98																		68,600
ESE	06/22/98																		68,300
ESE	01/05/99																		62,000
ESE	01/05/99	423	5.9			<266	0.92				314								62,000
ESE	07/06/99	351	6.7			<240	0.7				0.68								54,800
ESE	01/11/00	360	2.9			<403	1.5				1								64,500
	02/07/00																		64,500
	06/08/00																		54,700
	01/02/01																		58,700
	06/19/01																		60,600
ESE	12/04/01																		55,900
	04/09/03	384	<50				<10				<5		1,643				<2.5		59,300
	04/28/04	392	<50				<10				<5		1,698				<3		59,421
	05/08/06	388	<10			229.0	<2				9.0		1,603				1.1		52,770
	06/22/07	394	<5			167.0	2.01				<2.5		1,483				0.6		39,529
	07/08/08	303	0.27	0.29	5.40	175.0	0.61	1.93	2.28	5.45	<0.5	<0.5	1,296	<0.5	9.41	<0.5	1.0	<0.5	44,440
	05/07/09	362	0.57	<0.2	2.11	175.0	<0.76	0.56	0.60	5.61	0.867	<0.21	1,433	<0.12	8.22	<0.17	0.8	<0.25	42,777
	08/17/09	302	0.46	<0.20	2.52	177.0	0.76	<0.50	0.67	5.51	0.904	<0.21	1,266	<0.12	11.00	<0.17	0.9	<0.25	40,537
Fingerprint	06/14/10	266	<1.0	<0.9	2.13	171.0	<1.00	<2.5	<1.0	5.46	<0.9	<1.0	1,435	<1.0	8.20	<1.0	<1.0	<1.0	40,510

SAMPLE SITE	DATE	PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
		TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
AMC-13	**M#4673**																													
	04/27/83	1:10			6.80	1,345	8.2		6.40	1,347	722	30	59.2	26.4	7.7	3.5	0.0	94.5	200	54.1	30.0	7.3	4.53	16.3	36	0	10.4	756	0.16	
	07/26/88	13:42	19.80	8.0	6.60	1,030	11.9		6.52	1,195	618	40	60.9	28.9	8.3	5.7	0.0	92.3					2.35	13.00			10.6	633		
	09/28/88	2:30			6.64	549	9.0		6.57	574	202	132	46.3	19.9	28.1	43.1	0.0	36.7	57	14.7	39.3	4.3	1.05	3.42	161	0	14.5	108	0.20	
ESE	08/19/94				5.90	1309	9.4	35			835	40							244				3.78	19.4				677	0.5	
ESE	03/14/95				6.14	1285	9.4	46			755	40							207	57.4			4.02	17.2				664	0.5	
ESE	10/03/95				5.89	1279	9.3	42			756	44							194				4.22	15.7				686	0.5	
ESE	04/08/96				6.15	1291	10.3	24			672	52							168				3.99	13.8				616	0.5	
ESE	12/11/96				6.14	1250	9.3	-19			564	58							176	51.1	29.2	7.34	4.87	14.6	58	<10	19	533	0.5	
ESE	06/11/97				6.63	1209	9.4	-85			667	58							170	49.6	28.9	7.31	5.16	13.5	58.2	<10	17	587	0.5	
ESE	01/06/98				6.19	1146	8.2	63			584	59							154	48.4			4.61	12.7	59.2	<10	18	663	0.5	
ESE	06/22/98				7.66	1061	8.6	-180			572	81							147	47.3	33.2	8.53	6.32	8.64	80.6	<10	18	538	0.5	
ESE	01/07/99	10:11			6.25	1186	9.2	154			561	58							151	44.8	30.5	7.95	5.32	12.1	58.0	<10	18	505.9	0.5	
ESE	07/06/99	12:25			6.23	1175	9.6	118			495	47							134	39	25.6	6.68	5.11	11.4	46.6	<10	20	558.2	0.5	
ESE	07/06/99	12:30			6.23	1175	9.6	118			489	48							132	38.8	25.6	6.72	5.05	11.2	48.0	<10	19	563.2	0.5	
ESE	01/12/00	13:15			6.38	1139	9.3	32			585	54							161	44.3	26.8	7.05	5.9	13.3	54.4	<10	19.1	536.1	0.5	
ESE	06/08/00	18:12			7.00	1115	9.4	39			552	58							148	44.1	28.4	7.61	7.76	10.8	58	<10	18	554	0.5	
	02/26/01	3:30			6.70	1068	9.6		6.68	1138	538	81	55	28	11	13	0	82	142	44.6	31.6	7.39	4.04	9.71	99	0	18	508	<.5	
ESE	06/19/01	9:52			6.29	1086	9.3	-20			527	61							144	40.5	28.8	7.61	6.76	11.4	61.4	<10	18.3	437	0.5	
ESE	12/04/01	9:33			6.98	932	9.1	18			446	77							120	35.5	26	6.72	4.17	7.48	77.4	<10	17.7	377	0.5	
ESE	08/01/02	11:50			6.19	1018	9.6	235			497	50							135	38.9	27.2	7.18	6.56	10.6	50	<10	22	429	0.5	
ESE	08/01/02	12:30			6.19	1018	9.6	235			513	49							140	39.9	27.5	7.24	6.8	11	49.4	<10	17	445	0.5	
MBMG	07/09/08	14:35	9:36		6.39	770	11.5	343	6.31	790	351	54	53.4	26.1	11.3	12.0	0.0	81.5	94.2	28.1	22.7	5.51	6.66	7.23	66.1	0	16.4	361	<0.5	
MBMG	05/07/09	16:45	6:57	2.0	6.56	698	10.6	240	7.09	676	357	47	53.0	27.0	10.4	10.7	0.0	81.8	94.8	29.3	21.3	6.22	7.86	7.11	56.7	0	16.8	340.6	<0.5	

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Berylliun	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanun
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMC-13	**M#4673**																					
	04/27/83	37.2	0.4					120	21	0.30	90			9			16	36				
	07/26/88		0.46					60		0.40				10			4.0	23				
	09/28/88	36.1	11.40					<30.	<2.	0.40	80			6			2.0	14				
ESE	08/19/94		1.4							1				9.2				30				
ESE	03/14/95		1.17							1				5				2				
ESE	10/03/95		1.16							1				5				7				
ESE	04/08/96		1.44							1				5.1				3				
ESE	12/11/96		1.38					95.9		1.3				4.7				3.9				
ESE	06/11/97		1.02					18.5		1.1				<0.22				1.6				
ESE	01/06/98		1.37					15.2	6.8	1.2				3.3				2.8				
ESE	06/22/98		0.22					16.6		2.5				<0.23				6.8				
ESE	01/07/99		1.24					22.8		0.95				<0.658				1.5				
ESE	07/06/99		2.64					9.7		1.13				<0.83				2.2				
ESE	07/06/99		2.55					9.7		1.4				<0.77				2.2				
ESE	01/12/00		1.48					10.1		1.9				3.8				6.1				
ESE	06/08/00		0.05					12.9		1.3				<0.091				1.6				
	02/26/01	35.5	1.91					433	<1	<1	82.7	####	<2	<2		<2	<2	<2				
ESE	06/19/01		2.09					18.9		1.11				2.386				3.4				
ESE	12/04/01		0.63					30.8		0.98				<0.105				2.1				
ESE	08/01/02		2					46.9		0.96				2.651				7.2				
ESE	08/01/02		1.9					46.9		0.96				2.427				6.6				
MBMG	07/09/08	36.7	2.387					<1	<0.1	1.14	39.7	18.5	<0.1	<0.1	<0.5	0.926	<0.07	0.37	<0.04	<0.07	NA	<0.84
MBMG	05/07/09	39.6	2.51					<7.6	<0.04	1	41.6	29.3	<0.2	0.062	0.02	1.13	<0.04	<0.4	<0.04	<0.05	NA	<0.02

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SAMPLE SITE	DATE (MM/DD/YR)	Lithium Li (ug/L)	olybdenu Mo (ug/L)	Niobium Nb (ug/L)	eodymiu Nd (ug/L)	Nickel Ni (ug/L)	Lead Pb (ug/L)	Palladiun Pd (ug/L)	raseodymiu Pr (ug/L)	Rubidium Rb (ug/L)	Selenium Se (ug/L)	Tin Sn (ug/L)	trontiun Sr (ug/L)	Thorium Th (ug/L)	Titanium Ti (ug/L)	Thallium Tl (ug/L)	Uranium U (ug/L)	Tungsten W (ug/L)	Zinc Zn (ug/L)
		MINOR AND TRACE METALS																	
AMC-13	**M#4673**																		
	04/27/83	110	<20.			60.0	<40.						940						2110
	07/26/88						<40												2020
	09/28/88	20.0	<20.			10.0	<40.						320						1270
ESE	08/19/94					60	1												3300
ESE	03/14/95					70	1												2610
ESE	10/03/95					70	1												2250
ESE	04/08/96					40	3												1990
ESE	12/11/96	103	8.7			50	2.2				4.2								1940
ESE	06/11/97	105	7.5			37	0.68				4.1								1480
ESE	01/06/98	115	8.4			29	1.1				1.2								1660
ESE	06/22/98	104	5.4			14.9	3.2				1.3								294
ESE	01/07/99	107	5.9			27.9	0.92				1.06								1360
ESE	07/06/99	91.5	6.7			29.1	0.69				0.68								1260
ESE	07/06/99	92.2	6.7			31.1	0.69				0.68								1270
ESE	01/12/00	92.7	2.9			49.2	1.2				1.3								1610
ESE	06/08/00	98.2	6.5			48.1	0.64				1.05								635
	02/26/01	98.1	<10			67.6	<2				1.09		783						425
ESE	06/19/01	99.4	11.9			10.5	0.62				1.05								1340
ESE	12/04/01	90.9	10.2			28	0.48				0.94								709
ESE	08/01/02	95.9	9.9			35.1	0.75				3.74								1120
ESE	08/01/02	96.8	9.9			31	0.75				2.35								1160
MBMG	07/09/08	53.7	2.66	<0.03	<0.22	6.41	<0.5	1.26	<0.16	0.06	<0.38	<0.06	552	<0.1	2.94	<0.04	0.177	<0.05	382
MBMG	05/07/09	55.3	2.28	<0.04	<0.05	11.5	<0.15	0.17	<0.02	0.52	0.322	<0.04	584	<0.02	2.35	<0.03	0.121	0.07	260

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		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
AMC-23	**M#5018**																													
	08/18/94				6.06	2,000	7.40	72	6.06	2,000	1,190	154							360.0	0.0	0.0		1.9	0.09				865	0.90	
	03/13/95				6.30	1,930	7.64	-16	6.30	1,930	1,130	160							332.0	73.4	0.0		1.6	0.06				897	0.50	
	10/02/95									0	1,100	160							316.0	0.0	0.0		1.8	0.08				819	0.60	
	04/09/96	12:25			6.15	2,000	8.51	362	6.15	2,000	877	180							287.0	0.0	0.0		1.4	0.07				794	0.60	
	12/11/96	9:15			6.06	2,020	7.97	35	6.06	2,020	816	180							305.0	70.6	81.6	13.6	1.6	0.06	180	10	102	709	0.70	
	06/11/97	14:05			6.33	1,990	7.44	27	6.33	1,990	1,000	159							292.0	68.3	73.4	12.6	2.2	0.07	159	10	101	814	0.60	
	01/05/98	16:43			6.31	1,850	7.92	92	6.31	1,850	928	179							265.0	64.6	0.0		2.0	0.08	179	10	103	652	0.60	
	06/22/98				5.94	1,850	7.54	11	5.94	1,850	1,030	193							295.0	67.3	87.3	15.2	2.1	0.08	193	10	106	796	0.80	
	01/05/99				6.41	1,950	8.15	160	6.41	1,950	913	192							268.0	59.0	87.9	14.2	1.4	0.05		10	107	663	0.57	
	01/10/00				6.45	1,920	8.03	186	6.45	1,940	979	191							286.0	64.3	83.5	14.0	1.7	0.06	191	10	105	727	0.70	
	06/08/00				6.60	1,990	7.70	76	6.60	1,925	910	200							262.0	61.9	84.0	14.1	1.8	0.06	200	10	108	716	0.70	
	01/08/01								6.55	1,910									275.0	62.6	86.5	14.2	2.0	0.08	196	10	97	677	0.79	
	06/18/01								6.28	1,940									272.0	60.7	85.0	14.7	2.1	0.07	188	<10	90	622	0.68	
	12/04/01								6.78	1,760									271.0	62.3	81.2	14.6	6.2	0.26	162	<10	87	695	0.75	
	07/18/02	15:50			6.48	1,408		208	6.48	1,410	879	196							256.0	58.3	84.5	13.6	1.8	59.00	196		102	659	0.79	
	05/22/06	11:30	6.75	2.5	6.58	1,450	8.42	261	6.18	1,462	655	182	55.3	21.1	20.9	21.0	0.0	59.7	190.0	43.9	82.6	11.1	1.8	0.07	222	0	93	494	0.75	
	04/25/07	15:50	6.79		6.46	1,660	8.80	-65	6.36	1,555	684	181	56.6	22.1	18.1	19.0	0.0	62.1	197.0	46.7	72.5	11.5	3.2	0.09	221	0	101	567	0.92	
	07/14/08	10:50	8.15	1	6.97	1,450	10.47	257	6.95	1,420	604	205	52.8	22.0	20.9	23.0	0.0	58.1	170.7	43.2	77.6	14.7	4.4	0.27	250	0	94	496	0.65	
	10/07/09	13:59			6.71	1,510	7.36	129																						
Fingerprint	8/10/2010	12:35	9.56		6.91	1,595	13.72	149	7.10	1,604	763	195	57.12	21.47	17.31	21.70	0.00	59.51	222	50.6	77.2	12.9	6.82	0.55	237.7	0.0	96.6	513	0.771	227
	Mean				6.42	1,786	8.47	122	6.41	1,711	904	182	55.4	21.7	19.3	21.2	0.0	59.8	269.6	50.4	60.3	13.6	2.5	3.22	198	7	100	693	0.70	
	Max				6.97	2,020	13.72	362	7.10	2,020	1,190	205	57.1	22.1	20.9	23.0	0.0	62.1	360.0	73.4	87.9	15.2	6.8	59.00	250	10	108	897	0.92	
	Min				5.94	1,408	7.36	-65	5.94	0	604	154	52.8	21.1	17.3	19.0	0.0	58.1	170.7	0.0	0.0	11.1	1.4	0.05	159	0	87	494	0.50	

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		NON-METALS						MINOR AND TRACE METALS														
SAMPLE SITE	DATE (MM/DD/YR)	Silica SiO_2 (mg/L)	Nitrate NO_3-N (mg/L)	Ortho-Phosphate PO_4 (mg/L)	Tot. Phosphate (mg/L)	Tot Organic Carbon (mg/L)	Diss. Organic Carbon (mg/L)	Aluminum Al (ug/L)	Silver Ag (ug/L)	Arsenic As (ug/L)	Boron B (ug/L)	Barium Ba (ug/L)	Beryllium Be (ug/L)	Cadmium Cd (ug/L)	Cerium Ce (ug/L)	Cobolt Co (ug/L)	Cromium Cr (ug/L)	Copper Cu (ug/L)	Cesium Cs (ug/L)	Gallium Ga (ug/L)	Mercury Hg (ug/L)	Lanthanum La (ug/L)
AMC-23	**M#5018**																					
	08/18/94		9.20							5.0				12.5				127				
	03/13/95		10.30							4.0				14.1				147				
	10/02/95		9.22							4.0				13.5				147				
	04/09/96		10.60							3.0				13.0				74				
	12/11/96		10.80					25		4.1				13.9				136				
	06/11/97		8.42					19		3.4				12.5				114				
	01/05/98		9.26					35	5.5	4.4				12.1				112				
	06/22/98		8.88					17		10.7				11.2				118				
	01/05/99		5.80					23		4.6				11.4				124				
	01/10/00		10.10					10		5.5				7.5				111				
	06/08/00		9.60					13		3.3				10.7				105				
	01/08/01		9.13					19		6.1				10.3				117				
	06/18/01		8.69					<18.9		4.9				10.5			209	103				
	12/04/01		6.93					<30.8		1.1				9.8			225	59				
	07/18/02		8.15					<46.9		5.2				9.6				106				
	05/22/06	28.3	9.42					<10	<1	5.0	67.5	19.9	<2	6.4		<2	<2	40			NA	
	04/25/07	29.5	9.81					<30	<1	2.5	57.0	21.2	<0.1	4.2	<0.1	0.3	<0.1	22	<0.1	<0.1	NA	<0.1
	07/14/08	32.1	9.54					12	<0.5	1.1	86.8	14.5	<0.5	0.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	NA	<0.5
	10/07/09									1.1				3.2				10				
Fingerprint	8/10/2010	26.0	8.52	<0.05	<0.03	2.57	2.49	<4.2	<0.5	<0.6	77.0	21.00	<0.6	0.57	<0.5	0.05	<0.5	<3.0	<0.5	<0.5	NR	<0.5
	Mean	29.0	9.07					19	5.5	4.1	72.1	19.2	#DIV/0!	9.4		0.2	217	98			#DIV/0!	
	Max	32.1	10.80					35	5.5	10.7	86.8	21.2	0.00	14.1		0.3	225	147			0.00	
	Min	26.0	5.80					10	5.5	1.1	57.0	14.5	0	0.6		0.1	209	10			0	

			MINOR AND TRACE METALS																
SAMPLE SITE	DATE (MM/DD/YR)	Lithium Li (ug/L)	olybdenu Mo (ug/L)	Niobium Nb (ug/L)	eodymiu Nd (ug/L)	Nickel Ni (ug/L)	Lead Pb (ug/L)	Palladiun Pd (ug/L)	raseodymiu Pr (ug/L)	Rubidium Rb (ug/L)	Selenium Se (ug/L)	Tin Sn (ug/L)	trontiun Sr (ug/L)	Thorium Th (ug/L)	Titanium Ti (ug/L)	Thallium Tl (ug/L)	Uranium U (ug/L)	Tungsten W (ug/L)	Zinc Zn (ug/L)
AMC-23	**M#5018**																		
	08/18/94					30	1.0												2,760
	03/13/95					10	1.0												2,360
	10/02/95					10	1.0												2,110
	04/09/96					10	3.0												1,890
	12/11/96	204	8.7			16.2	2.6				5.0								2,010
	06/11/97	211	7.5			16.6	0.7				3.9								1,900
	01/05/98	263	7.1			15.8	1.7				1.2								1,580
	06/22/98	227	5.4			21.3	3.1				1.3								1,800
	01/05/99	203	5.9			20.0	0.9				1.0								1,560
	01/10/00	194	3.1			7.5	1.2				1.9								1,610
	06/08/00	199	6.5			8.5	0.6				1.1								1,470
	01/08/01	198	14.4			15.4	0.6												1,550
	06/18/01		<11.9			<10.5	<0.62				<1.05								1,480
	12/04/01		<10.2			19.3	<0.48				<0.94								1,190
	07/18/02	193	9.9			20.6	0.6				0.96								1,370
	05/22/06	149	<10			4.4	<2				2.8		2,256				69.6		905
	04/25/07	170	2.9	<0.1	<0.1	3.1	<0.2	5	<0.1	15	1.5	<0.1	2,605	0.1	5	<0.1	59.2	<1.0	630
	07/14/08	142.5	2.2	<0.5	<0.5	2.2	<0.5	6	<0.5	15	<0.5	<0.5	2,433	<0.5	7	<0.5	61.3	<0.5	212
	10/07/09						0.1												441
Fingerprint	8/10/2010	163.00	1.19	<0.7	<0.4	<0.6	<2.5	0.74	<0.5	15.8	1.07	<3.0	2,862	<2.5	4.40	<2.5	26.50	<0.6	207
	Mean	194	6.2			13.6	1.29				1.97		2,539				54.2		1,452
	Max	263	14.4			30.0	3.10				5.00		2,862				69.6		2,760
	Min	143	1.2			2.2	0.05				0.96		2,256				26.5		207

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		PHYSICAL AND CALCULATED PARAMETERS																	**MAJOR CATIONS AND ANIONS**											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
AMC-24	**M#: 5034**																													
	08/18/94	11:30			6.12	488	8.45	29	6.12	488	837	106							246.0	0.0	0.0		2.5	1.27				640	0.60	
	03/13/95	9:52			6.35	1,460	8.51	6	6.35	1,460	835	102							232.0	61.9	0.0		1.4	1.26				717	0.50	
	10/02/95	12:10			6.15	914	8.40	-33	6.15	914	733	114							198.0	0.0	0.0		4.3	1.32				809	0.50	
	04/09/96	11:30			6.23	1,650	8.81	278	6.23	1,650	795	110							223.0	0.0	0.0		6.6	1.94				760	0.50	
	12/11/96	9:52			6.13	1,730	8.72	-1	6.13	1,730	680	108							254.0	70.0	65.2	11.4	2.3	1.31	108	10.0	31	734	0.50	
	06/11/97	12:10			6.23	1,660	7.82	16	6.23	1,660	832	116							237.0	657.0	60.9	10.8	3.2	1.30	116	10.0	29	759	0.50	
	01/05/98	17:20			6.39	1,850	8.51	143	6.39	1,530	868	116							233.0	69.7	0.0		8.2	1.34	116	10.0	31	695	0.50	
	06/22/98				6.05	1,850	7.79	4	6.05	1,520	930	114							248.0	73.5	77.0	13.6	5.4	1.49	114	10.0	33	994	0.50	
	01/05/99	11:30	9.03		6.30	1,820	8.80		6.30	1,820	964	110	57.5	26.4	13.8	10.0	0.0	85.3	260.0	72.5	71.4	12.2	2.1	1.26	139	0.0	33	935	<.5	
	01/10/00				6.30	1,920	8.89	243	6.30	1,920	1,060	104							293.0	80.4	72.1	13.0	2.6	1.58	104	10.0	40	931	0.50	
	06/08/00				6.75	1,999	8.10	74	6.75	2,000	1,030	117							278.0	80.7	76.9	13.7	4.8	1.81	117	10.0	41	1,000	0.50	
	01/08/01								6.47	1,980									295.0	81.6	78.9	13.1	2.0	1.47	104	10.0	39	917	0.50	
	06/18/01								6.21	2,000									292.0	78.5	78.4	13.5	4.4	1.68	116	<10	40	885	<0.5	
	06/18/01								6.21	2,000									315.0	84.1	87.8	15.5	4.5	1.77	114	<10	39	498	<0.5	
	12/04/01								6.53	1,950									294.0	81.7	77.8	13.8	7.7	1.75	113	<10	37	959	<0.5	
	07/18/02	14:55			6.50	1,489	7.90	202	6.45	1,490	1,085	106							299.0	82.4	78.1	13.2	4.5	1.65	106		40	1,079	0.50	
	05/19/06	0:00	10.26	2	6.50	729	8.57	257	6.10	756	316	82	53.3	25.4	17.2	19.9	0.0	71.4	85.8	24.8	31.7	6.9	1.3	1.26	99	0.0	17	280	0.51	
	04/25/07	11:58	10.12		6.35	850	8.80	89	6.28	835	347	83	53.7	26.1	16.5	17.7	0.0	74.1	93.6	27.4	32.9	7.8	1.2	0.97	101	0.0	21	332	0.59	
Trec	12/21/07	14:11			6.10	771	8.87	347																						
	07/28/08	11:45	11.07	2	6.57	640	9.83	212	6.46	660	226	77	51.2	25.4	18.2	23.8	0.0	60.3	60.6	18.2	24.7	5.6	1.9	1.01	94	0.0	23	188	0.52	
Trec	10/13/09				6.31	522	8.85	130																						
Fingerprint	4/16/2010	17:45	11.21		6.37	440	12.83	195	6.53	465	169	58	49.00	23.14	18.53	25.72	0.00	49.90	46.1	13.2	20.0	5.3	4.96	0.55	71.0	0.0	25.3	108	0.482	81
	8/10/2010	15:00	11.19	2	5.61	505	10.41	394	6.48	527	176	71	50.66	26.05	18.23	27.12	0.00	51.68	46.5	14.5	19.2	4.9	1.11	0.56	85.9	0.0	26.4	129	0.5	<50
	Mean				6.28	1,226	8.89	144	6.32	1,398	699	100	52.6	25.4	17.1	20.7	0.0	65.4	215.7	79.6	45.4	10.9	3.7	1.36	107	5.4	32	683	0.51	
	Max				6.75	1,999	12.83	394	6.75	2,000	1,085	117	57.5	26.4	18.5	27.1	0.0	85.3	315.0	657.0	87.8	15.5	8.2	1.94	139	10.0	41	1,079	0.60	
	Min				5.61	440	7.79	-33	6.05	465	169	58	49.0	23.1	13.8	10.0	0.0	49.9	46.1	0.0	0.0	4.9	1.1	0.55	71	0.0	17	108	0.48	

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanun
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMC-24	**M#: 5034**																					
	08/18/94		2.50							3.0				1.9				6				
	03/13/95		2.00							2.0				1.5				2				
	10/02/95		1.67							17.0				1.8				5				
	04/09/96		1.79							30.0				1.9				3				
	12/11/96		2.32					25		6.8				2.4				3				
	06/11/97		1.70					19		16.5				1.9				2				
	01/05/98		1.26					30	3.3	11.4				1.0				2				
	06/22/98		2.12					17		17.7				1.5				8				
	01/05/99	27.1	2.11					<30	<1	4.9	120	19.7	<2	2.1		3.7	3.9	<2				
	01/10/00		2.71					10		7.3				3.2				2				
	06/08/00		1.50					13		25.2				2.5				2				
	01/08/01		1.87					19		4.3				3.0				7				
	06/18/01		2.33					<18.9		19.1				2.2			128.0	1				
	06/18/01		2.00					<18.9		19.0				2.2			144.0	<1.3				
	12/04/01		1.57					<30.8		35.1				1.6			126.0	<1.6				
	07/18/02		1.95					<46.9		24.1				1.6				4				
	05/19/06	28.5	2.75					<10	<1	2.2	74.2	23.2	<2	<1		<2	<2	<2			NA	
	04/25/07	29.7	2.15					30	<1	3.5	69.2	22.7	<0.1	0.98	<0.1	1.0	<0.1	1	<0.1	<0.1	NA	<0.1
Trec	12/21/07									1.5				1.42				4				
	07/28/08	26.3	5.01					<1	<0.1	1.2	67.0	20.2	<0.1	1.24	<0.5	0.6	<0.1	3	<0.1	<0.1	NA	<1
Trec	10/13/09									1.6				1.50				2				
Fingerprint	4/16/2010	32.3	5.09	<0.05	<0.03	2.2	<0.25	<4.2	<0.5	5.98	77.1	26.00	<0.6	<0.5	<0.5	<0.4	<0.5	<3.0	<0.5	<0.5	NR	<0.5
	8/10/2010	33.7	4.65	<0.05	<0.030	NR	NR	<2.02	0.3.99	1.15	59.6	31.96	<0.20	1.06	<0.20	0.29	<0.20	2	<0.51	<0.19	NR	<0.20
	Mean	29.6	2.43					20	3.3	11.3	78	24.0	#DIV/0!	1.8		1.4	100.5	3			#DIV/0!	
	Max	33.7	5.09					30	3.3	35.1	120	32.0	0	3.2		3.7	144.0	8			0	
	Min	26.3	1.26					10	3.3	1.2	60	19.7	0	0.98		0.3	3.9	1			0	

SAMPLE SITE	DATE (MM/DD/YR)	MINOR AND TRACE METALS Lithium Li (ug/L)	Iolybdenu Mo (ug/L)	Niobium Nb (ug/L)	Ieodymiu Nd (ug/L)	Nickel Ni (ug/L)	Lead Pb (ug/L)	Palladiun Pd (ug/L)	raseodymiu Pr (ug/L)	Rubidium Rb (ug/L)	Selenium Se (ug/L)	Tin Sn (ug/L)	Strontiun Sr (ug/L)	Thorium Th (ug/L)	Titanium Ti (ug/L)	Thallium Tl (ug/L)	Uranium U (ug/L)	Tungsten W (ug/L)	Zinc Zn (ug/L)
AMC-24	**M#: 5034**																		
	08/18/94					10.0	1.0												380
	03/13/95					10.0	1.0												360
	10/02/95					10.0	1.0												296
	04/09/96					10.0	3.0												386
	12/11/96	139	8.7			16.2	2.6				4.2								392
	06/11/97	122	7.5			16.6	0.7				3.7								345
	01/05/98	147	7.1			15.8	0.8				1.2								243
	06/22/98	137	5.4			14.9	3.2				1.3								346
	01/05/99	<100	<10			78.8	<2				<1		1,510						289
	01/10/00	127	2.9			10.2	1.2				0.8								489
	06/08/00	133	6.5			10.0	0.6				1.1								428
	01/08/01	120	11.9			15.4	0.6												501
	06/18/01		<11.9			<10.5	<0.62				<1.05								443
	06/18/01		<11.9			<10.5	<0.62				<1.05								483
	12/04/01		<10.2			<12.5	<0.48				<0.94								367
	07/18/02	131	9.9			20.6	0.6				1.0								416
	05/19/06	69.7	<10			2.2	<2				<1		595						431
	04/25/07	82.3	4.0	<0.1	<0.1	1.7	<0.2	1	<0.1	0.3	<0.5	<0.1	700	0.1	3	<0.1	2.34	<1.0	422
Trec	12/21/07						0.0												319
	07/28/08	39	4.1	<0.1	<0.2	1.4	<0.5	0	<0.1	<0.1	<0.5	<0.1	399	<0.1	1	<0.1	1.52	<0.1	349
Trec	10/13/09																		414
Fingerprint	4/16/2010	39.60	<0.4	<0.7	<0.4	0.69	<2.5	<0.6	<0.5	<0.5	<1.0	<3.0	313	<2.5	0.86	<2.5	<3.0	<0.6	70
	8/10/2010	30.10	2.04	<0.17	<0.20	0.57	<0.20	<0.51	<0.20	<0.51	0.51	<0.20	354	<0.20	1.05	<0.20	0.83	<0.20	430
	Mean	101	6.4			13.6	1.3				1.7		645				1.56		374
	Max	147	11.9			78.8	3.2				4.2		1,510				2.34		501
	Min	30	2.0			0.6	0.0				0.5		313				0.83		70

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		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS												
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS						
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
AMC-24B																															
Trec	**12/19/07**				6.24	1,905	8.70	270			903	66							265.0	58.7	102.0	15.6	0.1	0.07	66		30	1,070		
Trec	**09/10/08**				6.17	1,720	8.66	123	6.20	1,620	828	58							236.0	58.4	104.0	16.0	0.0	0.01	59		32	877		
Trec	**10/14/09**																													
Trec	4/18/2010	11:35	11.14	0.15	6.23	1,464	10.79	350	6.67	1,520	634	58	52.83	20.52	23.93	6.37	0.00	88.67	183	43.1	95.1	14.1	<0.006	0.00	70.8	0.0	28.0	775	0.639	73
Fingerprint	8/10/2010	13:30	10.88	0.17	5.18	1,552	13.89	482	6.42	1,434	658	55	56.24	20.12	21.02	6.15	0.00	88.89	194	42.1	83.2	13.3	<0.010	<0.005	67.3	0.0	37.2	765	0.643	<50
AMC-24C																															
Trec	5/28/2010	9:35									408	72							136	26.0	81.4	12.1	<0.009				29.0	528	0.485	
Fingerprint	6/2/2010	10:30	9.05		7.64	1,075	9.80	334	6.80	1,067	394	76	50.33	17.02	29.56	12.42	0.00	81.17	118	24.2	79.5	11.8	<0.010	0.02	92.7	0.0	26.6	477	0.497	73
MBMG	8/10/2010	13:00		3	5.85	1,158	10.35	491	6.94	1,105	405	66	50.25	19.34	26.96	11.24	0.00	82.75	117	27.3	72.0	13.9	<0.010	0.01	80.5	0.0	24.1	466	0.493	<50
AMW-01A																															
Trec	01/09/08	13:39				1,147	9.20	242	5.71																					
Trec	09/17/08	12:56			6.35	1,017	16.24	198	6.80	909	380	184		17.9					123.0		40.3	13.0	12.2	6	184		33	269		
Trec	11/05/09	13:17																												
Fingerprint	4/22/2010	16:30	10.76		6.43	868	9.60	252	6.48	898	315	84	32.02	35.42	16.21	19.05	0.00	20.64	59.9	40.2	34.8	6.5	21.20	2.40	103.1	0.0	185.6	88	1.95	930
AMW-1B	**M#211600**																														
MBMG	04/06/04	16:15			4.25	3,750	11.60	368	4.05	4,090	1,800	0	30.0	21.0	5.8	0.0	0.0	94.0	424.0	180.0	94.0	25.6	169.0	274	0	0.0	134	3,037	3.63	
MBMG	05/22/06	14:00	10.85	2.5	4.20	4,000	10.79	463	4.28	4,040	1,865	0	34.7	21.6	5.1	0.0	0.0	95.1	460.0	174.0	78.1	25.6	36.4	319	0	0.0	107	3,209	7.51	
MBMG	04/24/07	11:01	10.65	2.0	4.08	3,890	10.70	205	4.21	3,940	1,819	0	32.9	22.2	5.1	0.0	0.0	94.4	435.0	178.0	77.2	28.7	43.8	331	0	0.0	121	3,007	5.26	
Trec	12/20/07				4.37	4,400	10.10	287																						
MBMG	07/29/08	16:00	10.42	2.0	4.81	4,430	12.61	358	4.62	4,070	1,891	2	36.1	22.4	5.0	0.1	0.0	93.2	467.0	176.0	74.8	25.4	6.0	341	3	0.0	123	2,659	3.40	
Trec	09/17/08	14:26				3,800	12.43	224			1,870	9							450.0	182.0	77.8	26.9	4.3	340	9		111	3,200		
TRec	11/05/09	10:14																												
Pump Test	02/01/10	10:00	26.01	90.0	4.18	4,099	11.37	390	4.29	4,220	1,891	0	36.3	21.9	5.3	0.0	0.0	92.7	472.0	173.0	78.4	28.5	5.1	321	0	0	143.4	2,885	5.90	
Pump Test	02/01/10	16:00	27.96	90.0	4.06	4,045	11.35	383	4.24	4,160	1,848	0	35.6	22.3	5.3	0.0	0.0	92.9	455.0	173.0	77.6	28.1	8.5	313	0	0	136.1	2,853	5.86	
Pump Test	02/02/10	9:30	29.20	90.0	4.04	4,037	11.30	334	4.18	4,310	1,867	0	37.1	21.4	5.1	0.0	0.0	93.1	474.0	166.0	75.2	26.7	10.6	306	0	0	131.8	2,841	6.42	
Pump Test	02/02/10	16:20		90.0	4.05	4,031	11.30	335	4.13	4,290	1,827	0	36.6	22.0	5.1	0.0	0.0	93.2	458.0	166.0	74.8	26.8	11.9	293	0	0	132.2	2,875	6.53	
Pump Test	02/03/10	15:00	29.19	90.0	4.03	4,013	11.26	335	4.16	4,290	1,820	0	36.2	21.6	5.3	0.0	0.0	93.6	457.0	165.0	76.7	26.6	19.6	299	0	0	128.7	2,992	6.32	
Pump Test	02/04/10	9:30		90.0	4.06	4,027	11.12	314	4.30	4,340	1,849	0	36.9	21.0	5.1	0.0	0.0	92.9	472.0	163.0	75.4	26.0	28.4	296	0	0	136.8	2,830	6.34	
Fingerpring	4/22/2010	14:20	10.58		4.27	4,033	12.80	491	4.50	4,020	1,821	0	34.33	22.06	5.41	0.00	0.00	94.64	444	173	80.2	25.5	5.03	333.00	0.0	0.0	101.7	2,954	5.54	263
									4.90	3,990																				
	Mean				4.20	4,043	11.44	345	4.32	4,147	1,847	1	35.2	21.8	5.2	0.0	0.0	93.6	455.7	172.4	78.4	26.7	29.1	314	1.0	0.0	126	2,945	5.70	
	Max				4.81	4,430	12.80	491	4.90	4,340	1,891	9	37.1	22.4	5.8	0.1	0.0	95.1	474.0	182.0	94.0	28.7	169.0	341	8.8	0.0	143	3,209	7.51	
	Min				4.03	3,750	10.10	205	4.05	3,940	1,800	0	30.0	21.0	5.0	0.0	0.0	92.7	424.0	163.0	74.8	25.4	4.3	274	0.0	0.0	102	2,659	3.40	

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanun
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMC-24B																						
Trec	**12/19/07**									3.5				10.00				208				
Trec	**09/10/08**									4.3				10.00				240				
Trec	**10/14/09**									4.7				9.20				187				
Trec	4/18/2010	37.7	1.09	<0.05	<0.03	1.86	<0.25	<4.2	<0.5	4.09	79.2	18.50	<0.6	7.07	<0.5	<0.4	<0.5	158	<0.5	<0.5	NR	<0.5
Fingerprint	8/10/2010	38.4	1.24	<0.05	0.042	NR	NR	<10.10	<1.01	4.47	77.2	18.30	<1.01	7.00	<1.01	<0.93	<1.01	171	<2.53	<0.93	NR	<1.01
AMC-24C																						
Trec	5/28/2010	22.9	<0.003		0.063					6.92				4.03				54				
Fingerprint	6/2/2010	40.4	0.106	<0.05	<0.048	NR	NR	<38.38	<0.20	7.04	89.6	14.60	<1.01	3.74	0.11	<0.51	<0.20	53	<0.21	<0.25	NR	<0.11
MBMG	8/10/2010	48.1	<0.05	<0.05	0.042	NR	NR	<10.01	<1.01	7.17	79.8	13.50	<1.01	3.76	<1.01	<0.93	<1.01	57	<2.53	<0.93	NR	<1.01
AMW-01A																						
Trec	01/09/08									18.7				12				6				
Trec	09/17/08									20.0				42				19				
Trec	11/05/09									12.5				7				8				
Fingerprint	4/22/2010	26.2	0.148	<0.05	<0.03			42.8	<0.1	56.00	460	81.80	<0.1	0.13	<0.1	10.40	<0.1	2.24	<0.1	<0.1	NR	<0.1
AMW-1B	**M#211600**																					
MBMG	04/06/04	81.8	1.30					11,416	<10	<10	607	<20	<20	1,259		935.0	<20	97,040			NA	
MBMG	05/22/06	82.8	<2.5					15,109	<10	<10	<30	28.6	<20	1,260		807.0	<20	94,417			NA	
MBMG	04/24/07	80.8	<2.5					13,429	<5	<5	194	18.8	10.0	1,198	677	682.0	<0.5	91,847	<0.5	2.07	NA	154
Trec	12/20/07									6.9				1,280				84,900				
MBMG	07/29/08	71.1	4.45					6,579	<1	2.7	147	48.2	8.1	1,232	7,432	539.0	<0.5	83,994	<0.5	4.00	NA	3,079
Trec	09/17/08									5.6				1,100				87,300				
TRec	11/05/09									6.5				1,430				96,900				
Pump Test	02/01/10	77.5	5.57					11,359	<1.62	<4.04	169	12.0	11.0	57.1	930	627	<1.62	94,009	<1.7	3.88	NR	194
Pump Test	02/01/10	77.4	5.34					11,306	<1.62	<4.04	177	10.3	11.2	57.0	938	658	<1.62	88,998	<1.7	4.17	NR	195
Pump Test	02/02/10	74.7	4.49					12,440	<1.62	<4.04	168	10.2	12.8	55.4	1,026	694	<1.62	87,257	<1.7	4.02	NR	214
Pump Test	02/02/10	75.6	4.34					12,397	<1.62	<4.04	170	10.2	13.0	54.9	1,064	675	<1.62	85,571	<1.7	3.91	NR	228
Pump Test	02/03/10	74.7	4.02					12,908	2.18	<4.04	170	10.2	13.3	54.0	1,084	721	<1.62	85,178	<1.7	4.13	NR	231
Pump Test	02/04/10	73.1	3.94					13,057	3.76	<4.04	176	9.9	13.3	54.6	1,122	748	<1.62	85,513	<1.7	4.25	NR	242
Fingerpring	4/22/2010	77.5	4.53	<0.25	<0.3	2.38	<0.25	13,153	<1.1	1.40	154	11.60	9.00	1,200.00	657	538.00	<1.0	102,087	<1.0	2.83	NR	135
	Mean	77.0	4.22					12,105	2.97	4.64	213	17.0	11.3	735		693.1	#DIV/0!	90,358			#DIV/0!	
	Max	82.8	5.57					15,109	3.76	6.94	607	48.2	13.3	1,430		935.0	0	102,087			0	
	Min	71.1	1.30					6,579	2.18	1.40	147	9.9	8.1	54		538.0	0	83,994			0	

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			MINOR AND TRACE METALS																
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	Palladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMC-24B																			
Trec	**12/19/07**						0.1												2,190
Trec	**09/10/08**						0.1												2,100
Trec	**10/14/09**						0.1												1,720
Trec	4/18/2010	206.00	1.96	<0.7	<0.4	4.69	<2.5	<0.6	<0.5	15.1	<1.0	<3.0	2,191	<2.5	6.37	<2.5	<3.0	<0.6	1,568
Fingerprint	8/10/2010	196.00	2.16	<1.01	<1.01	5.36	<1.01	<2.53	<1.01	15.8	<0.93	<1.01	2,097	<1.01	7.08	<1.01	1.59	<1.01	1,590
AMC-24C																			
Trec	5/28/2010						<0.055												513
Fingerprint	6/2/2010	252.00	3.16	<0.20	<0.26	1.52	<0.77	1.56	<0.11	11.1	<0.51	<0.21	1,486	<0.12	4.89	<0.17	2.59	<0.25	473
MBMG	8/10/2010	206.00	3.41	<0.86	<1.01	1.19	<1.01	<2.53	<1.01	11.5	<0.93	<1.01	1,541	<1.01	5.21	<1.01	2.77	<1.01	58
AMW-01A																			
Trec	01/09/08						0.7												8,530
Trec	09/17/08																		11,800
Trec	11/05/09						0.2												4,860
Fingerprint	4/22/2010	324.00	7.83	<0.1	<0.1	6.69	<0.5	<0.1	<0.1	2.31	2.22	<0.6	285.00	<0.5	1.19	<0.5	1.60	0.46	2,697
AMW-1B	**M#211600**																		
MBMG	04/06/04	871	<100			308	27.4				<10		4,332				55.6		208,950
MBMG	05/22/06	954	<100			673	<20				16.8		4,744				82.6		215,461
MBMG	04/24/07	1003	<5	<0.5	83	516	19.1	9	26	30	3.9	<0.5	5,041	0.5	27	<0.5	63.1	<5.0	217,170
Trec	12/20/07						11.8												158,000
MBMG	07/29/08	732	<1.0	<0.5	287	570	35.5	8	139	26	<3.0	<1.0	4,417	<0.1	22	<0.5	30.1	<0.5	218,848
Trec	09/17/08						27.0												228,000
TRec	11/05/09						17.2												243,000
Pump Test	02/01/10	745	<1.62	<1.62	121	634	18.4	10.2	36.1	34.9	4.58	<1.66	4,621	<0.93	34.0	<1.33	57.2	<2.02	219,586
Pump Test	02/01/10	738	<1.62	<1.62	121	627	14.4	11.7	36.0	34.9	4.07	<1.66	4,429	<0.93	33.9	<1.33	59.6	<2.02	217,220
Pump Test	02/02/10	742	<1.62	<1.62	131	632	12.9	10.6	38.8	35.8	4.32	<1.66	4,444	<0.93	33.0	<1.33	64.6	<2.02	212,813
Pump Test	02/02/10	741	<1.62	<1.62	135	635	13.7	10.7	41.1	35.7	<4.04	<1.66	4,310	<0.93	32.2	<1.33	65.1	<2.02	209,832
Pump Test	02/03/10	717	<1.62	<1.62	136	622	12.9	11.4	41.0	34.9	<4.04	<1.66	4,313	<0.93	32.5	<1.33	67.4	<2.02	208,454
Pump Test	02/04/10	703	<1.62	<1.62	141	620	13.2	11.9	42.4	34.7	<4.04	<1.66	4,323	<0.93	29.3	<1.33	67.9	<2.02	207,545
Fingerpring	4/22/2010	713	<0.9	<1.4	84.9	581.0	12.20	7.97	25.2	36.0	3.28	<6.1	4,621	<5.1	22.7	<5.1	54.7	<1.3	222,675
	Mean	787	#DIV/0!			583	18.1				6.2		4,509				60.7		213,397
	Max	1,003	0.00			673	35.5				16.8		5,041				82.6		243,000
	Min	703	0.00			308	11.8				3.3		4,310				30.1		158,000

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		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
AMW-1C	**M#211601**																													
MBMG	04/06/04	13:00			5.12	2,190	11.28	353	5.67	2,430	1,092	8	47.5	20.0	24.1	0.5	0.0	97.7	308.0	78.5	179.0	27.6	3.3	21.50	10	0.0	17	1,531	1.81	
MBMG	05/22/06	13:45	9.56	2	5.41	2,380	10.65	412	5.47	2,440	1,094	18	48.3	19.3	24.8	1.1	0.0	98.7	313.0	75.9	184.0	29.5	0.1	16.00	22	0.0	<10	1,556	1.54	
MBMG	04/24/07	14:50	10.23	2	5.36	2,510	11.30	180	5.39	2,540	1,131	16	48.2	20.0	23.9	1.0	0.0	99.0	320.0	80.6	182.0	28.6	1.1	16.90	19	0.0	<25	1,526	<2.5	
MBMG	07/29/08	15:30	9.93	8	5.53	2,460	11.72	340	5.67	2,310	958	21	48.7	20.2	23.1	1.6	0.0	96.9	271.0	68.4	145.9	25.9	1.1	13.80	26	0.0	9	1,183	0.98	
Trec	11/05/09	12:37				3	10.68	275	5.32																					
Fingerprint	4/22/2010	16:15	10.76		5.49	2,570	12.79	391	6.30	2,550	1,117	21	47.34	20.76	24.29	1.21	0.00	97.57	311	83	183	28.2	0.01	16.80	26.0	0.0	11.9	1,644	1.27	<250
	Mean				5.38	2,019	11.40	325	5.64	2,454	1,078	17	48.0	20.1	24.0	1.1	0.0	98.0	304.6	77.2	174.8	28.0	1.1	17.00	20.7	0.0	12.7	1,488	1.40	
	Max				5.53	2,570	12.79	412	6.30	2,550	1,131	21	48.7	20.8	24.8	1.6	0.0	99.0	320.0	82.7	184.0	29.5	3.3	21.50	26.4	0.0	17.0	1,644	1.81	
	Min				5.12	3	10.65	180	5.32	2,310	958	8	47.3	19.3	23.1	0.5	0.0	96.9	271.0	68.4	145.9	25.9	0.0	13.80	10.0	0.0	9.2	1,183	0.98	
AMW-08	**M#137598**																													
	08/17/09	8:09	37.27		4.77	4,770	12.58	371	3.12	4,890	1,553	0	20.1	16.7	3.6	0.0	0.0	97.5	340.0	171.0	70.6	13.5	540.1	283	0.0	0.0	67	3,939	3.67	
	Mean				4.77	4,770	12.58	371	3.12	4,890	1,553	0	20.1	16.7	3.6	0.0	0.0	97.5	340.0	171.0	70.6	13.5	540.1	283.00	0.00	0.00	67.26	3,939	3.67	
	Max				4.77	4,770	12.58	371	3.12	4,890	1,553	0	20.1	16.7	3.6	0.0	0.0	97.5	340.0	171.0	70.6	13.5	540.1	283.00	0.00	0.00	67.26	3,939	3.67	
	Min				4.77	4,770	12.58	371	3.12	4,890	1,553	0	20.1	16.7	3.6	0.0	0.0	97.5	340.0	171.0	70.6	13.5	540.1	283.00	0.00	0.00	67.26	3,939	3.67	
AMW-09	**M#137601**																													
	08/17/09	21:05	23.19		4.29	2,160	10.25	435	4.10	2,320	897	0	56.0	11.1	8.5	0.0	0.0	96.8	300.0	36.0	52.2	13.8	48.0	26	0.0	0.0	31	1,556	3.30	
	Mean				4.29	2,160	10.25	435	4.10	2,320	897	0	56.0	11.1	8.5	0.0	0.0	96.8	300.0	36.0	52.2	13.8	48.0	25.70	0.00	0.00	31.47	1,556	3.30	
	Max				4.29	2,160	10.25	435	4.10	2,320	897	0	56.0	11.1	8.5	0.0	0.0	96.8	300.0	36.0	52.2	13.8	48.0	25.70	0.00	0.00	31.47	1,556	3.30	
	Min				4.29	2,160	10.25	435	4.10	2,320	897	0	56.0	11.1	8.5	0.0	0.0	96.8	300.0	36.0	52.2	13.8	48.0	25.70	0.00	0.00	31.47	1,556	3.30	
AMW-13																														
Fingerprint	4/16/2010	12:45	11.57		6.47	2,282	12.10	139	8.11	2,180	1,251	544	62.71	18.26	6.57	35.06	0.00	62.87	388	68.5	46.6	41.8	46.60	1.36	662.5	0.0	22.3	935	0.285	<250
	8/11/2010	10:00	10.06	2	5.75	667	16.29	145	6.72	670	459	377	80.86	11.43	3.50	61.47	0.00	36.15	161	13.8	8.0	10.7	0.83	0.23	338.0	0.0	7.2	156	0.226	<50
AMW-13B																														
Fingerprint	4/16/2010	13:15	11.14		7.09	305	9.87	240	7.50	395	94	89	42.94	16.93	37.15	53.32	0.00	37.76	26.9	6.4	26.7	3.3	0.01	0.00	108.3	0.0	7.2	60	1.22	55
	8/10/2010	16:30	10.89	2	6.38	319	10.20	458	6.93	310	88	86	44.88	15.74	36.44	52.41	0.00	38.52	26.0	5.5	24.2	3.0	<0.002	<0.001	104.7	0.0	7.2	61	1.23	<50
AMW-13C																														
	5/28/2010	10:20									372	58											<0.009				6.7	364	1.08	
Fingerprint	6/2/2010	11:30			7.82	805	9.65	327	6.90	808	311	53	51.41	20.43	25.17	11.82	0.00	86.95	89.2	21.5	40.1	9.0	<0.002	0.07	65.3	0.0	1.4	378	1.01	<50
	8/10/2010	16:00		3	5.50	862	10.50	474	6.82	826	362	59	54.08	24.83	17.91	12.86	0.00	84.12	99.5	27.7	37.8	10.3	0.01	0.05	71.7	0.0	7.6	369	1.04	<50

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanun
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMW-1C	**M#211601**																					
MBMG	04/06/04	53.8	<1					189	<5	6.4	241	4.0	<2	522		<10	<10	4,344			NA	
MBMG	05/22/06	52.2	<1.0					186	<2	6.9	167	3.7	<2	104		4.2	<2	4,357			NA	
MBMG	04/24/07	53.9	<2.5					235	<5	7.1	197	3.1	0.6	110	5	5.8	<0.5	5,033	0.67	<0.5	NA	0.8
MBMG	07/29/08	45.9	<0.5					146	<1	6.2	170	4.46	<1	86	17	3.6	<0.5	3,432	0.62	<1.0	NA	<10.0
Trec	11/05/09									8.6				127				5,230				
Fingerprint	4/22/2010	50.4	0.35	<0.25	<0.15	2.08	<0.25	180	<0.5	6.63	199	1.72	0.65	104.00	2.69	3.69	<0.5	4,916	0.65	<0.5	NR	<0.5
	Mean	51.2	0.35					187	#DIV/0!	7.0	195	3.4	0.6	176		4.3	#DIV/0!	4,552			#DIV/0!	
	Max	53.9	0.35					235	0	8.6	241	4.5	0.7	522		5.8	0	5,230			0	
	Min	45.9	0.35					146	0	6.2	167	1.7	0.6	86		3.6	0	3,432			0	
AMW-08	**M#137598**																					
	08/17/09	56.9	<2.5					7,323	0.74	29.10	92	12.3	7.2	266	206	569.0	2	8,103	<0.42	0.79	NR	88
	Mean	56.90	#DIV/0!					7,323	0.74	29.10	92.40	12.30	7.15	266.00		569.0	1.61	8,103			#DIV/0!	
	Max	56.90	0.00					7,323	0.74	29.10	92.40	12.30	7.15	266.00		569.0	1.61	8,103			0.00	
	Min	56.90	0.00					7,323	0.74	29.10	92.40	12.30	7.15	266.00		569.0	1.61	8,103			0.00	
AMW-09	**M#137601**																					
	08/17/09	68.8	<0.5					5,903	<0.20	<0.50	67	7.2	6.0	162	272	193.0	<0.20	16,233	<0.21	0.43	NA	114
	Mean	68.80	#DIV/0!					5,903	#DIV/0!	#DIV/0!	66.70	7.23	6.04	162.00		193.0	#DIV/0!	16,233			#DIV/0!	
	Max	68.80	0.00					5,903	0.00	0.00	66.70	7.23	6.04	162.00		193.0	0.00	16,233			0.00	
	Min	68.80	0.00					5,903	0.00	0.00	66.70	7.23	6.04	162.00		193.0	0.00	16,233			0.00	
AMW-13																						
Fingerprint	4/16/2010	21.3	<0.25	<0.25	<0.03	2.80	<0.25	<4.2	<0.5	6.59	1,606	38.50	<0.6	0.58	<0.5	1.08	<0.5	3.65	<0.5	<0.5	NR	<0.5
	8/11/2010	17.6	<0.05	<0.05	0.036	NR	NR	<2.02	0.23	0.70	387	365.00	<0.20	3.58	<0.20	0.27	<0.20	27.80	<0.51	<0.19	NR	<0.20
AMW-13B																						
Fingerprint	4/16/2010	33.7	0.428	<0.05	<0.03	1.66	<0.25	1.40	<0.1	3.28	28.3	28.20	<0.1	0.25	<0.1	<0.1	0.43	1.24	<0.1	<0.1	NR	<0.1
	8/10/2010	34.6	0.389	<0.05	0.044	NR	NR	<2.02	<0.20	3.53	27.6	28.10	<0.20	0.28	<0.20	<0.19	0.36	1.18	<0.51	<0.19	NR	<0.20
AMW-13C																						
	5/28/2010		0.10		0.063					4.47				2.76				0.88				
Fingerprint	6/2/2010	44.7	0.26	<0.05	0.054	NR	NR	<7.68	<0.04	5.00	22.2	16.80	<0.20	2.56	0.09	0.31	0.13	0.97	<0.04	<0.05	NR	0.04
	8/10/2010	47.7	0.093	<0.05	0.041	NR	NR	4.96	<0.20	5.35	21.7	16.80	<0.20	2.62	<0.20	<0.19	<0.20	1.84	<0.51	<0.19	NR	<0.20

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			MINOR AND TRACE METALS																
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	Palladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMW-1C	**M#211601**																		
MBMG	04/06/04	787	<50			109	<10				<5		7,288				<3		23,167
MBMG	05/22/06	829	<10			128	<2				1.4		7,881				1.3		25,063
MBMG	04/24/07	802	<5	<0.5	1.3	124	2.2	14	<0.5	62	<2.5	<0.5	8,684	<0.25	5	<0.5	1.2	<5.0	27,263
MBMG	07/29/08	585	<1	<0.5	<1.0	101	<5	7	<1.0	49	<3	<1.0	6,358	<0.1	11	<0.5	0.7	<0.5	22,196
Trec	11/05/09						0.2												28,100
Fingerprint	4/22/2010	796.00	<0.4	<0.7	1.08	115.00	<2.5	2.40	<0.5	58.0	<1.0	<3.0	######	<2.5	12.00	<2.5	<3.0	<0.6	25,900
	Mean	760	#DIV/0!			115	1.2				1.4		7,582				1.1		25,282
	Max	829	0			128	2.2				1.4		8,684				1.3		28,100
	Min	585	0			101	0.2				1.4		6,358				0.7		22,196
AMW-08	**M#137598**																		
	08/17/09	348	0.92	<0.40	56	282	27.7	4	15	2	3.3	<0.41	2,710	<0.23	34	<0.33	59.2	<0.50	313,280
	Mean	348.00	0.92			282.00	27.70				3.27		2,710				59.20		313,280
	Max	348.00	0.92			282.00	27.70				3.27		2,710				59.20		313,280
	Min	348.00	0.92			282.00	27.70				3.27		2,710				59.20		313,280
AMW-09	**M#137601**																		
	08/17/09	193	<0.20	<0.20	61	106	6.4	3	17	36	1.1	<0.21	1,557	<0.12	12	<0.17	22.8	<0.25	46,796
	Mean	193.00	#DIV/0!			106.00	6.35				1.13		1,557				22.80		46,796
	Max	193.00	0.00			106.00	6.35				1.13		1,557				22.80		46,796
	Min	193.00	0.00			106.00	6.35				1.13		1,557				22.80		46,796
AMW-13																			
Fingerprint	4/16/2010	77	1.86	<0.7	<0.4	<0.5	<2.5	0.97	<0.5	15.4	<1.0	<3.0	3,205	<2.5	7.63	<2.5	<3.0	<0.6	190
	8/11/2010	17	1.38	<0.17	<0.20	6.87	<0.20	<0.51	<0.20	6.1	<0.19	<0.20	1,000	<0.20	1.46	<0.20	1.24	<0.20	1,061
AMW-13B																			
Fingerprint	4/16/2010	9.04	28.30	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	1.06	0.30	<0.6	196	<0.5	0.50	<0.5	3.48	13.60	24
	8/10/2010	7.99	29.60	<0.17	<0.20	<0.19	<0.20	<0.51	<0.20	1.10	0.43	<0.20	202	<0.20	0.48	<0.20	3.68	13.50	24
AMW-13C																			
	5/28/2010						<0.055												325
Fingerprint	6/2/2010	49.90	127.00	<0.04	<0.05	0.81	<0.15	0.39	<0.02	5.01	0.52	<0.04	618	<0.02	3.23	<0.03	1.71	0.50	293
	8/10/2010	45.10	141.00	<0.17	<0.20	0.77	<0.20	<0.51	<0.20	5.30	0.28	<0.20	614	<0.20	3.19	<0.20	1.78	0.53	287

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		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
AMW-20																														
RI	03/30/97											10							383.0	20.9	75.8	21.0	42.8		10		16	1,170	0.50	
RI	06/30/97																													
AMW-22	**M#166182**																													
MBMG	05/06/04	15:00	37.71		7.09	555	13.4	381	6.94	610	223	95	56.0	17.8	23.6	31.0	0.0	44.0	68	13.1	32.8	5.2	0.03	0.006	115	0.0	27.9	129	0.53	
	10//8/08				6.55	377	8.9	348					34.3	7.4	25.0						25.0	3.9					17.1	78	0.41	
BMF05-1	**M#222920**																													
	12/22/05	13:15			5.47	2,075	9.9	371	6.43	2,140	1,119	21	48.8	22.9	5.4	1.3	0.0	97.5	305	86.9	39.0	15.4	1.46	125	26	0.0	11.8	1,545	1.10	
	04/25/06	10:30	23.75	6.5	5.27	2,470	10.4	371	4.42	2,480	1,284	0	48.9	24.8	4.7	0.0	0.0	99.3	341	105.0	37.7	17.2	8.58	131	0	0.0	6.7	1,574	0.95	
	08/15/06	11:50	22.42	5.0	4.19	2,230	12.3	127	4.84	2,270	1,145	11	49.5	24.7	4.9	0.6	0.0	97.7	306	92.6	34.8	14.9	7.71	114	13	0.0	15.4	1,564	<1	
	10/24/06	13:35	22.15		5.32	2,180	10.0	335	4.37	2,200	1,247	0	49.4	24.7	5.0	0.0	0.0	98.6	333	101.0	38.8	16.4	9.54	122	0	0.0	13.2	1,559	<1	
	03/27/07	9:20	23.00	5.0	5.47	2,090	9.9	406	3.84	2,330	1,204	0	48.2	25.8	5.0	0.0	0.0	100.0	314	102.0	37.4	16.5	11.20	125	0	0.0	<25	1,526	<2.5	
Duplicate	03/27/07	9:20	23.00	5.0	5.47	2,090	9.9	406	3.87	2,320	1,216	0	47.5	25.5	4.9	0.0	0.0	98.6	317	103.0	37.4	16.8	11.40	127	0	0.0	15.6	1,732	1.44	
	09/21/07	11:10	21.86	8.0	5.25	2,090	10.2	403	4.01	2,220	1,242	0	49.1	24.7	4.6	0.0	0.0	98.6	331	101.0	35.6	16.7	11.60	125	0	0.0	14.1	1,611	1.77	
	12/17/07	11:10	21.77		5.10	2,300	10.0	345	4.17	2,990	1,267	0	49.2	25.1	4.9	0.0	0.0	98.6	336	104.0	38.3	17.5	0.81	134	0	0.0	13.8	1,622	1.80	
	06/02/08	10:45		8.0	5.18	2,315	10.3	365	4.05	2,240	1,262	0	48.0	24.7	4.6	0.0	0.0	97.9	334	104.0	37.8	18.2	11.60	125	0	0.0	15.0	1,562	3.86	
	11/19/08	17:20		8.5	5.87	2,080	9.8	355	3.96	2,160	1,250	0	48.4	25.4	5.3	0.0	0.0	98.6	329	104.0	40.3	14.3	10.90	124	0	0.0	16.7	1,675	1.39	
	04/24/09	12:40	23.10	1.8	5.05	2,203	9.1	363	4.14	2,250	1,163	0	47.3	25.7	5.1	0.0	0.0	98.5	302	99.4	37.3	16.4	10.30	122	0	0.0	16.6	1,652	1.18	
	12/02/09	16:20	21.95	6.3	5.58	2,190	9.6	356	4.39	2,190	1,154	0	47.9	24.8	5.7	0.0	0.0	97.7	300	93.9	40.8	15.7	9.12	120	0	0.0	17.7	1,189	1.49	
Fingerprint	06/14/10	14:10	NR	NR	4.94	2,301	12.9	370	5.71	2,220	1,015	12	45.1	24.6	6.0	0.8	0.0	97.3	263	87.0	40.0	16.7	8.94	128	15	0.0	17.8	1,441	1.52	
	11/05/10	12:09	21.78	NR	4.93	2,385	9.8	379	3.75	2,208	1,184	0	49.1	24.7	5.5	0.0	0.0	98.0	316	96.0	40.6	15.4	7.23	118	0	0.0	19.7	1,547	1.74	
BMF05-2	**M#222921**																													
	12/22/05				6.42	480	10.5	324	7.97	595	211	91	57.2	22.7	17.7	33.7	0.0	37.9	61	14.6	21.5	4.2	0.023	0.032	111	0.0	30.5	98	0.29	
	04/04/06	15:15	44.25	5.0	6.45	510	10.9	380	6.22	570	230	94	56.0	22.1	18.2	32.9	0.0	36.2	67	15.5	24.1	4.1	0.037	0.006	114	0.0	32.8	99	0.22	
	08/16/06	11:55	43.25	5.0	6.34	700	13.7	84	6.06	630	222	91	57.7	22.5	17.8	30.8	0.0	35.5	64	15.1	22.7	3.9	0.006	0.004	111	0.0	37.8	101	0.19	
Duplicate	08/16/06	11:55	43.25	5.0	6.34	700	13.7	84	6.08	605	219	85	57.7	22.5	17.9	29.3	0.0	37.1	63	14.9	22.4	3.8	0.007	0.004	104	0.0	39.2	103	0.21	
	11/06/06	15:05	42.59	5.0	6.43	555	11.0	372	6.41	540	230	93	57.4	21.7	21.6	29.3	0.0	34.3	67	15.3	25.2	4.2	<0.005	0.002	113	0.0	40.7	104	0.21	
Duplicate	11/06/06	15:05	42.59	5.0	6.43	555	11.0	372	6.35	565	229	91	57.2	22.0	18.7	28.9	0.0	34.4	66	15.5	24.9	4.1	<0.005	0.002	111	0.0	40.8	104	0.21	
	03/26/07	15:30	42.81	5.0	6.64	490	11.0	437	5.94	525	219	87	57.7	23.5	16.8	32.2	0.0	37.1	62	15.4	20.8	4.0	<0.005	0.002	106	0.0	29.8	96	<0.5	
	09/21/07	12:30	42.21	8.0	6.41	503	11.3	345	6.47	548	233	85	63.1	22.6	16.9	29.3	0.0	41.4	67	15.8	22.3	4.1	0.011	0.002	104	0.0	29.2	116	0.26	
	11/14/07	10:45	41.90	8.0	6.39	580	10.0	324	6.41	566	182	94	56.6	24.1	17.1	36.6	0.0	35.5	51	13.2	17.7	3.6	<.005	<.001	115	0.0	28.5	88	0.18	
	06/02/08	12:00	42.57	8.0	6.25	585	11.3	374	6.59	625	243	84	60.2	22.4	15.3	32.2	0.0	47.3	71	16.0	20.7	4.3	0.006	0.002	103	0.0	34.8	119	0.23	
	11/19/08	11:15		8.0	6.91	530	11.9	357	6.91	560	235	90	57.9	24.1	16.9	30.5	0.0	37.3	66	16.7	22.2	2.1	<0.018	<0.003	110	0.0	35.1	104	<0.5	
	04/24/09	13:48	42.23	1.4	6.26	539	10.2	367	6.87	581	214	76	54.8	25.0	17.9	26.3	0.0	43.1	59	16.3	22.1	4.3	<0.043	<0.031	93	0.0	31.2	120	<0.5	
	12/03/09	15:12	41.02	5.0	6.34	515	11.0	401	6.64	513	188	77	56.3	23.4	18.1	30.8	0.0	41.5	53	13.4	19.6	3.5	<0.007	0.001	94	0.0	24.8	99	<0.5	
Fingerprint	06/17/10	15:16	NR	NR	6.09	482	11.3	386	6.94	507	206	71	56.7	22.8	18.4	29.2	0.0	43.0	59	14.3	21.9	3.9	0.003	0.004	86	0.0	23.6	99	0.21	
	11/05/10	15:19	40.80	NR	6.32	552	11.0	359	7.06	526	213	75	57.5	22.0	18.5	28.7	0.0	45.1	62	14.3	22.8	3.7	<0.002	0.008	91	0.0	26.0	113	0.18	
BMF05-3	**M#224152**																													
	02/27/06	15:30	39.69		6.49	445	10.4	404	6.30	515	230	125	56.3	22.2	19.5	42.8	0.0	39.1	66.1	15.8	26.2	4.0	0.062	0.020	152	0.0	14.1	109	0.22	
	04/04/06	17:00	39.80	6.0	6.75	475	10.5	369	6.32	610	219	99	56.8	21.1	20.1	41.4	0.0	41.3	63.8	14.4	25.9	3.8	0.017	0.016	121	0.0	14.0	95	0.22	
	08/14/06	16:08	33.17	5.0	6.69	495	12.3	247	6.35	535	178	122	55.2	21.0	21.9	50.1	0.0	34.1	51.7	11.9	23.5	3.3	<0.005	0.002	149	0.0	12.5	80	0.26	
	10/24/06	15:35	36.78		6.71	455	10.6	332	6.34	540	194	130	53.8	21.2	23.0	50.7	0.0	32.8	55.7	13.3	27.3	3.5	<0.005	0.006	158	0.0	14.0	81	0.24	

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanum
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMW-20																						
RI	03/30/97		0.05							1.9				180				9,820				
RI	06/30/97								`					152				8,820				
AMW-22	**M#166182**																					
MBMG	05/06/04	26.6	9.9					<30	<1	<1	79.7	26.8	<2	<1		<2	<2	13.2			NA	
	10//8/08	8.7	2.9															10				
BMF05-1	**M#222920**																					
	12/22/05	53.3	<0.5					64	<5	<10	61.0	25.8	<2	249		515	<10	2,057			NA	
	04/25/06	47.8	<0.5					633	<5	<5	64.7	20.2	2.12	260		564	<10	3,916			NA	
	08/15/06	47.4	<1					307	<1	2.70	66.7	16.5	<2	201		449	<2	3,417			NA	
	10/24/06	51.6	<1					388	<5	<5	74.9	16.9	2.18	235		527	<10	3,700			NA	
	03/27/07	46.5	<2.5					653	<5	1.74	60.6	14.0	1.40	192		426	<0.5	3,611			NA	
Duplicate	03/27/07	47.7	<0.5					673	<5	1.68	64.1	14.2	1.50	194		421	<0.5	3,672			NA	
	09/21/07	52.8	<1.0					586	<5	1.72	68.9	15.3	2.04	235		544	18	3,836			NA	
	12/17/07	36.3	<1					562	<2.5	<1	81.8	16.2	1.99	230		539	<0.5	3,846			NA	
	06/02/08	52.4	<0.5					537	<2.5	1.02	78.7	10.4	1.52	200	8.29	507	<0.5	3,951	<0.5	<0.5	NA	3.67
	11/19/08	51.7	<0.5					535	<0.5	<2.3	81.4	13.8	<2	191	9.45	475	<0.37	3,459	<0.26	<1.6	NA	4.54
	04/24/09	55.2	<0.5					555	<0.42	1.59	83.1	13.5	2.21	191	9.38	462	<0.40	3,451	<0.42	<0.47	NA	4.58
	12/02/09	51.8	<0.5					578	<1.2	1.08	76.2	13.4	1.98	181	9.51	470	0.92	3,411	<0.3	<1.0	NA	<4.7
Fingerprint	06/14/10	51.5	<0.25					545	<1.0	1.33	78	13.7	1.88	182	9.36	480	<1.0	3,376	<2.5	<0.9	NA	4.63
	11/05/10	48.3	0.11					699	<1.0	1.09	72.5	13.9	2.11	191	14.40	476	<1.0	3,520	<2.5	1.65	NA	7.55
BMF05-2	**M#222921**																					
	12/22/05	31.7	9.23					16	<1	2.32	<30	52.5	<2	1.08		<2	<2	7.7			NA	
	04/04/06	32.1	11.50					<10	<1	<1	<30	50.4	<2	<1		<2	9.76	3.7			NA	
	08/16/06	29.6	12.90					<10	<1	<1	<30	52.3	<2	<1		<2	<2	4.2			NA	
Duplicate	08/16/06	29.1	11.60					<10	<1	<1	<30	52.9	<2	<1		<2	<2	4.0			NA	
	11/06/06	33.1	16.00					<30	<1	<1	<30	31.4	<2	<1		<2	<2	3.7			NA	
Duplicate	11/06/06	32.1	16.10					<30	<1	<1	<30	49.4	<2	<1		<2	<2	4.1			NA	
	03/26/07	29.5	11.30					<30	<1	0.59	5.77	50.6	<0.1	0.58		<0.1	<0.1	3.8			NA	
	09/21/07	31.1	12.20					<2	<1.0	0.63	5.38	54.9	<0.1	0.68		<0.1	<0.5	4.4			NA	
	11/14/07	17.2	8.73					<2	<0.5	0.54	5.56	45.6	<0.1	0.42		0.1	<0.1	3.2			NA	
	06/02/08	29.9	1.06					<20	<5.0	<2	<20	37.4	<1	<1	<1	<1	<1	4.1	<1	<1	NA	<1
	11/19/08	30.3	13.45					<8.8	<0.5	<2.3	10.3	52.0	<1.9	<0.7	<0.37	<1.4	<0.37	8.2	<0.26	<1.63	NA	<0.27
	04/24/09	33.8	12.60					<38.2	0.28	0.51	10.6	53.7	<0.91	0.57	<0.1	<0.29	<0.2	4.5	<0.21	<0.23	NA	<0.11
	12/03/09	27.4	9.57					<8.0	<0.2	0.49	7.59	48.6	<0.2	0.68	<0.9	<0.1	0.16	7.0	<0.1	<0.2	NA	<0.9
Fingerprint	06/17/10	31.1	9.13					3	<0.2	0.51	6.93	42.7	<0.2	0.54	<0.2	<0.2	<0.2	5.1	<0.5	<0.2	NA	<0.2
	11/05/10	30.1	8.82					4	<0.2	0.56	7.24	48.3	<0.2	0.42	0.76	<0.2	<0.2	4.5	<0.5	<0.2	NA	0.89
BMF05-3	**M#224152**																					
	02/27/06	28.1	9.01					13	<1	<1	<30	38.2	<2	<1		<2	15.90	5.6			NA	
	04/04/06	27.1	5.81					14	<1	<1	<30	68.3	<2	<1		<2	<2	4.5			NA	
	08/14/06	24.1	5.64					<10	<1	<1	<30	67.2	<2	<1		<2	<2	3.6			NA	
	10/24/06	25.2	6.08					<10	<1	<1	<30	74.6	<2	<1		<2	<2	4.1			NA	

			MINOR AND TRACE METALS																
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	alladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
AMW-20																			
RI	03/30/97						8.8												
RI	06/30/97																		
AMW-22	**M#166182**																		
MBMG	05/06/04	9.6	<10				<2				1.3		406				2.7		101
	10//8/08												190						100
BMF05-1	**M#222920**																		
	12/22/05	347	<10			412	<10				11.4		1,913				<2.5		65,656
	04/25/06	382	<10			349	<10				<5		2,119				<3		51,684
	08/15/06	348	<10			296	<2				4.02		1,867				1.3		43,006
	10/24/06	380	<10			282	<10				<5		2,006				1.2		46,159
	03/27/07	386	<5			242	<1				<2.5		2,065				1.4		46,327
Duplicate	03/27/07	392	<5			238	<1				<2.5		2,066				1.7		47,184
	09/21/07	387	<5			256	1.71				<2.5		2,164				1.0		46,852
	12/17/07	402	<5			297	<1				<2.5		2,338				1.2		47,932
	06/02/08	420	<5	1.00	<0.5	271	<1	2.58	<0.5	1.92	<2.5	<0.5	2,220	<0.25	5.78	<0.5	0.3	<2.5	66,541
	11/19/08	255	2.37	<0.5	1.64	261	<2.6	3.58	0.47	3.11	<3.2	<0.55	1,917	8.99	16.90	<0.34	<3.3	<0.45	48,080
	04/24/09	306	2.02	<0.44	1.70	274	<1.54	0.68	0.44	2.91	1.3	<0.42	1,781	<0.24	9.60	<0.33	1.1	<0.51	44,476
	12/02/09	<4.7	1.72	<0.5	<4.0	258	<0.5	<1.0	<4.1	2.83	<1.2	<0.7	1,742	<1.4	13.00	<1.2	1.1	<13	41,079
Fingerprint	06/14/10	262	2.07	<0.9	1.61	260	<1.0	<2.5	<1.0	2.96	1.37	<1.0	1,917	<1.0	12.20	<1.00	<1.0	<1.0	42,587
	11/05/10	340	<1.0	<2.5	2.37	282	<1.0	<2.5	<1.0	2.91	1.52	<2.5	1,734	<1.0	22.30	<1.0	1.3	<1.0	42,056
BMF05-2	**M#222921**																		
	12/22/05	6.94	<10			<2	<2				3.27		402				0.76		83
	04/04/06	8.05	<10			6.9	<2				2.12		412				0.78		57
	08/16/06	7.83	<10			<2	<2				2.35		402				0.80		37
Duplicate	08/16/06	7.46	<10			<2	<2				2.28		395				0.83		37
	11/06/06	8.71	<10			<2	<2				1.29		437				0.65		35
Duplicate	11/06/06	7.95	<10			<2	<2				1.25		428				0.57		39
	03/26/07	7.80	7.44			0.7	0.31				1.30		418				0.71		41
	09/21/07	7.22	7.12			0.3	0.32				1.60		443				0.52		60
	11/14/07	6.30	6.32			1.7	<.2				1.38		366				0.47		28
	06/02/08	7.89	<10	<1	<1	<1	2.60	<2	<1	<1	<5	<1	463	<0.5	1.12	<1	<0.5	<5	26
	11/19/08	<5.3	7.75	<0.51	<0.73	<0.97	<2.6	<0.79	<0.38	0.49	<3.22	<0.55	397	<8.99	<2.3	<0.34	<3.3	<0.45	44
	04/24/09	6.93	7.57	<0.22	<0.26	<0.57	<0.77	<0.32	<0.11	0.44	1.62	<0.21	365	<0.12	<0.96	<0.17	0.45	<0.25	45
	12/03/09	2.93	8.05	<0.1	<0.8	0.3	<0.6	<0.2	<0.8	0.45	1.22	<0.1	343	<0.3	0.98	<0.2	0.41	<0.2	51
Fingerprint	06/17/10	2.66	8.06	<0.2	<0.2	0.4	<0.2	<0.5	<0.2	<0.2	1.15	<0.2	318	<0.2	0.81	<0.2	0.44	<0.2	42
	11/05/10	2.05	7.87	<0.5	0.76	0.9	<0.2	<0.5	0.69	<0.5	1.51	<05	356	<0.2	1.70	<0.2	0.44	<0.2	30
BMF05-3	**M#224152**																		
	02/27/06	6.32	14.7			8.6	<2				1.81		418				3.42		28
	04/04/06	5.13	24.8			2.5	<2				1.45		422				6.56		22
	08/14/06	4.00	30.5			<2	<2				1.44		351				6.04		10
	10/24/06	4.07	32.0			<2	<2				<1		377				7.08		19

		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
	04/23/07	11:50	37.30	5.0	6.90	450	10.4	439	6.50	585	195	133	53.1	20.7	24.1	49.7	0.0	31.8	56.3	13.3	29.3	3.9	<0.005	<0.001	162	0.0	14.9	82	0.23	
	09/21/07	14:30	36.55	8.0	6.89	436	10.9	329	6.79	494	193	141	53.2	20.0	24.8	53.0	0.0	30.2	56.1	12.8	30.0	3.7	0.006	0.001	172	0.0	14.2	77	0.26	
	11/09/07	14:40	36.18	8.0	6.70	472	10.8	306	6.86	534	193	142	55.0	20.5	22.4	54.0	0.0	30.1	56.2	12.7	26.3	3.6	0.053	0.002	173	0.0	13.6	76	0.21	
	06/03/08	10:15	37.37	8.0	6.75	473	10.6	355	6.78	493	191	149	56.2	20.2	21.5	56.9	0.0	29.0	56.4	12.3	24.7	3.6	0.006	0.001	182	0.0	14.4	73	0.26	
	11/19/08	14:30	36.45	8.0	7.14	425	10.6	436	6.92	485	180	139	53.1	20.2	25.3	60.9	0.0	23.9	52.3	12.1	28.5	1.4	<0.018	<0.003	169	0.0	13.2	52	<0.5	
	05/07/09	11:06	36.73	7.1	6.94	399	10.1	440	7.42	448	175	131	52.3	21.3	24.3	55.7	0.0	21.2	49.8	12.3	26.6	3.6	<0.043	<0.031	160	0.0	16.4	58	0.19	
	12/03/09	13:46	35.65	4.0	6.96	378	11.0	371	7.09	413	132	125	50.5	19.5	27.9	56.5	0.0	27.9	38.2	9.0	24.2	2.8	<0.007	<0.002	152	0.0	15.6	59	0.24	
Fingerprint	06/17/10	14:07	NR	NR	6.55	397	10.9	360	7.74	416	163	110	51.0	20.2	26.8	54.8	0.0	25.9	46.7	11.2	28.2	3.3	<0.002	0.006	134	0.0	15.8	50	0.24	
	11/05/10	14:13	35.26	NR	6.89	436	10.7	333	7.57	426	157	123	51.3	19.6	27.1	56.2	0.0	25.5	45.6	10.6	27.6	3.2	<0.002	0.016	150	0.0	16.2	54	0.22	
BMF05-4	**M#224153**																													
	03/08/06	13:00	77.27		6.30	450	9.8	401	6.15	530	243	37	61.4	19.2	16.7	12.6	0.0	78.6	74.2	14.1	23.1	5.5	0.013	0.127	44.5	0.0	5.7	219	0.64	
	04/25/06	11:30	77.03	6.0	6.36	595	10.1	337	5.88	580	238	29	61.6	19.5	16.2	9.2	0.0	81.5	72.6	13.9	21.9	5.2	0.014	0.156	35.9	0.0	6.9	250	0.62	
	08/15/06	15:30	76.81	5.0	5.35	670	12.1	145	6.05	610	234	30	62.6	19.2	15.8	9.7	0.0	93.6	71.6	13.3	20.7	4.8	<0.005	0.018	38.8	0.0	7.1	244	0.64	
	10/24/06	14:45	75.85		6.29	565	9.9	340	6.25	585	256	36	62.5	19.3	15.7	11.7	0.0	79.3	78.4	14.7	22.6	5.2	<0.005	0.023	44.4	0.0	7.1	237	0.66	
	03/26/07	16:20	75.24	5.0	6.59	535	9.7	411	5.75	560	246	29	61.5	19.7	14.5	9.2	0.0	81.6	74.6	14.5	22.5	5.3	<0.05	0.006	34.9	0.0	7.3	245	0.59	
	09/21/07	12:00	75.53	8.0	6.39	536	9.9	352	6.42	686	258	33	61.9	19.0	16.6	10.6	0.0	80.5	79.2	14.7	24.3	5.5	0.008	0.025	40.0	0.0	6.3	238	0.53	
	12/17/07	12:00	74.95	8.0	6.13	590	9.8	337	6.25	609	257	34	62.3	19.7	15.3	10.8	0.0	80.2	78.3	15.0	22.0	5.8	0.029	0.032	40.7	0.0	6.4	238	0.58	
	06/02/08	15:00	75.28	8.0	6.05	600	9.8	353	6.21	635	273	34	62.6	19.1	15.5	9.6	0.0	83.0	83.6	15.5	23.7	6.3	<0.005	0.003	41.2	0.0	7.2	280	0.61	
	11/19/08	15:45	78.14	8.0	6.81	570	9.3	410	6.72	585	280	33	64.2	19.4	14.9	9.8	0.0	80.3	86.1	15.8	23.6	3.4	<0.018	<0.003	39.7	0.0	7.2	254	1.18	
	05/07/09	13:15	74.49	7.1	6.56	575	9.3	489	6.88	574	259	40	61.7	20.2	15.6	11.4	0.0	79.8	78.1	15.5	22.6	5.5	<.043	<0.031	48.8	0.0	7.2	269	0.57	
	12/02/09	15:40	73.48	6.7	6.51	610	9.5	383	6.56	630	266	36	62.1	19.4	16.1	11.1	0.0	80.2	81.2	15.4	24.2	5.3	<0.007	0.004	43.9	0.0	6.8	250	0.59	
Fingerprint	06/11/10	14:45	NR	NR	5.84	644	10.0	405	7.34	706	268	42	61.7	20.3	15.4	12.7	0.0	78.7	80.7	16.1	23.1	5.6	0.004	0.002	21.2	0.0	7.6	251	0.55	
	11/04/10	16:28	73.17	NR	6.07	687	10.2	386	6.79	617	272	38	62.4	19.3	15.9	11.4	0.0	79.5	83.3	15.6	24.4	5.4	<0.002	<0.001	45.8	0.0	7.8	250	0.55	
BPS07-08A																														
Fingerprint	4/23/2010	18:40	NR		NR	NR	NR	NR	7.43	1,790	858	513	57.26	22.72	14.89	45.65	0.00	42.65	246	59.2	73.4	23.1	<0.006	9.16	625.5	0.0	88.5	460	2.02	572
BPS07-09A																														
Fingerprint	4/26/2010	14:15	9.40		7.03	1,324	9.11	319	7.85	1,351	619	265	56.72	25.54	15.09	33.39	0.00	50.42	171	46.7	52.2	9.1	<0.006	3.31	323.0	0.0	75.6	384	1.03	249
BPS07-11A																														
Fingerprint	4/20/2010	14:20	13.90		5.21	1,044	10.21	424	5.48	1,053	440	11	53.90	24.05	11.98	2.25	0.00	91.58	122	33.0	31.1	6.8	0.01	20.60	16.2	0.0	20.0	520	0.495	53
BPS07-11B																														
Fingerprint	4/20/2010	14:35	13.47		4.99	2,066	10.32	354	3.27	2,130	962	0	47.20	23.05	8.04	0.00	0.00	89.89	259	76.7	50.6	14.9	41.90	56.80	0.0	0.0	97.4	1,186	0.552	<250
BPS07-15A																														
Fingerprint	4/23/2010	11:45	19.18		6.77	893	9.23	192	7.02	923	241	112	40.30	14.98	39.12	25.03	0.00	25.04	70.5	15.9	75.5	7.5	4.13	1.29	136.9	0.0	153.1	108	1.53	168
BPS07-17A																														
Fingerprint	4/23/2010	16:53	10.46		6.01	1,073	7.75	241	7.40	1,061	338	49	39.21	16.90	29.51	8.30	0.00	73.89	94.5	24.7	81.6	5.6	19.40	9.32	59.8	0.0	73.4	419	0.63	197
BPS07-21B																														
Fingerprint	8/11/2010	11:30	13.96	3	5.90	513	10.08	487	6.79	491	163	72	46.03	20.95	28.77	31.49	0.00	59.86	44.9	12.4	32.2	7.3	0.01	0.01	87.8	0.0	9.5	131	1.6	<50

Montana Bureau of Mines and Geology
Butte Priority Soils Groundwater-Quality Data

		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanun
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
	04/23/07	26.2	7.76					<1	<1	0.69	8.05	75.4	<0.1	0.16		<0.1	0.17	3.8			NA	
	09/21/07	25.6	6.65					4	<1	0.73	7.63	75.8	<0.1	0.16		<0.1	<0.5	2.9			NA	
	11/09/07	17.3	6.09					<2	<0.5	0.89	8.55	82.5	<0.1	0.22		0.2	0.17	3.8			NA	
	06/03/08	23.6	4.54					<2	<0.5	0.66	7.62	57.7	<0.1	<0.1	<0.1	0.1	0.16	3.0	<0.1	<0.1	NA	<0.1
	11/19/08	23.1	4.80					<8.8	<0.57	<2.3	12	67.1	<1.9	<0.7	<0.37	<1.4	<0.37	5.1	<0.26	<1.63	NA	<0.27
	05/07/09	28.1	5.61					<7.60	<0.04	1.10	11	65.2	<0.20	<1.38	<0.02	<0.10	0.25	2.2	<0.04	<0.05	NA	<0.02
	12/03/09	23.0	3.31					<8.0	<0.2	0.62	11	53	<0.2	<0.1	<0.9	<0.1	0.30	5.1	<0.1	<0.2	NA	<0.9
Fingerprint	06/17/10	24.1	4.36					2	<0.2	0.65	9.84	57.1	<0.2	<0.2	<0.2	<0.2	<0.2	3.1	<0.5	<0.2	NA	<0.2
	11/05/10	22.3	4.71					4	<0.2	0.68	9.69	61	<0.2	<0.2	0.29	<0.2	<0.2	3.5	<0.5	<0.2	NA	0.33
BMF05-4	**M#224153**																					
	03/08/06	31.6	4.45					<10	<1	<1	<30	39.9	<2	2.60		<2	<2	27.8			NA	
	04/25/06	30.4	5.10					<10	<1	<1	<30	47.5	<2	2.73		<2	<2	34.9			NA	
	08/15/06	30.6	4.32					<10	<1	<1	<30	48.2	<2	1.70		<2	<2	29.3			NA	
	10/24/06	32.7	4.55					<10	<1	<1	<30	51.7	<2	2.52		<2	<2	28.1			NA	
	03/26/07	30.7	4.73					<30	<1	0.66	5.87	49	<0.1	2.12		<0.1	0.17	24.7			NA	
	09/21/07	33.0	4.82					<2	<1	0.65	6.01	57.2	<0.1	2.09		0.2	<0.5	28.1			NA	
	12/17/07	23.4	4.82					6.04	35.8	1.34	9.76	91.4	<0.1	4.24		0.5	<.1	35.1			NA	
	06/02/08	32.9	3.87					<2	<0.5	0.64	4.06	40.2	<0.1	<0.1	<0.1	<0.1	<0.1	28.7	<0.1	<0.1	NA	<0.1
	11/19/08	32.2	5.07					<8.8	<0.57	<2.34	10.1	49.4	<2	2.05	<0.37	<1.4	<0.37	27.6	<0.26	<1.63	NA	<0.27
	05/07/09	36.7	5.33					<7.6	<0.04	1.02	8.47	47.9	<0.20	2.18	0.02	<0.10	0.06	24.0	<0.04	<0.05	NA	0.03
	12/02/09	34.0	4.85					<8.0	<0.2	0.61	7.66	49.7	<0.2	2.24	<0.9	<0.1	0.45	29.2	<0.1	<0.2	NA	<0.9
Fingerprint	06/11/10	32.4	4.57					<2.0	<0.2	0.65	7.59	52.7	<0.2	2.29	<0.2	<0.2	<0.2	28.7	<0.5	<0.2	NA	<0.2
	11/04/10	30.9	4.83					5	<0.2	0.68	7.13	49.2	<0.2	2.20	<0.2	<0.2	<0.2	30.5	<0.5	<0.2	NA	<0.2
BPS07-08A																						
Fingerprint	4/23/2010	35.8	0.356	<0.05	<0.03	4.54	<0.25	<4.2	<0.5	18.50	1,234	26.00	<0.6	1.79	<0.5	0.74	<0.5	53.70	<0.5	<0.5	NR	<0.5
BPS07-09A																						
Fingerprint	4/26/2010	31.3	5.33	<0.05	<0.03	0.32	<0.25	<0.001	<0.5	39.40	110	6.94	<0.6	1.46	<0.5	<0.4	<0.5	192	<0.5	<0.5	NR	<0.5
BPS07-11A																						
Fingerprint	4/20/2010	51.1	1.95	<0.05	<0.03	1.77	<0.25	267	<0.1	0.67	189	11.70	0.34	31.20	1.88	95.30	<0.1	312	<0.1	<0.1	NR	0.81
BPS07-11B																						
Fingerprint	4/20/2010	48.3	<0.25	<0.25	<0.03	1.43	<0.25	388	<0.5	0.63	67.9	13.70	0.77	140.00	11.70	498.00	<0.5	1,539	<0.5	<0.5	NR	4.49
BPS07-15A																						
Fingerprint	4/23/2010	31.0	1.1	<0.05	<0.03	2.22	<0.25	<0.8	<0.1	89.40	81.60	91.00	<0.1	1.36	<0.1	1.26	<0.1	17.40	<0.1	<0.1	NR	<0.1
BPS07-17A																						
Fingerprint	4/23/2010	34.8	<0.05	<0.05	<0.03	3.11	<0.25	10.7	<0.5	62.50	152	20.10	<0.6	14.90	0.76	24.60	<0.5	119	<0.5	<0.5	NR	0.60
BPS07-21B																						
Fingerprint	8/11/2010	28.5	0.6	<0.05	0.061	NR	NR	5.73	<0.20	5.46	33.40	5.44	<0.20	1.78	<0.20	<0.18	<0.20	0.81	<0.51	<0.19	NR	<0.20

			MINOR AND TRACE METALS																
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	alladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
	04/23/07	4.39	28.6			0.2	<0.2				0.93		420				7.49		11
	09/21/07	4.16	28.6			<0.1	<0.2				1.03		400				7.29		15
	11/09/07	3.83	35.5			0.9	<.2				1.32		398				7.73		14
	06/03/08	3.74	22.8	<0.1	<0.1	<0.1	<0.2	0.62	<0.1	<0.1	0.77	<0.1	403	<0.05	0.76	<0.1	9.64	<0.5	7
	11/19/08	<5.3	31.9	<0.51	<0.73	<0.97	<2.6	<0.79	<0.38	<0.43	<3.22	<0.55	315	<8.99	<2.3	<0.34	<3.3	<0.45	18
	05/07/09	2.60	32.9	<0.04	<0.05	<0.10	<0.15	<0.10	<0.02	0.14	0.61	<0.04	316	<0.02	0.60	<0.03	6.66	0.52	7
	12/03/09	<1.5	35.6	<0.1	<0.8	<0.3	<0.6	<0.2	<0.8	0.12	0.48	<0.1	253	<0.3	<0.7	<0.2	4.76	0.17	4
Fingerprint	06/17/10	<0.2	34.9	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.5	0.60	<0.2	280	<0.2	0.42	<0.2	5.57	<0.2	10
	11/05/10	<2.0	35.3	<0.5	0.33	0.6	<0.2	<0.5	0.29	<0.5	0.76	<0.5	287	<0.2	0.93	<0.2	5.91	<0.2	12
BMF05-4	**M#224153**																		
	03/08/06	5.20	138			4.6	<2				3.61		439				<0.5		291
	04/25/06	5.48	89.2			3.9	<2				3.31		448				<1		377
	08/15/06	4.98	92.8			3.1	<2				3.10		430				<1		292
	10/24/06	5.12	92.0			4.0	<2				2.76		462				0.27		282
	03/26/07	5.51	86.3			2.3	<0.2				2.67		475				0.39		327
	09/21/07	5.37	79.8			2.5	0.24				2.40		498				0.21		339
	12/17/07	5.38	161			6.4	0.21				5.18		504				0.43		348
	06/02/08	5.90	94.6	<0.1	<0.1	2.5	<0.2	0.58	<0.1	1.59	2.80	<0.1	531	0.06	1.29	<0.1	0.07	<0.5	446
	11/19/08	<5.3	85.5	<0.51	<0.73	3.4	<2.6	0.80	<0.38	2.23	<3.22	<0.55	443	<9	3.09	<0.34	<3.3	<0.45	311
	05/07/09	3.33	85.0	<0.04	<0.05	2.7	<0.15	0.11	<0.02	2.15	2.92	<0.04	439	<0.02	2.16	<0.03	0.25	0.26	301
	12/02/09	1.64	90.3	<0.1	<0.8	2.4	<0.6	<0.2	<0.8	2.05	2.50	<0.1	418	<0.3	2.25	<0.2	0.33	<0.2	273
Fingerprint	06/11/10	<2.0	90.1	<0.2	<0.2	2.4	<0.2	<0.5	<0.2	2.23	2.83	<0.2	444	<0.2	2.21	<0.2	0.29	<0.2	331
	11/04/10	<2.0	92.4	<0.5	<0.2	3.3	<0.2	<0.5	<0.2	2.13	2.57	<0.5	416	<0.2	3.45	<0.2	0.39	<0.2	308
BPS07-08A																			
Fingerprint	4/23/2010	107.00	95.30	<0.7	<0.4	0.93	<2.5	0.70	<0.5	3.98	1.37	<3.0	2,464	<2.5	3.49	<2.5	21.70	<0.6	89
BPS07-09A																			
Fingerprint	4/26/2010	35.60	8.62	<0.7	<0.4	<0.6	<2.5	<0.6	<0.5	1.16	<1.0	<3.0	1,251	<2.5	1.47	<2.5	13.80	1.92	818
BPS07-11A																			
Fingerprint	4/20/2010	89.00	0.36	<0.1	0.46	27.70	1.22	0.21	0.12	<0.1	0.42	<0.6	736	0.53	3.15	1.02	1.28	<0.1	4,594
BPS07-11B																			
Fingerprint	4/20/2010	253	<0.4	<0.7	2.16	133.0	4.62	0.60	0.61	<0.5	<1.0	<3.0	1,433	<2.5	9.4	<2.5	<3.0	<0.6	36,473
BPS07-15A																			
Fingerprint	4/23/2010	21.10	8.67	<0.1	<0.1	0.60	<0.5	0.13	<0.1	6.30	0.57	<0.6	386	<0.5	0.82	<0.5	4.01	21.70	375
BPS07-17A																			
Fingerprint	4/23/2010	122.00	0.80	<0.7	<0.4	6.38	<2.5	<0.6	<0.5	2.45	<1.0	<3.0	1,424	<2.5	3.06	<2.5	<3.0	0.95	5,044
BPS07-21B																			
Fingerprint	8/11/2010	48.30	19.50	<0.17	<0.20	0.59	<0.20	<0.51	<0.20	5.30	0.38	<0.20	428.00	<0.20	1.40	<0.20	1.49	<0.20	190

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		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
BPS07-21C																														
Fingerprint	8/11/2010	10:50	12.91	3	5.62	898	10.69	486	6.54	882	343	63	48.50	21.79	26.56	12.77	0.00	84.98	94.7	25.8	59.5	10.7	0.00	0.02	77.2	0.0	5.7	404	1.09	<50
BPS07-24																														
Fingerprint	8/10/2010	12:30	7.95	3	6.27	1,851	10.00	162	7.01	2,150	1,371	121	59.23	23.77	14.09	7.43	0.00	89.05	392.0	95.4	107.0	23.6	<0.003	0.47	148.0	0.0	38.6	1,396	1.02	137.00
GS-08																														
Fingerprint	4/17/2010	15:50	11.21		6.38	1,406	11.62	340	6.69	1,509	522	68	50.66	15.15	31.00	8.02	0.00	85.36	161	29.2	113	16.4	<0.003	0.00	83.4	0.0	38.6	698	0.619	76
GS-09																														
Trec	3/15/2010	13:54	11.41		5.38	3,260	10.00	187	5.92	3,130	1,868	31	54.99	27.44	10.28	1.33	0.00	93.48	499	151	107	23.0	<0.001	30.90	37.8	0.0	77.7	2,086	0.564	<50
Trec	3/15/2010	13:58	NR		NR	NR	NR	NR	6.01	3,150	1,756	32	54.52	26.92	10.90	1.39	0.00	93.43	471	141	108	23.2	<0.001	30.70	39.0	0.0	77.0	2,065	0.559	<50
Fingerprint	4/17/2010	16:25	11.31		5.59	3,137	11.54	411	6.08	3,110	1,847	52	54.06	28.55	9.93	2.24	0.00	92.63	484	155	102	23.3	<0.006	30.50	64.3	0.0	78.0	2,096	0.589	<250
GS-09-01	**M#251420**																													
	8/18/2009	14:30	33.22	3	3.84	5,470	9.53	490	3.94	5,505	1,984	0	49.1	7.8	21.4	0.0	0.0	52.8	686.0	65.8	343.0	15.1	0.3	13.0	0	0.0	1166	1,818	3.35	
	Mean				7.18	355	10.64	211	7.09	389	132	116	48.0	22.7	27.5	59.9	0.0	22.6	35.8	10.3	23.6	1.9	0.2	0.0	141	0.0	13	42	0.24	
	Max				7.18	355	10.64	211	7.09	389	132	116	48.0	22.7	27.5	59.9	0.0	22.6	35.8	10.3	23.6	1.9	0.2	0.0	141	0.0	13	42	0.24	
	Min				7.18	355	10.64	211	7.09	389	132	116	48.0	22.7	27.5	59.9	0.0	22.6	35.8	10.3	23.6	1.9	0.2	0.0	141	0.0	13	42	0.24	
GS-09-02	**M#251418**																													
	08/18/09	16:35	31.87	3	4.55	2,640	8.59	379	2.95	2,580	1,156	0	47.1	13.8	3.4	0.0	0.0	97.6	358.0	63.6	29.4	10.1	114.0	32.4	0	0.0	18	1,935	5.89	
	Mean				4.55	2,640	8.59	379	2.95	2,580	1,156	0	47.1	13.8	3.4	0.0	0.0	97.6	358.0	63.6	29.4	10.1	114.0	32.40	0.00	0.00	18.41	1,935	5.89	
	Max				4.55	2,640	8.59	379	2.95	2,580	1,156	0	47.1	13.8	3.4	0.0	0.0	97.6	358.0	63.6	29.4	10.1	114.0	32.40	0.00	0.00	18.41	1,935	5.89	
	Min				4.55	2,640	8.59	379	2.95	2,580	1,156	0	47.1	13.8	3.4	0.0	0.0	97.6	358.0	63.6	29.4	10.1	114.0	32.40	0.00	0.00	18.41	1,935	5.89	
GS-09-03	**M#251419**																													
	08/18/09	18:20	37.86	1.28	4.37	3,450	10.43	452	3.94	3,520	1,491	0	43.8	17.9	10.8	0.0	0.0	95.0	424.0	105.0	120.0	23.9	3.6	92.3	0	0.0	57	2,496	9.04	
	Mean				4.37	3,450	10.43	452	3.94	3,520	1,491	0	43.8	17.9	10.8	0.0	0.0	95.0	424.0	105.0	120.0	23.9	3.6	92.30	0.00	0.00	56.58	2,496	9.04	
	Max				4.37	3,450	10.43	452	3.94	3,520	1,491	0	43.8	17.9	10.8	0.0	0.0	95.0	424.0	105.0	120.0	23.9	3.6	92.30	0.00	0.00	56.58	2,496	9.04	
	Min				4.37	3,450	10.43	452	3.94	3,520	1,491	0	43.8	17.9	10.8	0.0	0.0	95.0	424.0	105.0	120.0	23.9	3.6	92.30	0.00	0.00	56.58	2,496	9.04	
GS-11																														
Fingerprint	4/17/2010	17:00	12.08		6.19	2,673	11.75	412	6.43	2,550	1,123	72	48.76	18.09	12.78	4.22	0.00	90.06	328	73.8	98.6	23.4	0.05	23.20	87.8	0.0	67.8	1,475	0.742	266
GS-29D																														
Fingerprint	4/10/2010	15:45	35.75		7.76	1,379	16.13	244	8.01	1,390	315	144	21.96	18.85	56.75	18.42	0.00	77.61	67.8	35.3	201	12.4	<0.006	0.00	175.7	0.0	17.1	583	2.66	63
GS-29SR																														
Trec	3/15/2010		5.97		6.19	117	8.04	169	8.17	442	136	107	46.50	18.98	31.66	49.66	0.00	28.92	38.8	9.6	30.3	4.0	<0.001	0.00	130.3	0.0	23.4	60	1.21	99
Fingerprint	4/16/2010	13:20	6.65		6.82	399	8.08	328	7.26	401	132	103	45.96	18.97	32.14	48.31	0.00	29.76	37.4	9.4	30.0	4.0	0.00	0.00	124.7	0.0	23.6	60	1.24	100
GS-30D																														

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanum
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
BPS07-21C																						
Fingerprint	8/11/2010	44.3	0.1	<0.05	0.1	NR	NR	5.73	<0.20	5.46	33.40	5.44	<0.20	1.78	<0.20	0.19	<0.20	0.53	<0.51	<0.19	NR	<0.20
BPS07-24																						
Fingerprint	8/10/2010	33.8	0.137	<0.05	0.086	N R	NR	<10.10	<1.01	4.14	85.80	42.80	<1.01	19.80	<1.01	<0.93	< 1.01	834.00	<2.53	<0.93	NR	<1.01
GS-08																						
Fingerprint	4/17/2010	41.3	0.077	<0.05	<0.03	1.31	<0.25	<4.2	<0.5	3.58	115	11.50	<0.6	5.07	<0.5	<0.4	<0.5	13.10	<0.5	<0.5	NR	<0.5
GS-09																						
Trec	3/15/2010	48.8	2.62	<0.05	<0.09			33.0	0.78	3.26	125	22.00	1.64	95.00	2.51	2.17	<0.51	9,752	<0.51	<0.51	NR	1.71
Trec	3/15/2010	46.4	2.58	<0.05	<0.09			32.8	0.80	3.33	121	21.90	1.66	95.00	2.46	2.06	<0.51	9,873	<0.51	<0.51	NR	1.66
Fingerprint	4/17/2010	48.7	2.63	<0.25	<0.15	2.07	<0.25	21.2	<0.5	3.22	130	22.20	1.59	97.10	2.03	1.81	<0.5	9,997	<0.5	<0.5	NR	1.44
GS-09-01	**M#251420**																					
	8/18/2009	75..9	11.90					60,030	24.0	1.1	602	8.9	17.4	783.0	828	165.0	6.20	173,662	<0.42	1.22		261
	Mean	27.1	4.18					#DIV/0!	#DIV/0!	0.7	10	73.3	#DIV/0!	#DIV/0!		0.2	#DIV/0!	#DIV/0!			#DIV/0!	
	Max	27.1	4.18					0	0.0	0.7	10	73.3	0.0	0.0		0.2	0.00	0			0.0	
	Min	27.1	4.18					0	0.0	0.7	10	73.3	0.0	0.0		0.2	0.00	0			0.0	
GS-09-02	**M#251418**																					
	08/18/09	74.3	2.03					10,323	0.4	3.3	56	14.7	9.0	431.0	146	238.0	0.54	44,586	<0.21	0.27	NR	67
	Mean	74.30	2.03					10,323	0.40	3.30	55.60	14.70	9.04	431.00		238.0	0.54	44,586			#DIV/0!	
	Max	74.30	2.03					10,323	0.40	3.30	55.60	14.70	9.04	431.00		238.0	0.54	44,586			0.00	
	Min	74.30	2.03					10,323	0.40	3.30	55.60	14.70	9.04	431.00		238.0	0.54	44,586			0.00	
GS-09-03	**M#251419**																					
	08/18/09	73.6	9.31					35,363	3.4	<0.50	242	10.3	15.8	574.0	1,269	1,137.0	1.08	56,755	<0.21	2.03	NA	263
	Mean	73.60	9.31					35,363	3.44	#DIV/0!	242.00	10.30	15.80	574.00		1,137.0	1.08	56,755			#DIV/0!	
	Max	73.60	9.31					35,363	3.44	0.00	242.00	10.30	15.80	574.00		1,137.0	1.08	56,755			0.00	
	Min	73.60	9.31					35,363	3.44	0.00	242.00	10.30	15.80	574.00		1,137.0	1.08	56,755			0.00	
GS-11																						
Fingerprint	4/17/2010	20.4	<0.367	<0.25	0.255	4.08	<0.25	51.1	<0.5	2.03	4,860	13.60	0.96	455.00	4.95	31.40	<0.5	31,720	<0.5	<0.5	NR	1.59
GS-29D																						
Fingerprint	4/10/2010	13.1	<0.05	<0.05	<0.03	1.62	<0.25	<4.2	<0.5	16.00	297	11.50	<0.6	<0.5	<0.5	<0.4	<0.5	<3.0	8.52	<0.5	NR	<0.5
GS-29SR																						
Trec	3/15/2010	31.1	2.73	0.061	0.046			2.92	<0.1	3.23	29.3	51.30	<0.1	1.40	<0.1	0.19	0.35	1.00	<0.1	<0.1	NR	<0.1
Fingerprint	4/16/2010	32.4	2.75	<0.05	<0.03	1.61	<0.05	<0.8	<0.1	2.93	30.5	52.40	<0.1	1.42	<0.1	0.10	0.21	1.24	<0.1	<0.1	NR	<0.1
GS-30D																						

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			MINOR AND TRACE METALS																
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	Palladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
BPS07-21C																			
Fingerprint	8/11/2010	88.40	58.10	<0.17	<0.20	0.52	<0.20	<0.51	<0.20	6.56	0.26	<0.30	957.00	<0.20	3.13	<0.20	1.92	0.33	256
BPS07-24																			
Fingerprint	8/10/2010	398.00	2.97	<0.86	<1.01	21.40	<1.01	<2.53	<1.01	27.70	0.99	<1.01	######	<1.01	13.70	<1.01	41.10	<1.01	5,379
GS-08																			
Fingerprint	4/17/2010	347.00	1.45	<0.7	<0.4	1.16	<2.5	0.65	<0.5	14.0	<1.0	<3.0	2,584	<2.5	5.98	<2.5	3.11	<0.6	547
GS-09																			
Trec	3/15/2010	626.00	0.77	<1.01	<0.51	202.00	<0.51	1.84	<0.51	34.4	<1.01	<0.51	6,348	<0.51	16.60	<0.51	1.42	<0.51	36,643
Trec	3/15/2010	632.00	0.74	<1.01	<0.51	203.00	<0.51	1.72	<0.51	34.4	1.22	<0.51	6,348	<0.51	15.90	<0.51	1.38	<0.51	36,724
Fingerprint	4/17/2010	511.00	0.70	<0.7	0.42	205.00	<2.5	1.72	<0.5	32.2	1.03	<3.0	6,515	<2.5	15.30	<2.5	<3.0	<0.6	37,550
GS-09-01	**M#251420**																		
	8/18/2009	335	<.4	<0.40	300	189.0	4.9	9	73	54	5.6	<0.41	2,819	0	16	1	141.0	<0.50	67,083
	Mean	3	0.8			#DIV/0!	#DIV/0!				0.8		259				2.1		#DIV/0!
	Max	3	0.8			0.0	0.0				0.8		259				2.1		0
	Min	3	0.8			0.0	0.0				0.8		259				2.1		0
GS-09-02	**M#251418**																		
	08/18/09	318	<0.20	<0.20	39	171.0	16.8	3	11	1	1.9	<0.21	1,375	<0.12	20	<0.17	27.6	<0.25	110,200
	Mean	318.00	#DIV/0!			171.00	16.80				1.93		1,375				27.60		110,200
	Max	318.00	0.00			171.00	16.80				1.93		1,375				27.60		110,200
	Min	318.00	0.00			171.00	16.80				1.93		1,375				27.60		110,200
GS-09-03	**M#251419**																		
	08/18/09	440	<0.20	<0.20	353	232.0	13.5	13	87	44	3.7	<0.21	2,176	0	22	1	248.0	<0.25	108,842
	Mean	440.00	#DIV/0!			232.00	13.50				3.70		2,176				248.00		108,842
	Max	440.00	0.00			232.00	13.50				3.70		2,176				248.00		108,842
	Min	440.00	0.00			232.00	13.50				3.70		2,176				248.00		108,842
GS-11																			
Fingerprint	4/17/2010	167.00	1.54	<0.7	2.42	27.40	212.00	1.04	0.58	7.79	1.82	<3.0	2,724	<2.5	10.40	<2.5	30.20	<0.6	126,757
GS-29D																			
Fingerprint	4/10/2010	543.00	46.30	<0.7	<0.4	<0.6	<2.5	<0.6	<0.5	18.4	<1.0	<3.0	1,375	<2.5	5.05	<2.5	12.20	2.30	<3.3
GS-29SR																			
Trec	3/15/2010	25	11.20	<0.2	<0.1	0.37	<0.1	<0.1	<0.1	0.60	0.89	<0.1	327	<0.1	0.52	<0.1	7.62	6.04	169
Fingerprint	4/16/2010	26	11.80	<0.1	<0.1	0.33	<0.5	<0.1	<0.1	0.60	0.73	<0.6	330	<0.5	0.49	<0.5	7.32	6.34	159
GS-30D																			

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		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
Fingerprint	4/17/2010	14:55	10.05		5.79	2,848	9.99	381	6.19	2,810	1,599	74	58.51	28.43	9.26	3.61	0.00	88.44	431	127	78.2	16.3	<0.006	14.60	89.6	0.0	101.9	1,730	0.595	<250
GS-30S																														
Fingerprint	4/17/2010	14:20	10.90		6.37	1,720	9.58	120	7.03	1,740	804	216	50.38	24.35	12.91	20.23	0.00	72.22	217	63.6	63.8	10.3	24.90	25.90	262.9	0.0	56.6	739	0.226	165
GS-32D																														
Fingerprint	4/18/2010	14:10	5.45		5.78	284	7.49	399	6.77	2,850	1,656	68	61.77	25.04	10.98	3.35	0.00	91.87	472	116	96.2	18.4	0.01	0.23	82.7	0.0	54.1	1,784	0.548	170
GS-32S																														
Fingerprint	4/18/2010	13:35	5.11		3.99	1,690	9.87	353	6.36	1,719	853	163	56.29	25.52	15.14	14.44	0.00	76.21	235	64.6	72.5	9.0	0.12	7.19	198.9	0.0	65.8	826	0.478	193
GS-34S																														
Fingerprint	4/23/2010	15:30	8.93		6.70	NR	4.46	351	7.23	1,150	518	125	51.52	24.76	17.65	18.22	0.00	65.55	140	40.8	55.0	7.3	<0.003	9.13	153.3	0.0	75.8	434	1.39	225
GS-10A (D)	**M#4668**																													
MBMG	07/25/88	10:45	NR	Bailed	5.49	3,150	11.60	NR	4.24	2,445	1,230	0	62.3	10.8	14.6	0.0	0.0	94.5	420.0	44.0	113.0	14.3	53.0	22	0	0.0	52	1,484	6.40	
MBMG	10/04/88	11:00	NR	Bailed	NR	2,721	9.50	NR	3.21	3,237	1,779	0	48.5	21.3	5.3	0.0	0.0	98.1	495.0	132.0	62.5	20.9	113.0	104	0	0.0	29	2,340	2.00	
MBMG	05/09/89	10:10	NR	Bailed	6.00	2,750	NR	NR	4.48	2,457	1,446	0	59.6	10.3	5.0	0.0	0.0	97.0	482.0	50.5	46.3	16.1	126.0	37	0	0.0	32	1,860	5.60	
MBMG	02/23/01	15:25	NR	Bailed	5.30	3,360	9.40	NR	3.28	1,682	711	0	56.6	12.9	6.0	0.0	0.0	94.2	232.0	32.1	28.3	12.7	43.7	22	0	0.0	39	949	2.53	
MBMG	08/17/09	12:55	20.74	2	4.74	3,380	9.66	384	4.34	3,410	2,075	0	53.5	19.4	3.8	0.0	0.0	97.8	610.0	134.0	49.2	18.9	77.6	131	0	0.0	41	2,481	<1.0	
	Mean				5.38	3,072	10.04	384	3.91	2,646	1,448	0	56.1	14.9	6.9	0.0	0.0	96.3	447.8	78.5	59.9	16.6	82.7	63.22	0.00	0.00	38.34	######	4.13	
	Max				6.00	3,380	11.60	384	4.48	3,410	2,075	0	62.3	21.3	14.6	0.0	0.0	98.1	610.0	134.0	113.0	20.9	126.0	131.00	0.00	0.00	52.10	######	6.40	
	Min				4.74	2,721	9.40	384	3.21	1,682	711	0	48.5	10.3	3.8	0.0	0.0	94.2	232.0	32.1	28.3	12.7	43.7	21.70	0.00	0.00	29.10	949.00	2.00	
GS-10B	**M#4666**																													
MGMG	07/25/88	10:45	NR	Bailed	5.11	2,340	11.90	NR	4.38	1,824	652	0	43.5	9.5	15.1	0.0	0.0	91.0	214.0	28.5	85.1	12.0	104.0	13	0.0	0.0	67	994	2.60	
MGMG	10/04/88	10:05	NR	Bailed	NR	1,602	9.50	NR	3.81	1,980	771	0	45.7	9.4	11.4	0.0	0.0	91.6	256.0	32.1	73.1	11.8	131.0	16	0.0	0.0	74	1,141	2.00	
MGMG	05/09/89	9:45	NR	Bailed	5.28	2,020	11.00	NR	3.74	1,990	769	0	45.7	9.3	11.9	0.0	0.0	84.1	256.0	31.7	76.2	9.6	132.0	16	0.0	0.0	72	1,147	1.90	
MBMG	08/19/09	12:18	18.40	2	3.37	2,220	9.44	635	3.50	2,320	795	0	54.1	7.6	19.9	0.0	0.0	61.6	279.0	23.9	118.0	8.6	1.2	15	0.0	0.0	307	850	1.53	
	Mean				4.59	2,046	10.46	635	3.86	2,028	747	0	47.2	9.0	14.6	0.0	0.0	82.1	251.3	29.1	88.1	10.5	92.0	14.63	0.00	0.00	129.88	######	2.01	
	Max				5.28	2,340	11.90	635	4.38	2,320	795	0	54.1	9.5	19.9	0.0	0.0	91.6	279.0	32.1	118.0	12.0	132.0	15.70	0.00	0.00	306.80	######	2.60	
	Min				3.37	1,602	9.44	635	3.50	1,824	652	0	43.5	7.6	11.4	0.0	0.0	61.6	214.0	23.9	73.1	8.6	1.2	12.80	0.00	0.00	67.40	849.70	1.53	
GS-40	**M#150403**																													
MBMG	8/17/2009	10:00	21.93	2	5.53	2,620	9.60	290	4.40	2,710	1,178	0	45.9	18.4	4.4	0.0	0.0	98.6	337.0	81.7	37.2	19.0	116	88.7	0	0	15.72	1,861	1.73	
	Mean				5.53	2,620	9.60	290	4.40	2,710	1,178	0	45.9	18.4	4.4	0.0	0.0	98.6	337.0	81.7	37.2	19.0	116	88.70	0.00	0.00	15.72	1,861	1.73	
	Max				5.53	2,620	9.60	290	4.40	2,710	1,178	0	45.9	18.4	4.4	0.0	0.0	98.6	337.0	81.7	37.2	19.0	116	88.70	0.00	0.00	15.72	1,861	1.73	
	Min				5.53	2,620	9.60	290	4.40	2,710	1,178	0	45.9	18.4	4.4	0.0	0.0	98.6	337.0	81.7	37.2	19.0	116	88.70	0.00	0.00	15.72	1,861	1.73	
GS-41S	**M#150401**																													
RI	08/15/89							85	3.80	6,010	1,662	0	53.0	38.0	9.0	0.0	0.0	99.0	387.0	169.0	67.2	14.2	1,100	100	0.0	0.0	61	8,050	14.60	
RI	11/08/89							185	4.10	5,340	1,549	0	85.0	0.0	14.0	0.0	0.0	99.0	340.0	170.0	60.0	14.0	890	110	0.0	0.0	67	8,610	6.54	
RI	04/16/90								3.80	6,360	1,694	0	52.0	39.0	8.8	0.0	0.0	98.1	388.0	176.0	66.3	15.0	1,140	110	0.0	0.0	96	6,650	0.32	
RI	03/18/97										1,070	0							181.0	150.0	78.9	15.4	645	92	0.0	0.0	119	4,000	0.50	
RI	06/25/97										1,640	0							436.0	134.0	75.3	14.8	621	80	0.0	0.0	106	4,190	0.50	
RI	09/24/97										1,760	0							460.0	148.0	77.7	15.0	683	80	0.0	0.0	142	4,180	0.50	

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanun
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Fingerprint	4/17/2010	41.5	4.72	<0.25	<0.15	1.32	<0.25	7.65	<0.5	2.65	146	18.60	<0.6	32.80	0.66	3.38	<0.5	2,341	<0.5	<0.5	NR	<0.5
GS-30S																						
Fingerprint	4/17/2010	44.4	<0.05	<0.05	<0.03	3.37	<0.25	<4.2	<0.5	14.70	879	34.10	<0.6	<0.5	<0.5	<0.4	<0.5	<3.0	<0.5	<0.5	NR	<0.5
GS-32D																						
Fingerprint	4/18/2010	36.5	5.32	<0.05	<0.03	1.93	<0.25	2.80	<0.1	4.45	39.3	21.70	0.19	24.90	<0.1	0.35	<0.1	788	<0.1	<0.1	NR	0.19
GS-32S																						
Fingerprint	4/18/2010	29.6	3.18	<0.05	<0.03	1.15	<0.25	<4.2	<0.5	5.01	116	15.50	<0.6	16.30	<0.5	11.60	<0.5	360	<0.5	<0.5	NR	<0.5
GS-34S																						
Fingerprint	4/23/2010	18.1	0.366	<0.05	<0.03	<0.03	<0.25	<4.2	<0.5	4.67	182	26.90	<0.6	20.40	<0.5	3.32	<0.5	751	<0.5	<0.5	NR	<0.5
GS-10A (D)	**M#4668**																					
MBMG	07/25/88	51.7	0.05					260	4	4.9	120	NR	NR	140		NR	4	140			NR	
MBMG	10/04/88	50.2	0.12					1,090	51	4.4	180	NR	NR	220		NR	29	1,060			NR	
MBMG	05/09/89	50.4	0.08					900	10	8.2	130	NR	NR	260		NR	8	170			NR	
MBMG	02/23/01	53.8	<1					2,880	<10	<10	49	212	4.4	175		278.0	<20	6,490			NR	
MBMG	08/17/09	45	<1.0					668	0.689	0.9	74.9	16.9	3.1	289	194	1,808.0	<0.20	8,717	<0.21	0.49	NA	28
	Mean	50.22	0.08					1159.60	16.42	4.59	110.78	114.45	3.76	216.80		1043.00	13.67	3315.40				
	Max	53.80	0.12					2880.00	51.00	8.20	180.00	212.00	4.44	289.00		1808.00	29.00	8717.00				
	Min	45.00	0.05					260.00	0.69	0.86	49.00	16.90	3.08	140.00		278.00	4.00	140.00				
GS-10B	**M#4666**																					
MGMG	07/25/88	58.5	0.13					2,000	3.00	7.90	100	NR	NR	150		NR	4	10,100			NR	
MGMG	10/04/88	57.0	0.09					1,670	5.00	15.00	90	NR	NR	180		NR	2	4,880			NR	
MGMG	05/09/89	51.7	0.08					1,170	4.00	11.00	100	NR	NR	190		NR	3	3,230			NR	
MBMG	08/19/09	54.9	32.23					18,002	3.07	1.74	113	6.1	3.5	283	207	70.1	10	30,241	<0.21	0.34	NA	101
	Mean	55.53	8.13					5710.50	3.77	8.91	100.75	6.09	3.45	200.75		70.10	4.68	12112.75			#DIV/0!	
	Max	58.50	32.23					18002.00	5.00	15.00	113.00	6.09	3.45	283.00		70.10	9.72	30241.00			0.00	
	Min	51.70	0.08					1170.00	3.00	1.74	90.00	6.09	3.45	150.00		70.10	2.00	3230.00			0.00	
														189				10,900				
GS-40	**M#150403**																					
MBMG	8/17/2009	42.4	<1.0					335	<0.20	0.668	63.5	6.81	<1.00	108	20	384.0	<0.20	170	<0.21	<0.25	NR	14
	Mean	42.40	#DIV/0!					335	#DIV/0!	0.67	63.50	6.81	#DIV/0!	108.00		384.0	#DIV/0!	170			#DIV/0!	
	Max	42.40	0.00					335	0.00	0.67	63.50	6.81	0.00	108.00		384.0	0.00	170			0.00	
	Min	42.40	0.00					335	0.00	0.67	63.50	6.81	0.00	108.00		384.0	0.00	170			0.00	
GS-41S	**M#150401**																					
RI	08/15/89		<0.05					92,400		21.6		16.7	36.9	1,780		810.0	<2.8	492,000				
RI	11/08/89		0.47					84,000		63.0		<12	29.0	1,700		960.0	48	52,000				
RI	04/16/90		<0.01					103,000		43.4		16.2	38.9	1,800		996.0	29.2	540,000				
RI	03/18/97		0.05					95,000		26.6				1,650				449,000				
RI	06/25/97		0.18					81,200		29.0				1,410				415,000				
RI	09/24/97		1.66					90,500		43.4				1,520				436,000				

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		MINOR AND TRACE METALS																	
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	alladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Fingerprint	4/17/2010	341.00	1.25	<0.7	<0.4	52.10	<2.5	1.11	<0.5	27.4	<1.0	<3.0	4,187	<2.5	13.90	<2.5	<3.0	<0.6	6,811
GS-30S																			
Fingerprint	4/17/2010	78.70	6.10	<0.7	<0.4	<0.6	<2.5	<0.6	<0.5	1.74	<1.0	<3.0	1,243	<2.5	5.08	<2.5	<3.0	<0.6	<3.3
GS-32D																			
Fingerprint	4/18/2010	217	1.02	<0.1	0.11	21.5	0.56	1.56	<0.1	20.6	0.77	<0.6	5,966	<0.5	12.5	<0.5	8.52	<0.1	6,606
GS-32S																			
Fingerprint	4/18/2010	149.00	6.26	<0.7	<0.4	12.20	<2.5	<0.6	<0.5	3.70	<1.0	<3.0	1,884	<2.5	7.13	<2.5	11.90	<0.6	2,351
GS-34S																			
Fingerprint	4/23/2010	93.40	7.73	<0.7	<0.4	2.11	4.55	<0.6	<0.5	2.28	<1.0	<3.0	945	<2.5	3.68	3.04	19.90	1.25	7,885
GS-10A (D)	**M#4668**																		
MBMG	07/25/88	120	20			72	40.0				NR		1,450				NR		1,890
MBMG	10/04/88	360	30			250	100.0				NR		2,640				NR		66,800
MBMG	05/09/89	180	20			160	92.0				NR		1,660				NR		46,600
MBMG	02/23/01	185	<100			100	<20				<10		963				NR		32,200
MBMG	08/17/09	417	<0.20	<0.20	12	306	18.0	2	3	7	1.6	<0.21	2,970	<0.12	22	<0.17	10.4	<0.25	112,921
	Mean	252.40	23.33			177.50	62.50				1.62		######				10.40		52082.20
	Max	417.00	30.00			306.00	100.00				1.62		######				10.40		#######
	Min	120.00	20.00			72.00	18.00				1.62		963.00				10.40		1890.00
GS-10B	**M#4666**																		
MGMG	07/25/88	120	<20			80	40.0				NR		980				NR		29,500
MGMG	10/04/88	120	<20			100	70.0				NR		1,120				NR		36,200
MGMG	05/09/89	130	30.00			100	56.2				NR		1,080				NR		36,000
MBMG	08/19/09	147	<0.20	<0.20	68	52	1.0	1	19	7	2.0	<0.21	627	1	7	<0.17	38.4	<0.25	30,975
	Mean	129.25	30.00			83.03	41.79				2.03		951.75				38.40		33168.75
	Max	147.00	30.00			100.00	70.00				2.03		######				38.40		36200.00
	Min	120.00	30.00			52.10	0.97				2.03		627.00				38.40		29500.00
GS-40	**M#150403**																		
MBMG	8/17/2009	278	1.27	<0.20	3.9	202	1.01	0.7	1.1	78	0.8	<0.21	2,200	<0.12	16	0.6	1.0	<0.25	45,683
	Mean	278.00	1.27			202.00	1.01				0.83		2,200				1.00		45,683
	Max	278.00	1.27			202.00	1.01				0.83		2,200				1.00		45,683
	Min	278.00	1.27			202.00	1.01				0.83		2,200				1.00		45,683
GS-41S	**M#150401**																		
RI	08/15/89					613	101.0												316,000
RI	11/08/89					470	93.0				<5.0								360,000
RI	04/16/90					717	99.5												389,000
RI	03/18/97						63.8												276,000
RI	06/25/97						77.2												245,000
RI	09/24/97						119.0												246,000

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		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
RI	12/17/97										1,870	0							482.0	162.0	88.0	17.0	760	88	0.0	0.0	170	4,830	0.50	
MBMG	04/11/03	11:15			3.79	5,350	9.10		3.44	5,920	1,687	0	17.1	10.1	2.5	0.0	0.0	100.0	425.0	152.0	71.5	13.2	902	77	0.0	0.0	<12.5	6,204	<12.5	
MBMG	11/10/03	14:00	33.66		3.72	5,510	8.13	155	3.69	5,490	1,623	0	17.2	10.4	2.4	0.0	0.0	96.5	404.2	149.0	65.1	12.7	915	66	0.0	0.0	132	5,301	5.54	
MBMG	04/06/04	13:00	33.89		3.27	5,600	9.25	385	3.74	5,940	1,817	0	16.5	10.6	2.7	0.0	0.0	96.2	444.0	172.0	81.7	15.0	900	81	0.0	0.0	187	6,755	6.25	
MBMG	05/16/05	13:35	34.72		4.22	7,020	8.96	467	3.65	6,940	2,031	0	12.8	9.2	1.8	0.0	0.0	97.3	474.0	206.0	76.5	15.0	1,373	104	0.0	0.0	153	8,082	6.24	
MBMG	05/04/06	15:05	34.76	0.8	3.79	7,390	9.05	402	3.63	7,010	1,849	0	12.4	9.0	1.9	0.0	0.0	96.6	429.0	189.0	75.3	15.0	1,280	97	0.0	0.0	198	8,322	11.20	
MBMG	04/13/07	11:40	33.92	1.0	3.67	9,560	8.70	139	3.50	8,260	2,304	0	12.9	10.5	1.8	0.0	0.0	95.7	509.0	251.0	82.9	16.9	1,400	106	0.0	0.0	250	8,510	18.50	
MBMG	05/27/08	14:00	34.18	1.5	3.45	9,635	9.08		3.37	9,530	2,116	0	8.0	7.9	1.5	0.0	0.0	96.7	427.0	255.0	88.7	15.7	2,045	123	0.0	0.0	229	10,545	21.40	
MBMG	04/23/09	16:05	34.44		3.51	7,732	8.45	382	3.28	7,620	1,907	0	11.4	8.7	1.7	0.0	0.0	96.6	434.0	200.0	72.4	15.7	1,450	86	0.0	0.0	196	8,715	17.11	
MBMG	08/17/09	14:00	33.54		4.01	7,960	8.61	384	4.12	8,120	1,862	0	11.1	8.1	1.6	0.0	0.0	96.4	431.0	191.0	69.9	13.8	1,615	83	0.0	0.0	212	8,342	10.73	
Fingerprint	4/20/2010	12:00	34.24		4.04	7,620	8.93	356	3.31	7,610	1,911	0	6.28	8.50	1.63	0.00	0.00	96.64	429	204	74.2	14.9	1,636.00	87.60	0.0	0.0	174.4	7,919	15.64	304.0
	Mean				3.75	7,338	8.83	294	3.65	6,935	1,785	0	24.3	13.1	3.9	0.0	0.0	97.3	416.5	181.1	74.8	14.9	1,139	92	0.0	0	156	7,012	8.50	
	Max				4.22	9,635	9.25	467	4.12	9,530	2,304	0	85.0	39.0	14.0	0.0	0.0	100.0	509.0	255.0	88.7	17.0	2,045	123	0.0	0	250	10,545	21.40	
	Min				3.27	5,350	8.13	85	3.28	5,340	1,070	0	6.3	0.0	1.5	0.0	0.0	95.7	181.0	134.0	60.0	12.7	621	66	0.0	0	61	4,000	0.32	
GS-41D	**M#150402**																													
RI	08/15/89							120	3.90	6,835	1,988	0				0.0	0.0	99.7	435.0	219.0	75.8	14.8	1,800	153	0.0	0.0	22	10,010	14.10	
RI	11/08/89							250	4.20	5,780	1,864	0				0.0	0.0	90.6	400.0	210.0	74.0	15.0	1,570	160	0.0	0.0	18	234	18.00	
RI	04/16/90								3.90	7,215	1,802	0				0.0	0.0	99.7	382.0	206.0	75.1	16.4	2,010	143	0.0	0.0	19	8,690	0.34	
MBMG	03/02/01								4.10	8,630	2,079	0				0.0	0.0		419.0	251.0	77.2	17.5	1,790	151	0.0	0.0	132	9,480	13.30	
MBMG	04/11/03	10:50			3.86	6,370	9.20		3.52	7,080	1,781	0	11.4	9.4	1.8	0.0	0.0	100.0	392.0	195.0	69.5	15.1	1,470	157	0.0	0.0	<125	7,867	<12.5	
MBMG	11/10/03	13:20	33.70		3.70	6,920	8.43	157	3.56	6,910	1,845	0	12.0	10.1	1.8	0.0	0.0	97.5	401.0	205.0	69.0	13.1	1,417	160	0.0	0.0	128	7,940	<2.5	
MBMG	04/19/04	15:30	33.87		3.38	6,790	8.87	381	4.05	7,050	1,960	0	11.8	9.6	1.8	0.0	0.0	97.5	432.0	214.0	77.1	16.7	1,523	192	0.0	0.0	148	7,871	<6	
MBMG	05/16/05	11:50	35.02		4.15	7,380	8.94	469	3.66	7,300	1,974	0	10.0	8.4	1.5	0.0	0.0	97.4	428.0	220.0	75.6	16.8	1,938	178	0.0	0.0	159	9,031	9.94	
MBMG	05/04/06	14:30	34.75	1	3.80	8,220	8.90	321	3.63	7,140	1,982	0	10.8	9.1	1.7	0.0	0.0	97.4	431.0	220.0	76.1	16.7	1,611	163	0.0	0.0	156	9,406	15.90	
MBMG	04/13/07	12:15	34.02	1	3.73	8,460	9.00	137	3.44	7,810	1,959	0	10.3	9.3	1.7	0.0	0.0	96.9	412.0	226.0	79.0	20.3	1,617	172	0.0	0.0	164	8,496	19.30	
MBMG	05/22/08	14:20	34.17	1.5	4.13	7,550	8.84	402	3.02	7,900	2,009	0	11.1	10.3	2.1	0.0	0.0	97.7	417.0	235.0	89.7	18.3	1,226	171	0.0	0.0	116	8,823	20.90	
MBMG	04/23/09	16:48	34.44		3.53	7,921	8.63	363	3.32	7,910	2,016	0	11.1	9.8	1.8	0.0	0.0	98.1	430.0	229.0	78.6	17.9	1,395	183	0.0	0.0	101	9,348	16.23	
MBMG	08/17/09	14:31	33.56		3.90	8,130	8.89	395	4.20	8,260	1,907	0	10.2	9.2	1.7	0.0	0.0	97.8	401.0	220.0	77.1	15.7	1,518	178	0.0	0.0	121	8,816	14.72	
Fingerprint	4/20/2010	16:10	34.27		3.93	7,912	9.02	345	3.28	7,940	1,952	0	9.91	9.18	1.81	0.00	0.00	98.09	406	228	85.1	17.4	1,552.00	192.00	0.0	0.0	83.9	8,294	18.98	<250
	Mean				3.81	7,565	8.87	304	3.70	7,411	1,937	0	10.9	9.5	1.8	0.0	0.0	97.6	413.3	219.9	77.1	16.6	1,603	168	0.0	0.0	105	8,165	14.70	
	Max				4.15	8,460	9.20	469	4.20	8,630	2,079	0	12.0	10.3	2.1	0.0	0.0	100.0	435.0	251.0	89.7	20.3	2,010	192	0.0	0.0	164	10,010	20.90	
	Min				3.38	6,370	8.43	120	3.02	5,780	1,781	0	9.9	8.4	1.5	0.0	0.0	90.6	382.0	195.0	69.0	13.1	1,226	143	0.0	0.0	18	234	0.34	
GS-42S	**M# 150404**																													
MBMG	05/17/06	10:00	15.39	1.5	4.05	3,680	9.45	525	3.81	5,370	1,537	0	16.6	7.6	2.5	0.0	0.0	95.8	423.0	117.0	72.4	14.4	1,227	37	0	0.0	162	5,441	7.89	
MBMG	04/13/07	15:55	12.73	1	3.71	5,560	8.20	204	3.30	5,640	1,530	0	17.2	7.9	2.5	0.0	0.0	94.9	420.0	117.0	70.6	16.0	1,146	39	0	0.0	151	5,100	8.55	
MBMG	07/28/08	15:00	14.54	2	3.82	6,460	9.89	393	3.16	5,840	1,587	0	17.4	7.7	2.5	0.0	0.0	99.4	441.0	118.0	70.5	16.2	1,213	37	0	0.0	147	5,449	8.99	
MBMG	08/17/09	15:40	14.61	3.5	4.05	6,100	9.00	419	3.99	6,020	1,630	0	16.0	7.9	2.4	0.0	0.0	95.4	437.0	131.0	74.5	14.7	1,296	43.90	0	0.0	173	5,343	8.15	
Fingerprint	4/26/2010	16:45	15.61		3.84	5,645	9.39	427	3.04	5,570	1,602	0	17.00	7.85	3.14	0.00	0.00	92.98	439	4,123	93.0	17.9	1,178.00	34.90	0.0	0.0	232.7	4,911	10.08	421
	Mean				3.89	5,489	9.19	394	3.46	5,688	1,577	0	16.8	7.8	2.6	0.0	0.0	95.7	432.0	921.2	76.2	15.8	1,212	38	0	0.0	173	5,249	8.73	
	Max				4.05	6,460	9.89	525	3.99	6,020	1,630	0	17.4	7.9	3.1	0.0	0.0	99.4	441.0	4123.0	93.0	17.9	1,296	44	0	0.0	233	5,449	10.08	
	Min				3.71	3,680	8.20	204	3.04	5,370	1,530	0	16.0	7.6	2.4	0.0	0.0	93.0	420.0	117.0	70.5	14.4	1,146	35	0	0.0	147	4,911	7.89	
GS-42D	**M#150405**																													

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanun
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
RI	12/17/97		0.52					111,000		36.2				1,770				437,000				
MBMG	04/11/03	66	<12.5					88,100	<10	53.7	357	<20	36.0	1,750		732.0	<20	538,000				
MBMG	11/10/03	73.4	<2.5					76,061	<10	67.1	332	<20	28.8	1,434		603.0	<20	460,110			NA	
MBMG	04/06/04	83.9	<2.5					112,056	<10	76.1	389	<20	38.5	2,227		814.0	<20	634,636			NA	
MBMG	05/16/05	87.1	<1.25					163,304	<10	98.8	347	<20	42.4	3,692		1,092.0	<20	918,660			NA	
MBMG	05/04/06	89.3	<5					143,283	<10	82.8	310	<20	38.0	3,371		1,083.0	<20	887,814			NA	
MBMG	04/13/07	88.8	<10					193,000	<10	36.5	320	7.51	42.9	3,443	2,148	976.0	12.2	976,000	<1.0	3.50	NA	750
MBMG	05/27/08	91.1	<0.5					251,494	<10	13.9	347	5.71	54.7	6,639	2,911	1,421.0	11.6	1,579,944	<2	3.69	NA	1,000
MBMG	04/23/09	91.5	<5.0					165,290	<4.18	73.4	276	9.6	43.3	4,063	1,932	1,167.0	11.2	1,010,388	<4.20	<4.69	NA	686
MBMG	08/17/09	88.5	<5.0					153,391	1.84	103.0	194	8.7	34.1	4,060	2,487	953.0	11.9	1,005,218	<1.20	2.17	NA	826
Fingerprint	4/20/2010	86.9	<0.25	<0.25	0.598	5.04	1.26	156,869	<2.2	71.60	187	7.00	36.50	4,231.00	1,632	1,213.00	10.80	986,507	<2.0	4.54	NR	582
	Mean	84.7	0.58					127,056	2	55.3	306	10	38.5	2,738		986.2	19.3	695,193			#DIV/0!	
	Max	91.5	1.66					251,494	2	103.0	389	17	54.7	6,639		1,421.0	48.0	1,579,944			0	
	Min	66.0	0.05					76,061	2	13.9	187	6	28.8	1,410		603.0	10.8	52,000			0	
GS-41D	**M#150402**																					
RI	08/15/89		0.11					71,800		3.0		13.8	40.8	1,640		1,130.0	<2.8	294,000				
RI	11/08/89		0.39					63,000		38.0		<12	28.0	1,700		1,300.0	85	320,000				
RI	04/16/90		<0.01					74,700		24.8		19.2	37.2	1,930		1,200.0	<8	338,000				
MBMG	03/02/01		<2.5					155,000		<100		<20	61.9	335		1,720.0	<20	866,000				
MBMG	04/11/03	62.8	<12.5					117,000	<10	55.6	<300	<20	53.5	2,470		1,494.0	<20	677,000				
MBMG	11/10/03	76.5	<2.5					112,480	<10	48.9	<300	<20	45.0	2,153		1,565.0	<20	604,631				
MBMG	04/19/04	77.7	<2.5					127,206	<10	43.8	<300	<20	50.3	2,838		1,824.0	<20	715,265				
MBMG	05/16/05	79.1	<1.25					143,099	<10	55.7	<300	<20	54.5	3,591		1,611.0	<20	881,000			NA	
MBMG	05/04/06	78.7	<5					144,887	<10	60.5	<300	<20	53.2	3,633		1,787.0	<20	937,999			NA	
MBMG	04/13/07	82	<10					141,430	<10	22.2	254	7.86	48.2	3,504	1,955	1,519.0	1.2	955,865	<1.0	3.33	NA	6,678
MBMG	05/22/08	60.3	<0.5					157,389	115	20.5	259	5.74	54.8	4,192	2,466	1,774.0	<2	1,052,319	<2.0	3.04	NR	857
MBMG	04/23/09	84.3	<5.0					160,370	4.38	28.3	229	9.86	55.5	3,962	2,470	2,030.0	<3.93	1,023,977	<4.16	5.11	NA	868
MBMG	08/17/09	77.4	<5.0					153,937	3.36	21.4	195	9.74	47.0	3,839	2,882	1,706.0	2.1	1,016,048	<1.20	2.75	NA	1,099
Fingerprint	4/20/2010	77.9	<0.25	<0.05	0.587	5.93	0.81	164,867	2.77	24.10	184	7.36	49.50	3,516.00	2,263	2,332.00	<2.0	1,062,860	<2.0	6.24	NR	757
	Mean	75.7	0.25					127,655	31	34.4	224.20	11	49	2,807		1,642.3	29	767,497			#DIV/0!	
	Max	84.3	0.39					164,867	115	60.5	259.00	19	62	4,192		2,332.0	85	1,062,860			0.00	
	Min	60.3	0.11					63,000	3	3.0	184.00	6	28	335		1,130.0	1.2	294,000			0.00	
GS-42S	**M# 150404**																					
MBMG	05/17/06	82.8	<5.0					83,948	<10	<10	<300	<20	27.6	910		499.0	<20	324,722			NA	
MBMG	04/13/07	86.9	<5.0					79,900	<10	<2	97.0	8.97	24.7	850	930	384.0	<1	299,000	<1.0	1.47	NA	334
MBMG	07/28/08	77.8	2.90					81,956	<1	<2	71.9	9.85	31.2	853	9,108	384.0	<0.5	304,096	<0.5	3.00	NA	6,149
MBMG	08/17/09	79.2	<5.0					95,039	<1.30	<1.90	83.1	10.8	32.6	1,070.0	1,433	493.0	1.39	361,819	<1.20	1.31	NA	518
Fingerprint	4/26/2010	83.7	8.81	<0.25	<0.3	4.89	0.47	98,436	<1.1	<1.2	57.0	9.86	33.70	768.00	939	358.00	1.36	331,406	<1.0	2.19	NR	323
	Mean	82.1	5.86					87,856	#DIV/0!	#DIV/0!	77.3	9.9	30.0	890		423.6	1.4	324,209			#DIV/0!	
	Max	86.9	8.81					98,436	0.0	0.0	97.0	10.8	33.7	1,070		499.0	1.4	361,819			0.0	
	Min	77.8	2.90					79,900	0.0	0.0	57.0	9.0	24.7	768		358.0	1.4	299,000			0.0	
GS-42D	**M#150405**																					

			MINOR AND TRACE METALS																
		Lithium	Iolybdenu	Niobium	Ieodymiu	Nickel	Lead	alladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
RI	12/17/97						91.8												257,000
MBMG	04/11/03	655	<100				81.0				21.2		2,540				368		277,000
MBMG	11/10/03	571	<100				74.6				13.0		2,470				353		234,931
MBMG	04/06/04	687	<100				78.9				31.8		2,776				451		325,832
MBMG	05/16/05	785	<100			914	91.1				51.8		3,215				640		520,593
MBMG	05/04/06	851	<100			873	91.5				47.4		3,009				597		497,859
MBMG	04/13/07	957	<10	<1.0	699	700	102.0	8.3	200	3	5.8	<1.0	3,710	4.0	75.1	<1.0	468	<10.0	515,000
MBMG	05/27/08	1108	<20	1,010	<2	1,047	56.5	8.7	277	<2	<10	<2	4,157	6.8	45.1	<2	815	<10	857,449
MBMG	04/23/09	744	<4.34	<4.45	728	917	86.1	22.0	179	3.3	<10.48	<4.18	2,692	6.1	43.8	<3.33	588	<5.07	550,393
MBMG	08/17/09	604	<1.60	<3.40	776	712	92.7	30.5	206	2.9	5.6	<1.60	2,831	6.7	54.6	<1.40	633	<1.30	483,891
Fingerprint	4/20/2010	600	<1.7	<2.7	576	708.0	58.40	25.4	145.0	2.48	6.99	<12.1	2,746	<10.1	48.8	<10.1	581.0	<2.5	525,850
	Mean	756	#DIV/0!			767	85.8				22.9		3,015				549		404,576
	Max	1,108	0			1,047	119.0				51.8		4,157				815		857,449
	Min	571	0			470	56.5				5.6		2,470				353		234,931
GS-41D	**M#150402**																		
RI	08/15/89					681	50.3												373,000
RI	11/08/89					460	120.0				<5								420,000
RI	04/16/90					670	31.8												434,000
MBMG	03/02/01					812	62.8				<100								585,000
MBMG	04/11/03	827	<100				47.1				28.1		2,900				491		420,000
MBMG	11/10/03	761	<100				43.2				27.3		2,920				489		408,754
MBMG	04/19/04	930	<100				45.6				27.1		3,003				524		480,107
MBMG	05/16/05	979	<100			996	54.3				50.8		3,210				613		552,000
MBMG	05/04/06	999	<100			1,035	57.5				71.8		3,239				629		581,201
MBMG	04/13/07	1,164	<10	<1.0	520	704	53.8	7.7	154	5.5	6.0	<1.0	3,353	1.2	68.5	<1.0	647	<10.0	599,721
MBMG	05/22/08	1,050	<20	699	<2	886	30.0	6.2	197	3.3	<10	<2	3,366	1.3	39.2	<2	580	<10	638,510
MBMG	04/23/09	873	<4.30	<4.40	759	1,047	48.2	29.1	195	7.3	<10.38	<4.14	2,735	<2.34	44.4	<3.30	575	<5.02	527,747
MBMG	08/17/09	879	<1.60	<3.40	791	972	53.2	35.5	233	6.3	6.0	<1.60	2,823	<1.80	67.0	<1.40	641	<1.30	547,061
Fingerprint	4/20/2010	1,060	<1.7	<2.7	632	820.0	22.10	32.5	164.0	5.89	7.96	<12.1	2,867	<10.1	58.1	<10.1	613.0	<2.5	624,272
	Mean	952	#DIV/0!			826	51.4				28.1		3,042				580		513,670
	Max	1,164	0.00			1,047	120.0				71.8		3,366				647		638,510
	Min	761	0.00			460	22.1				6.0		2,735				489		373,000
GS-42S	**M# 150404**																		
MBMG	05/17/06	704	<100			369	<20				20.9		2,314				126		208,713
MBMG	04/13/07	760	<10	<1.0	253	268	6.7	4.4	71	2.9	<5	<1.0	2,230	0.8	47.2	<1.0	124	<10.0	199,000
MBMG	07/28/08	624	<1	<0.5	763	259	7.0	4.53	333	3.33	<3	<0.5	1,942	<0.1	41.8	<0.5	136	<0.5	197,328
MBMG	08/17/09	565.0	<1.60	<3.40	406	333.0	6.7	15	114	4	2.9	<1.60	2,310	<1.80	36	<1.40	179.0	<1.30	223,706
Fingerprint	4/26/2010	541	<0.9	<1.4	280	251.0	<5.1	11.3	71.5	3.77	3.37	<6.1	2,125	<5.1	26.9	<5.1	145.0	<1.3	208,033
	Mean	639	#DIV/0!			296	6.8				20.9		2,184				142		207,356
	Max	760	0.0			369	7.0				20.9		2,314				179		223,706
	Min	541	0.0			251	6.7				20.9		1,942				124		197,328
GS-42D	**M#150405**																		

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		PHYSICAL AND CALCULATED PARAMETERS																	**MAJOR CATIONS AND ANIONS**											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
MBMG	02/21/01								4.27	3,990	1,799	0	36.4	21.2	6.3	0.0	0.0	96.2	455.0	161.0	90.4	23.5	0.7	262	0	0.0	56.3	3,058	10.80	
MBMG	05/17/06	11:20	15.39	2	4.05	3,680	9.45	525	4.20	4,910	1,688	0	40.0	19.8	6.5	0.0	0.0	95.0	452.0	136.0	84.2	24.7	0.5	210	0	0.0	62.0	2,561	12.70	
MBMG	04/13/07	14:25	14.97	1	4.01	3,560	9.50	171	3.91	3,610	1,695	0	37.5	19.3	5.9	0.0	0.0	95.1	448.0	140.0	80.6	27.4	0.5	256	0	0.0	62.6	2,805	14.90	
MBMG	07/28/08	10:00	14.65	2	4.05	4,140	10.92	503	4.12	3,840	1,727	0	38.9	18.9	5.5	0.0	0.0	95.1	466.0	137.0	75.0	25.5	2.8	253	0	0.0	63.4	2,614	11.20	
MBMG	08/17/09	16:00	14.71	2.5	4.13	3,780	9.65	454	4.15	3,890	1,558	0	38.6	18.6	5.9	0.0	0.0	91.6	421.0	123.0	73.9	23.2	0.1	226	0	0.0	72.4	2,694	9.29	
Fingerprint	4/26/2010	15:34	15.52		4.03	3,703	9.63	453	4.01	3,690	1,750	0	38.71	19.02	5.87	0.00	0.00	95.60	470	140	81.7	25.6	0.06	227.00	0.0	0.0	63.0	2,868	12.34	258
	Mean				4.05	3,773	9.83	421	4.11	3,988	1,703	0	38.3	19.5	6.0	0.0	0.0	94.8	452.0	139.5	81.0	25.0	0.8	239	0	0.0	63.3	2,767	11.87	
	Max				4.13	4,140	10.92	525	4.27	4,910	1,799	0	40.0	21.2	6.5	0.0	0.0	96.2	470.0	161.0	90.4	27.4	2.8	262	0	0.0	72.4	3,058	14.90	
	Min				4.01	3,560	9.45	171	3.91	3,610	1,558	0	36.4	18.6	5.5	0.0	0.0	91.6	421.0	123.0	73.9	23.2	0.1	210	0	0.0	56.3	2,561	9.29	
GS-44S	**M#150409**																													
RI	08/17/89							230	5.30	340	104	8	52.1	22.2	25.7	2.5	0.0	80.2	29.3	7.6	14.4	3.7	0.1	5.67		0.0	19.2	121	1.12	
RI	11/07/89							220	6.30	300	87	27	51.9	23.6	24.4	8.0	0.0	78.2	24.0	6.6	11.0	3.3	0.0	7.00		0.0	16.2	125	0.82	
RI	04/18/90								4.80	390	113		52.4	23.4	24.1		0.0	89.1	31.4	8.5	13.9	4.7	0.2	6.95		0.0	18.0	200	1.10	
RI	03/20/97										136	26					0.0		39.5	9.1	15.0	9.9	0.0	4.68		0.0	27.7	111	0.50	
RI	06/24/97										158	12					0.0		43.7	11.9	17.4	4.8	0.3	5.93		0.0	24.0	156	0.80	
RI	09/23/97										144	10					0.0		39.6	11.1	16.1	4.4	0.0	6.12		0.0	28.5	150	0.76	
RI	12/16/97										125	10					0.0		34.4	9.6	15.4	4.4	0.0	5.66		0.0	25.0	137	0.60	
MBMG	02/26/01								5.40	307	88	9					0.0		24.5	6.6	15.4	3.6	0.0	3.50		0.0	23.2	77	0.71	
MBMG	04/10/03	11:15			5.68	1,580	8.90		5.99	2,560	36	18	40.2	18.0	28.7	27.2	0.0	58.8	9.8	2.7	8.1	2.1	0.0	0.95	22	0.0	5.0	39	0.79	
MBMG	11/07/03	14:00	18.82		5.51	100	12.15		6.02	133	21	13	27.5	13.7	46.1	26.6	0.0	53.2	5.7	1.7	11.0	2.1	0.0	0.53	16	0.0	4.9	25	1.04	
MBMG	04/13/04	11:40	19.42		4.91	85	8.20	336	5.99	121	22	16	32.0	15.1	38.4	35.8	0.0	41.2	5.9	1.7	8.2	1.9	0.0	0.61	19	0.0	4.4	17	1.30	
MBMG	05/06/04	14:10	19.47		5.73	90	7.74	391	6.11	150	22	17	34.6	15.4	36.3	36.5	0.0	38.3	6.1	1.6	7.3	1.8	<0.005	0.61	21	0.0	5.6	17	1.37	
MBMG	05/17/05	12:30	20.71		5.85	140	9.73	345	5.79	165	39	13	38.1	17.4	30.4	19.0	0.0	44.4	10.6	2.9	9.7	2.7	<0.005	0.82	16	0.0	12.2	30	0.99	
MBMG	05/03/06	15:15	20.24	1	5.49	198	9.15	425	5.29	227	50	8	41.1	18.3	27.6	8.9	0.0	45.4	13.9	3.8	10.7	3.0	<0.005	0.80	10	0.0	16.6	41	0.80	
MBMG	04/23/07	16:51	14.80	1	5.07	270	9.60	173	5.08	275	62	8	41.5	18.2	25.9	9.3	0.0	49.5	17.2	4.6	12.3	3.6	<0.005	1.13	10	0.0	24.0	42	0.88	
MBMG	05/27/08	15:20	19.80	1.5	5.22	265	9.22	372	5.40	290	80	11	44.2	17.8	21.1	9.3	0.0	43.9	23.0	5.6	12.6	4.0	0.0	2.16	14	0.0	27.9	50	0.87	
MBMG	04/23/09	13:57	21.61		5.00	341	9.22	519	4.29	510	103	0	43.3	19.2	20.9	0.0	0.0	46.1	28.5	7.7	15.8	4.7	<0.043	3.71	0	0.0	36.0	71	1.02	
Fingerprint	4/19/2010	15:20	21.50		5.23	350	9.66	439	5.27	465	98	7	43.99	17.98	21.25	4.18	0.00	45.32	27.8	6.9	15.4	4.1	<0.001	3.84	8.8	0.0	35.7	75	0.944	94
	Mean				5.37	342	9.36	345	5.50	445	83	13	41.8	18.5	28.5	15.6	0.0	54.9	23.1	6.1	12.8	3.8	0.1	3.37	13.7	0.0	19.7	82	0.91	
	Max				5.85	1,580	12.15	519	6.30	2,560	158	27	52.4	23.6	46.1	36.5	0.0	89.1	43.7	11.9	17.4	9.9	0.3	7.00	22.4	0.0	36.0	200	1.37	
	Min				4.91	85	7.74	173	4.29	121	21	0	27.5	13.7	20.9	0.0	0.0	38.3	5.7	1.6	7.3	1.8	0.0	0.53	0.0	0.0	4.4	17	0.50	
GS-44D	**M#150410**																													
RI	08/17/89							220	5.50	1,085	440	16	58.9	27.6	13.6	1.3	0.0	95.4	120.0	34.1	26.2	9.3	0.0	33.40	16	0.0	14.3	561	1.52	
RI	11/07/89							210	6.20	820	314	32	56.3	29.1	14.7	2.6	0.0	92.0	83.0	26.0	21.0	6.5	0.2	34.00	32	0.0	23.1	532	7.92	
RI	04/18/90								5.30	900	361	8	57.2	28.2	14.6	0.8	0.0	94.4	96.8	28.9	23.7	7.9	0.1	31.50	8	0.0	16.0	430	1.10	
MBMG	02/21/01								6.50	585	200	22					0.0		55.2	15.2	17.1	5.6	0.0	13.20	22	0.0	19.9	242	0.87	
MBMG	04/10/03	10:00	20.31		5.28	5,340	9.80		5.52	5,320	160	12	44.9	21.5	14.5	4.8	0.0	81.8	43.5	12.6	16.1	5.2	0.1	10.70	15	0.0	17.3	203	0.74	
MBMG	04/10/03	10:30	20.31		5.28	460	9.80		5.43	499	159	13	45.5	21.3	14.3	5.3	0.0	84.6	43.2	12.3	15.7	5.1	0.1	10.70	15	0.0	17.5	193	1.40	
MBMG	11/07/03	13:40	19.60		5.24	475	9.20	102	5.95	464	162	11	45.7	21.1	16.5	4.0	0.0	83.3	44.3	12.4	18.4	4.7	0.0	10.20	13	0.0	16.5	213	1.39	
MBMG	04/13/04	11:20	20.10	1.2	4.41	435	9.80	333	5.85	540	159	12	44.5	21.8	15.1	4.7	0.0	83.8	42.8	12.7	16.6	5.2	0.0	11.00	14	0.0	15.0	204	1.18	
MBMG	05/17/05	10:45	21.05	2	5.66	400	9.50	333	5.59	440	137	11	45.1	21.3	15.4	4.8	0.0	84.8	37.3	10.7	14.6	4.6	0.0	8.77	13	0.0	12.8	178	0.82	
MBMG	05/03/06	14:40	20.58	1	5.53	398	9.58	413	5.52	402	123	11	44.8	21.1	15.9	5.4	0.0	84.8	33.6	9.6	13.7	4.6	0.0	7.93	13	0.0	11.0	167	0.89	
MBMG	04/13/07	16:35	21.82	2	5.35	315	10.00	148	5.29	610	111	10	44.0	20.3	17.5	5.6	0.0	81.4	30.5	8.5	13.9	4.5	0.0	7.38	12	0.0	12.4	142	0.87	
MBMG	05/22/08	12:20	20.18	1	5.73	341	9.58	379	5.78	375	113	17	44.8	20.8	16.6	9.6	0.0	72.8	30.9	8.7	13.1	4.6	0.0	7.23	21	0.0	15.5	124	0.95	

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanun
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
MBMG	02/21/01	84.9	5.15					22,800	<10	<100	<300	<20	21.6	1,200		594.0	<20	102,000			NA	
MBMG	05/17/06	85.7	5.48					23,308	<5	8.0	152	10.4	15.9	1,080		568.0	<10	88,236			NA	
MBMG	04/13/07	87.7	6.89					23,845	<10	<2	195	8.78	17.9	1,018	1,664	512.0	<1	106,000	<1.0	4.42	NA	363
MBMG	07/28/08	79.6	5.60					23,266	5	<2	157	13.3	17.3	1,026	1,531	574.0	<0.5	99,346	<0.5	6.35	NA	6,039
MBMG	08/17/09	81.1	5.97					22,181	6.06	<1	164	10.9	17.8	1,021	1,930	635.0	<0.40	96,937	<0.42	2.77	NA	390
Fingerprint	4/26/2010	83.7	4.54	<0.25	<0.3	1.35	<0.25	28,594	<10.9	<11.6	163	<10.4	20.00	942.00	1,550	612.00	<10.1	113,836	<10.1	<10.1	NR	337
	Mean	83.8	5.61					23,999	6	8.0	166	10.8	18.4	1,048		582.5	#DIV/0!	101,059			#DIV/0!	
	Max	87.7	6.89					28,594	6	8.0	195	13.3	21.6	1,200		635.0	0	113,836			0	
	Min	79.6	4.54					22,181	5	8.0	152	8.8	15.9	942		512.0	0	88,236			0	
GS-44S	**M#150409**																					
RI	08/17/89		5.53					686		<0.6		23.2	2.1	25.4		34.9	<2.8	1,980				
RI	11/07/89		8.33					720		<3		31	1.3	36.0		47.0	<8	2,000				
RI	04/18/90		8.50					1,040		<0.7		18.7	2.2	41.2		45.7	<8	2,790				
RI	03/20/97		11.81					300						24.9				741				
RI	06/24/97		9.34					683						38.9				2,220				
RI	09/23/97		12.14					694						39.1				2,200				
RI	12/16/97		9.06					690						36.2				2,030				
MBMG	02/26/01		4.57					473		<10		274		22.8		<20	<20	1,260				
MBMG	04/10/03	28.7	0.16					158	<5	<5	<150	16.7	<2	5.7		<10	<10	269			NA	
MBMG	11/07/03	35.4	0.08					215	<1	<1	33.5	25.4	<2	3.2		2.4	<2	156			NA	
MBMG	04/13/04		0.07					302	<1	<1	<30	25.1	<2	2.5		<2	<2	112			NA	
MBMG	05/06/04		0.09					258	<1	<1	<30	26.7	<2	3.2		2.6	<2	114			NA	
MBMG	05/17/05	40.8	1.68					243	<1	<1	41.8	42.2	<2	5.8		2.6	<2	178			NA	
MBMG	05/03/06	44.7	4.88					215	<1	<1	47.2	49.2	<2	7.6		2.1	<2	363			NA	
MBMG	04/23/07	49.0	5.83					400	<1	0.37	40.7	52.9	0.4	10.5	0.59	2.4	<0.1	533	<0.1	<0.1	NA	0.2
MBMG	05/27/08	44.4	3.94					391	<0.5	0.28	44	44	0.3	0.4	0.60	1.6	<0.1	896	<0.1	<0.1	NA	0.2
MBMG	04/23/09	51.7	9.26					528	0.495	0.35	68.6	68	0.7	22.7	1.47	5.4	<0.04	989	<0.04	<0.05	NA	0.6
Fingerprint	4/19/2010	48.5	9.58	<0.05	<0.03	1.47	<0.25	415	0.47	0.36	69.6	62.30	0.59	24.80	<0.1	7.43	<0.1	1,222	<0.1	<0.5	NR	4.49
	Mean	42.9	5.83					467	0.48	0.34	49.3	54.2	1.1	19.5		14.0	#DIV/0!	1,114			#DIV/0!	
	Max	51.7	12.14					1,040	0.50	0.37	69.6	274.0	2.2	41.2		47.0	0.00	2,790			0.00	
	Min	28.7	0.07					158	0.47	0.28	33.5	16.7	0.3	0.4		1.6	0.00	112			0.00	
GS-44D	**M#150410**																					
RI	08/17/89		2.01					382		<0.6		21.7	1.6	91.7		175.0	<2.8	3,119			<0.2	
RI	11/07/89		1.40					540		<3		16	1.5	100		230.0	17	4,600				
RI	04/18/90		0.91					513		1.1		13.1	1.5	102		197.0	<8	3,930				
MBMG	02/21/01		2.44					363		<10		<20		52.8		84.3	<2	1,990				
MBMG	04/10/03	51.3	2.33					319	<1	1.1	70	15.5	<2	45.2		50.4	<2	1,920			NA	
MBMG	04/10/03	49.8	2.35					294	<1	1.2	69.9	15.9	<2	43.2		53.3	<2	1,960			NA	
MBMG	11/07/03	48.0	1.87					245	<1	<1	64.4	17	<2	41.6		49.9	<2	1,777			NA	
MBMG	04/13/04	52.3	1.41					<30	<1	<1	74.3	17.2	<2	44.5		53.1	<2	1,858			NA	
MBMG	05/17/05	48.1	0.72					239	<1	1.2	65.9	16.3	<2	34.0		41.0	<2	1,434			NA	
MBMG	05/03/06	49.1	0.64					174	<1	1.3	71.3	17.6	<2	30.1		36.2	<2	1,250			NA	
MBMG	04/13/07	51.2	1.13					188	<1	1.0	54.7	17.0	0.4	25.4	0.40	29.1	<0.1	1,059	<0.1	<0.1	NA	0.1
MBMG	05/22/08	37.8	1.93					89	<0.5	0.9	55.3	15.4	0.3	0.8	0.31	21.8	<0.1	1,075	<0.1	<0.1	NA	<0.1

Montana Bureau of Mines and Geology
Butte Priority Soils Groundwater-Quality Data

		MINOR AND TRACE METALS																	
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	alladium	raseodymiu	Rubidium	Selenium	Tin	trontium	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
MBMG	02/21/01	848	<100			564	<20				<100		4,410				NA		214,000
MBMG	05/17/06	883	<50			580	15.6				17.7		4,528				122.0		170,067
MBMG	04/13/07	947	<10	<1.0	182	489	16.3	7.9	59	28.6	<5	<1.0	4,700	<0.5	28	<1.0	116.0	<10.0	200,000
MBMG	07/28/08	792	<1	<0.5	520	480	<1	7.0	261	29.2	<3	<0.5	3,720	<0.1	44	<0.5	117.0	<0.5	200,439
MBMG	08/17/09	612	<0.40	<0.40	226	519	14.1	16.2	68	28.6	3.3	<0.41	4,644	<0.23	24	<0.33	118.0	<0.50	183,018
Fingerprint	4/26/2010	818	<5.6	<13.7	207	457.0	<50.5	13.7	59.2	24.9	<13.2	<6.1	3,990	<5.1	17.6	<5.1	96.7	<1.3	204,915
	Mean	817	#DIV/0!			515	15.3				10.5		4,332				113.9		195,407
	Max	947	0			580	16.3				17.7		4,700				122.0		214,000
	Min	612	0			457	14.1				3.3		3,720				96.7		170,067
GS-44S	**M#150409**																		
RI	08/17/89					23.2	<0.5												7,520
RI	11/07/89					29.0					<5								8,300
RI	04/18/90					3.4													9,680
RI	03/20/97																		6,400
RI	06/24/97																		9,300
RI	09/23/97																		9,150
RI	12/16/97																		8,220
MBMG	02/26/01						<20				<10								5,380
MBMG	04/10/03	28.7	<50			22.4	<10				<5		90				<2.5		1,400
MBMG	11/07/03	24.2	<10				<2				<1		58				<0.5		872
MBMG	04/13/04	19.3	<10				<2				<1		58				<1		798
MBMG	05/06/04	20.4	<10				<2				<1		60				<1		601
MBMG	05/17/05	41.4	<10			7.6	<2				<1		109				<0.5		1,847
MBMG	05/03/06	52.8	<10			9.2	<2				<1		148				<1		2,296
MBMG	04/23/07	69.0	<1	<0.1	0.1	9.9	1.6	0.29	<0.1	<0.1	<0.5	<0.1	190	<0.05	<1	<0.1	0.4	<1.0	3,069
MBMG	05/27/08	72.7	<1	<0.1	<0.1	13.8	<0.2	0.21	<0.1	<0.1	0.5	<0.1	243	<0.05	<1	<0.1	0.6	<0.5	5,791
MBMG	04/23/09	54.6	0.06	<0.04	0	20.7	<0.15	<0.06	0	0	0.9	<0.04	258	<0.02	0	<0.03	1.3	<0.05	6,090
Fingerprint	4/19/2010	253	<0.4	<0.7	2.16	133.0	4.62	0.6	0.61	<0.5	1.02	<0.6	243	<0.5	0.50	<0.5	<0.6	<0.1	6,126
	Mean	63.6	0.1			27.2	3.11				0.82		146				0.78		5,158
	Max	253.0	0.1			133.0	4.62				1.02		258				1.32		9,680
	Min	19.3	0.1			3.4	1.59				0.50		58				0.39		601
GS-44D	**M#150410**																		
RI	08/17/89					157	<0.5												23,300
RI	11/07/89					110	<0.4				<5								25,000
RI	04/18/90					137	<0.5												23,500
MBMG	02/21/01					6.8	<2				<1								11,400
MBMG	04/10/03	115	<10			44.5	<2				<1		314				0.5		9,400
MBMG	04/10/03	112	<10				<2				<1		315				0.5		8,980
MBMG	11/07/03	105	<10				<2				<1		300				0.5		7,258
MBMG	04/13/04	107	<10				<2				<1		308				0.6		9,272
MBMG	05/17/05	102	<10			37.9	<2				1.3		262				<0.5		7,529
MBMG	05/03/06	107	<10			39.4	<2				1.2		259				<1		6,697
MBMG	04/13/07	109	<1	<0.1	<0.1	26.3	0.77	0.4	<0.1	0.1	<0.5	<0.1	241	<0.05	1	<0.1	0.3	<1.0	6,001
MBMG	05/22/08	107	<1	<0.1	<0.1	28.3	<0.2	<0.2	<0.1	<0.1	<0.5	<0.1	250	<0.05	<1	<0.1	0.3	<0.5	5,860

		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
MBMG	04/23/09	14:52	22.20		5.29	349	9.62	492	5.46	347	112	14	44.4	21.1	16.2	7.9	0.0	70.0	30.3	8.7	12.7	4.5	<0.043	7.40	17	0.0	19.8	121	0.73	
Fingerprint	4/19/2010	14:40	22.16		5.50	359	10.13	419	6.23	374	98	16	43.32	20.17	17.56	8.49	0.00	68.69	26.9	7.6	12.5	4.2	<0.007	7.01	19.5	0.0	21.5	124	0.84	66
	Mean				5.33	887	9.70	305	5.72	912	189	15	47.6	22.7	15.6	5.0	0.0	82.9	51.3	14.9	16.8	5.5	0.1	14.32	16.6	0.0	16.6	245	1.52	
	Max				5.73	5,340	10.13	492	6.50	5,320	440	32	58.9	29.1	17.6	9.6	0.0	95.4	120.0	34.1	26.2	9.3	0.2	34.00	32.0	0.0	23.1	561	7.92	
	Min				4.41	315	9.20	102	5.29	347	98	8	43.3	20.2	13.6	0.8	0.0	68.7	26.9	7.6	12.5	4.2	0.0	7.01	8.0	0.0	11.0	121	0.73	
GS-46S	**M#150412**																													
RI	08/17/89								6.70	355	134	106	47.0	22.4	30.6	43.1	0.0	45.6	36.4	10.5	24.6	4.4	0.13	0.543	106	0.0	9.8	53	0.37	
RI	11/06/89								6.80	450	173	135	48.3	24.2	27.5	50.2	0.0	34.9	46.0	14.0	27.0	5.1	0.02	0.068	135	0.0	14.0	45	0.29	
RI	04/18/90								6.66	515	192	190	49.3	22.7	27.9	51.0	0.0	34.4	52.6	14.7	31.9	3.9	<0.005	0.004	190	0.0	19.0	61	0.36	
RI	03/18/97										198	162							54.9	14.8	24.0	3.4	0.01	0.003	162	0.0	17.3	48	0.50	
RI	06/24/97										174	141							48.6	12.7	20.1	3.0	0.01	0.004	141	0.0	13.0	43	0.60	
RI	09/23/97										144	140							39.4	11.2	18.3	2.6	0.02	0.004	140	0.0	13.5	40	0.55	
RI	12/16/97										141	143							38.5	11.0	18.6	2.7	0.02	0.004	143	0.0	11.0	39	0.60	
	02/21/01								6.99	550	204	158							57.5	14.6	22.3	3.1		<0.001	158	0.0	24.5	55	0.32	
	04/10/03	14:50			6.89	470	10.8		6.90	480	147	135	48.2	19.3	30.5	59.8	0.0	17.1	42.0	10.2	30.5	3.2	0.01	0.001	164	0.0	23.8	37	0.40	
	11/10/03	11:35	25.25		6.76	465	9.4	89	7.09	455	169	124	46.3	18.8	32.8	52.2	0.0	16.0	48.2	11.9	39.2	3.2	0.01	0.006	151	0.0	32.8	36	0.30	
	04/19/04	14:30	25.63		5.98	425	10.2	342	6.93	470	176	137	49.9	20.9	26.8	58.8	0.0	17.9	49.6	12.6	30.6	3.4	0.01	<0.001	167	0.0	27.0	40	0.28	
	05/17/05	10:20	20.61		6.87	525	9.9	198	7.05	570	220	176	51.4	21.0	25.4	57.6	0.0	20.1	62.5	15.5	35.5	3.7	0.01	<0.001	214	0.0	26.6	59	0.27	
	05/04/06	11:10	26.29	0.8	7.01	602	10.2	342	6.68	599	233	183	52.2	20.3	24.6	52.9	0.0	18.5	66.5	16.2	35.9	4.1	0.01	<.0001	223	0.0	26.3	61	0.44	
	06/22/07	21:00	25.34	2	6.93	660	10.5	542	6.69	630	244	169	52.5	21.7	23.5	55.6	0.0	21.0	69.1	17.3	35.4	4.2	<0.005	0.001	206	0.0	26.1	61	0.45	
	05/27/08	16:40	25.45	1.5	6.81	565	10.2	325	7.45	610	244	185	55.2	21.7	20.5	53.3	0.0	17.3	70.1	16.7	29.8	4.3	<0.005	<0.001	226	0.0	24.5	51	<0.5	
	04/23/09	10:12	26.84	1.7	6.76	472	10.3	352	6.78	695	194	161	52.3	22.1	23.2	63.8	0.0	18.5	54.5	14.0	27.7	3.6	<0.043	<0.031	196	0.0	17.8	45	0.46	
	06/10/10	12:00	26.94		8.14	311	10.1	382	8.19	303	116	90	49.2	20.2	28.0	66.0	0.0	23.0	32.9	8.2	21.5	2.7	<0.001	0.001	110	0.0	9.8	30	<0.05	
GS-46D	**M#150413**																													
RI	08/17/89								6.30	555	235	<1	2.3	1.0	96.6			75.5	65.0	17.7	30.1	5.2	0.11	0.132		0.0	28.1	117	0.26	
RI	11/06/89							200	6.50	655	215	117	50.9	24.6	24.6	28.1	0.0	59.0	58.0	17.0	29.0	5.3	<0.012	0.062	117	0.0	18.8	117	<0.1	
RI	04/18/09								6.30	580	227	100	53.0	24.0	23.0	21.5	0.0	63.2	62.6	17.2	28.8	4.0	<0.005	0.003	100	0.0	25.0	140	0.20	
	02/21/01								7.70	580	215	135							60.7	15.5	32.9	3.7	<0.005	<0.001	135	0.0	26.5	96	0.13	
	04/10/03	14:30			6.19	555	11.0		6.51	550	183	111	49.6	21.3	26.9	42.9	0.0	38.3	51.3	13.4	31.9	3.5	0.02	<0.001	136	0.0	22.3	95	0.12	
	11/10/03	11:10	24.82		6.32	520	9.5	96	6.62	530	193	115	44.9	19.6	33.7	42.6	0.0	35.3	53.7	14.2	46.3	3.5	0.01	<0.001	141	0.0	24.5	92	0.14	
	04/19/04	14:10	25.13		5.19	470	10.1	346	6.59	520	186	113	47.4	21.2	29.3	44.3	0.0	36.4	51.6	14.0	36.6	3.6	0.01	<0.001	138	0.0	23.2	89	0.11	
	05/17/05	10:00	25.96	2	6.59	490	9.8	210	6.78	535	191	120	48.8	21.3	28.0	43.2	0.0	34.7	53.1	14.1	35.0	3.5	<0.005	<0.001	146	0.0	23.8	93	0.15	
	05/04/06	10:35	25.64	1	6.60	535	9.7	361	6.44	561	188	122	50.1	21.0	26.8	40.8	0.0	31.2	53.1	13.5	32.6	3.5	0.01	<.001	149	0.0	24.3	89	0.22	
	06/25/07	10:15	24.64	2	6.88	575	10.2	589	6.32	620	201	130	51.1	21.7	25.0	45.7	0.0	35.0	56.4	14.5	31.6	3.9	<0.005	<0.001	158	0.0	21.6	94	0.27	
	05/27/08	16:05	24.78	1.5	6.37	500	10.1	333	6.58	545	206	126	53.6	21.3	22.9	49.3	0.0	32.1	59.0	14.2	28.9	4.0	<0.005	<0.001	154	0.0	18.7	79	0.19	
	04/23/09	11:20	26.66	1.8	6.46	482	10.0	483	6.65	620	196	117	53.7	22.1	22.1	45.0	0.0	37.4	55.7	13.9	26.3	3.7	<0.043	<0.031	143	0.0	17.7	93	<0.5	
	06/10/10	14:14	26.68		7.77	469	10.2	368	7.32	449	200	119	56.9	22.3	18.8	46.7	0.0	39.6	57.7	13.7	21.9	3.5	<0.001	0.001	145	0.0	14.2	97	0.31	
GS-45	**M#137594**																													
MBMG	08/18/09	8:10	31.85	3	3.91	3,090	9.36	501	3.71	4,750	1,846	0	59.5	11.3	5.3	0.0	0.0	92.1	621.3	71.5	63.7	14.1	0.0	107.00	0.0	0.0	111.0	2,162	3.70	
Duplicate	08/18/09	8:15	31.83	3	3.91	3,090	9.36	501	4.02	3,040	1,354	0	48.2	13.7	6.5	0.0	0.0	92.0	422.0	72.9	65.1	24.0	3.6	93.60	0.0	0.0	111.2	2,164	3.94	
	Mean				3.91	3,090	9.36	501	3.87	3,895	1,600	0	53.8	12.5	5.9	0.0	0.0	92.0	521.7	72.2	64.4	19.1	1.8	100.30	0.00	0.00	111.10	2,163	3.82	
	Max				3.91	3,090	9.36	501	4.02	4,750	1,846	0	59.5	13.7	6.5	0.0	0.0	92.1	621.3	72.9	65.1	24.0	3.6	107.00	0.00	0.00	111.20	2,164	3.94	
	Min				3.91	3,090	9.36	501	3.71	3,040	1,354	0	48.2	11.3	5.3	0.0	0.0	92.0	422.0	71.5	63.7	14.1	0.0	93.60	0.00	0.00	111.00	2,162	3.70	

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Berylliun	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanun
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
MBMG	04/23/09	52.8	2.85					146	0.099	1.0	63.6	20.8	0.6	26.8	0.37	32.8	<0.04	1,050	<0.04	<0.05	NA	0
Fingerprint	4/19/2010	45.2	2.93	<0.05	<0.03	0.93	<0.25	149	<0.1	1.00	58.2	22.70	0.50	26.20	0.36	32.20	<0.1	1,089	<0.1	<0.1	NR	<0.1
Mean		48.6	1.78					280	0.10	1.09	64.8	17.4	0.9	47.5		77.6	17.0	2,008			#DIV/0!	
Max		52.8	2.93					540	0.10	1.31	74.3	22.7	1.6	102.0		230.0	17.0	4,600			0	
Min		37.8	0.64					89	0.10	0.90	54.7	13.1	0.3	0.8		21.8	17.0	1,050			0	
GS-46S	**M#150412**																					
RI	08/17/89		5.26					238	<1	<0.6		92.0	1.6	10.0		<2.6	<2.8	221.0			<20	
RI	11/06/89		6.05					<41	<0.2	<3		46.0	<1	5.6		<12	<8	19.0				
RI	04/18/90		6.00					37		1.30		65.0	<1	5.4		<8	<8	23.5				
RI	03/18/97		5.74					20		4.00				2.9				16.9				
RI	06/24/97		4.30					20		2.00				2.4				23.0				
RI	09/23/97		5.61					20		1.37				2.7				17.0				
RI	12/16/97		4.28					20		1.30				2.1				19.7				
	02/21/01		7.46					<30	<10	1.79		62.8	<2	2.6		<2	3.36	14.6				
	04/10/03	24.1	4.90					<30	<1	1.69	65.8	47.1	<2	< 2		<2	<2	8.4				
	11/10/03	29.2	7.99					<30	<1	1.55	70.4	50.1	<2	2.0		<2	<2	10.3			NA	
	04/19/04	30.2	4.25					<30	<1	1.57	79.7	52.4	<2	9.8		<2	<2	10.9			NA	
	05/17/05	28.3	8.27					<10	<1	1.76	172	87.6	<2	2.5		<2	6.17	9.8			NA	
	05/04/06	28.3	17.00					<10	<1	2.02	189	68.1	<2	2.2		<2	<2	16.9			NA	
	06/22/07	29.0	9.35					<5	<1	1.67	202	59.4	<0.1	1.9		0.19	0.24	11.4			NA	
	05/27/08	28.2	8.99					<2	<0.5	1.89	294	46.0	<0.1	<0.1	<0.1	<0.1	0.49	12.2	<0.1	<0.1	NA	<0.1
	04/23/09	30.2	5.10					<7.64	0.052	1.88	195	53.0	<0.18	1.6	<0.02	0.07	0.74	12.0	<0.04	<0.05	NA	<0.02
	06/10/10	26.4	<0.05					<1.00	<0.10	2.05	100	<0.10	<0.10	1.0	<0.10	<0.10	0.37	7.9	<0.10	<0.20	NA	<0.10
GS-46D	**M#150413**																					
RI	08/17/89		10.00					20	<1	<0.6		41.3	<1	5		3.8	<2.8	11.8			<0.2	
RI	11/06/89		10.20					140	<0.2	<3		41.0	<1	9		15	<8	15.0				
RI	04/18/09		11.00					36		1.20		40.7	<1	3		<8	<8	16.8				
	02/21/01		7.37					<30	<1	<1		43.0	<2	<2		<2	<2	10.6				
	04/10/03	27.7	4.98					<30	<1	<1	42.2	40.0	<2	<2		<2	<2	11.0				
	11/10/03	31.6	7.01					<30	<1	<1	54.7	37.8	<2	<1		<2	<2	10.9			NA	
	04/19/04	32.2	4.56					<30	<1	<1	51.9	36.1	<2	2.8		<2	<2	10.4			NA	
	05/17/05	31.8	7.63					<10	<1	<1	50.3	120	<2	<1		<2	<2	16.9			NA	
	05/04/06	30.4	13.60					<10	<1	1.05	42.8	38.6	<2	<1		<2	<2	10.8			NA	
	06/25/07	31.8	6.91					<2.5	<1	0.83	31.4	37.1	<0.1	0.6		<0.1	<0.1	8.7			NA	
	05/27/08	30.5	5.85					5.6	<0.5	0.65	28.1	26.0	<0.1	<0.1	<0.1	<0.1	<0.1	8.9	<0.1	<0.1	NA	<0.1
	04/23/09	31.9	5.78					<37.82	<0.21	0.71	33.5	37.4	<0.90	0.5	<0.1	<0.28	<0.2	8.2	<0.21	<0.23	NA	<0.11
	06/10/10	30.5	3.88					<1.00	<0.10	0.70	12.5	<0.10	<0.10	0.5	<0.10	0.146	<0.20	6.2	<0.10	<0.20	NA	<0.10
GS-45	**M#137594**																					
MBMG	08/18/09	81.5	7.81					26,894	3.47	1.87	121.0	10.9	11.0	804.0	1,146	943.0	0.4	37,352	<0.21	1.84	NR	259
Duplicate	08/18/09	82.4	7.83					34,080	3.45	<0.50	241.0	10.4	15.2	596.0	1,264	1,183.0	1.1	55,512	<0.21	2.01	NR	262
Mean		81.95	7.82					30,487	3.46	1.87	181.00	10.65	13.10	700.00		1,063.0	0.72	46,432			#DIV/0!	
Max		82.40	7.83					34,080	3.47	1.87	241.00	10.90	15.20	804.00		1,183.0	1.07	55,512			0.00	
Min		81.50	7.81					26,894	3.45	1.87	121.00	10.40	11.00	596.00		943.0	0.36	37,352			0.00	

SAMPLE SITE	DATE (MM/DD/YR)		MINOR AND TRACE METALS																
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	Palladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
		Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
		(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
MBMG	04/23/09	74.1	1.19	<0.04	<0.05	29.8	<0.15	<0.06	<0.02	0	0.2	<0.04	206	<0.02	1	<0.03	0.4	<0.05	5,898
Fingerprint	4/19/2010	66.90	1.07	<0.1	<0.1	29.10	1.26	<0.1	<0.1	0.11	0.34	<0.6	200.00	0.84	0.82	1.10	1.21	<0.1	5,363
	Mean	101	1.13			58.7	1.02				0.77		266				0.5		11,104
	Max	115	1.19			157.0	1.26				1.31		315				1.2		25,000
	Min	67	1.07			6.8	0.77				0.22		200				0.3		5,363
GS-46S	**M#150412**																		
RI	08/17/89					8.8	0.90												1,750
RI	11/06/89					4.5	<0.4				<5								1,000
RI	04/18/90					6.0	<0.5												823
RI	03/18/97						1.00												657
RI	06/24/97						3.50												575
RI	09/23/97						1.00												491
RI	12/16/97						0.47												428
	02/21/01					3.9	<2				1.5								452
	04/10/03	8.18	<10				<2				<1		327				11.5		293
	11/10/03	10.6	34				<2				<1		337				12.5		418
	04/19/04	10.4	38				<2				<1		375				13.8		402
	05/17/05	10.9	68			<2	<2				1.8		452				41.7		411
	05/04/06	9.55	49			<2	<2				1.9		507				41.5		396
	06/22/07	10.8	43			1.2	1.14				1.3		547				43.5		338
	05/27/08	10.6	42	<0.1	<0.1	0.7	<0.2	0.70	<0.1	<0.1	1.4	<0.1	546	0.24	<1	<0.1	48.4	0.50	484
	04/23/09	6.77	58	<0.04	<0.05	0.6	<0.15	0.07	<0.02	0.08	0.9	<0.04	384	<0.02	0.23	<0.03	33.8	0.06	296
	06/10/10	3.17	55	<0.10	<0.10	0.6	<0.10	<0.10	<0.10	<0.10	0.6	<0.10	219	<0.10	<0.40	<0.10	10.2	0.11	191
GS-46D	**M#150413**																		
RI	08/17/89					2.8	<0.5												444
RI	11/06/89					2.5	<0.4				<5								430
RI	04/18/09					2.6	<0.5												339
	02/21/01					4.0	<2												281
	04/10/03	15.2	<10				<2				1.2		369				2.95		299
	11/10/03	15.8	<10				<2				1.3		357				3.39		289
	04/19/04	15.7	<10				<2				1.2		369				3.03		284
	05/17/05	13.1	<10			<2	<2				1.7		372				2.66		233
	05/04/06	13.6	<10			<2	<2				1.9		385				4.45		214
	06/25/07	12.5	2.78			1.2	0.84				1.2		433				3.99		193
	05/27/08	12.5	2.21	<0.1	<0.1	0.7	<0.2	0.41	<0.1	0.16	0.8	<0.1	436	<0.05	<1	<0.1	5.69	<0.5	265
	04/23/09	8.69	3.72	<0.22	<0.25	0.6	<0.76	<0.32	<0.11	0.25	0.9	<0.21	357	<0.12	<0.95	<0.17	4.46	<0.25	<0.23
	06/10/10	3.87	4.13	<0.10	<0.10	0.8	<0.10	0.13	<0.10	0.33	0.7	<0.10	357	<0.1000	0.68	<0.10	3.86	<0.10	127
GS-45	**M#137594**																		
MBMG	08/18/09	363	<0.20	<0.20	301	326.0	<0.76	989	69	45	3.72	<0.21	2,637	<0.12	17	0.21	155.0	<0.25	129,648
Duplicate	08/18/09	435	<0.20	<0.20	347	294.0	13.50	12	83	44	3.16	<0.21	2,671	0	21	1	210.0	<0.25	130,284
	Mean	399.00	#DIV/0!			310.00	13.50				3.44		2,654				182.50		129,966
	Max	435.00	0.00			326.00	13.50				3.72		2,671				210.00		130,284
	Min	363.00	0.00			294.00	13.50				3.16		2,637				155.00		129,648

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		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
MF-07	**M#4617**																													
	4/20/2010	12:00	9.98		6.23	1,401	7.11	370	6.56	1,436	508	226	46.56	19.25	23.48	28.15	0.00	52.13	144	36.1	83.3	7.5	0.01	35.60	276.0	0.0	100.8	402	0.631	401
	Mean	12:00	9.98		6.23	1,401	7.11	370	6.56	1,436	508	226	46.56	19.25	23.48	28.15	0.00	52.13	144	36.1	83.3	7.5	0.01	35.60	276.0	0.0	100.8	402	0.631	401
	Max	12:00	9.98		6.23	1,401	7.11	370	6.56	1,436	508	226	46.56	19.25	23.48	28.15	0.00	52.13	144	36.1	83.3	7.5	0.01	35.60	276.0	0.0	100.8	402	0.631	401
	Min	12:00	9.98		6.23	1,401	7.11	370	6.56	1,436	508	226	46.56	19.25	23.48	28.15	0.00	52.13	144	36.1	83.3	7.5	0.01	35.60	276.0	0.0	100.8	402	0.631	401
MF-10																														
MBMG	4/24/1988																		118	33.7	48.4	8.5	<.002	0.75	192.0		21.2	339	0.5	
MBMG	5/9/1989	14:00																	113	29.4	44.5	6.9	0.02	0.69	174.7		21.4	320	0.5	
Trec	12/1/2007				6.14	820	8.03	286																						
Trec	10/2/2008				6.15	809	10.35	108	6.50	707	265	108		19.90					73		31.4	7.5	8.20	1.80	108.0		35.9	216		
Trec	10/7/2009				6.56	1,112	10.34	201																						
Fingerprint	8/11/2010	12:30	9.11	0.17	4.90	1,303	16.29	493	6.02	1,197	542	44	52.03	16.90	6.61	5.59	0.00	87.01	164.0	32.3	23.9	14.0	19.60	7.79	54.1	0.0	38.4	663	1.7	<50
MSD-1A	**M#212801**																													
	05/17/06	16:05	10.31	2	4.46	1,393	7.98	451	4.40	1,432	351	0	38.0	7.2	45.0	0.0	0.0	72.1	118.0	13.6	160.0	6.1	6.3	7.04	0	0.0	153	551	1.02	
	04/24/07	15:55	10.14	2	4.09	1,710	8.60	185	4.31	1,720	438	0	42.1	7.5	41.6	0.0	0.0	66.1	149.0	16.1	169.0	6.6	8.0	8.52	0	0.0	211	564	<1	
	08/20/08	11:40	9.81	2	4.42	925	11.95	394	4.45	970	357	0	53.6	10.9	26.4	0.0	0.0	75.4	119.0	14.5	67.4	5.4	0.8	6.49	0	0.0	98	427	1.03	
Fingerprint	4/18/2010	16:56	10.57		4.82	1,407	7.81	363	4.61	1,413	448	4	52.21	11.97	27.13	0.57	0.00	62.56	146	20	87.0	5.7	1.11	8.67	5.3	0.0	190.7	458	1.28	248
	Mean				4.45	1,359	9.09	348	4.44	1,384	398	1	46.5	9.4	35.0	0.1	0.0	69.0	133.0	16.1	120.9	5.9	4.1	7.68	1	0.0	163	500	1.11	
	Max				4.82	1,710	11.95	451	4.61	1,720	448	4	53.6	12.0	45.0	0.6	0.0	75.4	149.0	20.3	169.0	6.6	8.0	8.67	5	0.0	211	564	1.28	
	Min				4.09	925	7.81	185	4.31	970	351	0	38.0	7.2	26.4	0.0	0.0	62.6	118.0	13.6	67.4	5.4	0.8	6.49	0	0.0	98	427	1.02	
MSD-1B	**M#211606**																													
	04/15/04	12:53	13.41		4.25	4,690	10.55		4.31	5,120	2,267	0	31.4	21.3	7.7	0.0	0.0	80.6	540.0	223.0	152.0	18.5	357.0	221	0	0.0	543	3,098	4.90	
	05/18/06	11:45	9.73	1.5	4.61	3,830	10.26	369	4.34	3,880	1,868	0	38.1	23.5	7.0	0.0	0.0	90.8	463.0	173.0	97.3	14.2	185.0	144	0	0.0	209	2,786	<2.5	
	04/26/07	16:12	9.51	1.5	4.56	3,420	10.40	162	3.13	4,050	1,904	0	38.1	24.3	7.3	0.0	0.0	90.7	466.0	180.0	97.1	15.9	155.0	170	0	0.0	204	2,708	<2.5	
	08/20/08	15:30	9.50	8	4.80	3,220	11.74	394	3.28	3,400	1,974	14	45.1	27.3	6.6	0.0	0.0	93.4	492.0	181.0	82.1	14.2	63.1	147	0	0.0	125	2,464	<0.5	
Fingerprint	4/18/2010	17:08	9.92		4.90	3,330	10.25	346	7.31	3,120	1,836	101	1.30	25.96	10.46	4.28	0.00	92.92	506	139	106	14.1	3.86	44.40	123.2	0.0	46.2	2,104	0.315	<250
	Mean				4.62	3,698	10.64	318	4.47	3,914	1,970	23	30.8	24.5	7.8	0.9	0.0	89.7	493.4	179.2	106.9	15.4	152.8	145	25	0.0	225	2,632	2.61	
	Max				4.90	4,690	11.74	394	7.31	5,120	2,267	101	45.1	27.3	10.5	4.3	0.0	93.4	540.0	223.0	152.0	18.5	357.0	221	123	0.0	543	3,098	4.90	
	Min				4.25	3,220	10.25	162	3.13	3,120	1,836	0	1.3	21.3	6.6	0.0	0.0	80.6	463.0	139.0	82.1	14.1	3.9	44	0	0.0	46	2,104	0.32	
MSD-1C	**M#211603**																													
MBMG	04/15/04	13:20	10.92	1.5	5.69	2,810	10.52		6.38	3,170	1,903	57	27.1	24.3	11.4	2.5	0.0	96.1	543.0	133.0	118.0	14.4	0.2	30	70	0.0	19	2,132	2.40	
MBMG	05/18/06	10:40	10.47	2	5.87	3,000	10.23	278	5.76	3,090	1,819	25	55.3	25.1	10.5	1.1	0.0	96.4	501.0	138.0	109.0	13.8	22.4	44	31	0.0	39	2,070	<2.5	
MBMG	06/26/07	12:30	9.62	8	5.49	2,600	11.44	318	6.37	3,020	1,967	42	60.5	24.3	9.4	1.8	0.0	98.2	562.0	137.0	99.8	14.8	7.1	38	51	0.0	<25	2,143	<2.5	
MBMG	08/19/08	15:00	9.85	8	6.10	2,800	11.23	319	4.39	1,090	1,949	13	59.3	25.1	9.1	0.0	0.0	98.1	549.0	140.4	95.8	13.7	9.8	42	0	0.0	30	2,233	<0.5	
Fingerprint	4/18/2010	16:50	10.43		5.75	3,150	11.27	298	3.49	3,110	1,634	0	44.02	30.05	6.37	0.00	0.00	94.22	389	161	64.6	13.1	36.70	122.00	0.0	0.0	101.0	2,230	<0.25	<250

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		NON-METALS						MINOR AND TRACE METALS														
SAMPLE SITE	DATE (MM/DD/YR)	Silica SiO_2 (mg/L)	Nitrate NO_3-N (mg/L)	Ortho-Phosphate PO_4 (mg/L)	Tot. Phosphate (mg/L)	Tot Organic Carbon (mg/L)	Diss. Organic Carbon (mg/L)	Aluminum Al (ug/L)	Silver Ag (ug/L)	Arsenic As (ug/L)	Boron B (ug/L)	Barium Ba (ug/L)	Beryllium Be (ug/L)	Cadmium Cd (ug/L)	Cerium Ce (ug/L)	Cobolt Co (ug/L)	Cromium Cr (ug/L)	Copper Cu (ug/L)	Cesium Cs (ug/L)	Gallium Ga (ug/L)	Mercury Hg (ug/L)	Lanthanun La (ug/L)
MF-07	**M#4617**																					
	4/20/2010	44.6	4.12	<0.05	<0.03	3.54	<0.25	<4.2	<0.5	3.07	350	24.20	<0.6	12.00	<0.5	10.70	<0.5	11.50	<0.5	<0.5	NR	<0.5
	Mean	44.6	4.12	<0.05	<0.03	3.54	<0.25	<4.2	<0.5	3.07	350	24.20	<0.6	12.00	<0.5	10.70	<0.5	11.50	<0.5	<0.5	NR	<0.5
	Max	44.6	4.12	<0.05	<0.03	3.54	<0.25	<4.2	<0.5	3.07	350	24.20	<0.6	12.00	<0.5	10.70	<0.5	11.50	<0.5	<0.5	NR	<0.5
	Min	44.6	4.12	<0.05	<0.03	3.54	<0.25	<4.2	<0.5	3.07	350	24.20	<0.6	12.00	<0.5	10.70	<0.5	11.50	<0.5	<0.5	NR	<0.5
MF-10																						
MBMG	4/24/1988	31.2	1.74					<30		2.10	180			2.00				28.00				
MBMG	5/9/1989	25.8	1.2					<30	<2	2.30	200			2.00			2.00	90.00				
Trec	12/1/2007									56.60				12.00				33.30				
Trec	10/2/2008									55.00				6.60				39.00				
Trec	10/7/2009									111.00				6.90				23.90				
Fingerprint	8/11/2010	23.4	<0.05	<0.05	<0.030	NR	NR	223.00	2.19	52.70	209.00	24.60	<1.01	481.00	11.70	9.75	<1.01	6,420.00	<2.53	<0.93	NR	5.82
MSD-1A	**M#212801**																					
	05/17/06	54.8	0.96					2,025	<1	<1	162	9.93	<2	37.3		48.2	<2	5,919			NA	
	04/24/07	44.5	1.18					1,702	<1	0.5	121	10.5	0.6	36.3	36	43.3	<0.1	5,255	<0.1	<0.1	NA	14.4
	08/20/08	50.8	2.14					1,400	0.20	0.4	272	11.2	0.6	44.4	48	30.9	<0.07	3,193	<0.04	0.12	NA	21.9
Fingerprint	4/18/2010	51.6	2.46	<0.05	<0.03	2.41	<0.25	2,184	<0.5	<0.6	248	10.30	1.34	60.40	30.00	52.70	<0.5	3,624.00	<0.5	<0.5	NR	13.50
	Mean	50.4	1.68					1,828	0.20	0.4	201	10.5	0.8	44.6		43.8	#DIV/0!	4,498			#DIV/0!	
	Max	54.8	2.46					2,184	0.20	0.5	272	11.2	1.3	60.4		52.7	0.0	5,919			0.00	
	Min	44.5	0.96					1,400	0.20	0.4	121	9.9	0.6	36.3		30.9	0.0	3,193			0.00	
MSD-1B	**M#211606**																					
	04/15/04	64.7	<1					<300	<10	<10	<300	38.5	<20	665		1,918.0	<20	4,201			NA	
	05/18/06	56.7	<2.5					249	<10	<10	<300	<20	<20	376		1,630.0	<20	3,307			NA	
	04/26/07	57.5	<2.5					408	<10	<2	71	14.7	<1	348	55	1,574.0	<1	3,169	<1.0	<1.0	NA	18.0
	08/20/08	41	<0.5					121	<0.36	0.9	82.3	15.4	<0.78	217	88	1,321.0	<0.34	1,821	<0.19	0.86	NA	33.1
Fingerprint	4/18/2010	35.1	<0.25	<0.25	<0.15	0.55	<0.25	4.83	<0.5	<0.6	96.6	23.10	<0.6	68.80	9.12	143.00	<0.5	330	<0.5	<0.5	NR	2.68
	Mean	51.0	#DIV/0!					196	#DIV/0!	0.94	83.30	22.9	#DIV/0!	335		1,317.2	#DIV/0!	2,566			#DIV/0!	
	Max	64.7	0.00					408	0.00	0.94	96.60	38.5	0.0	665		1,918.0	0	4,201			0	
	Min	35.1	0.00					5	0.00	0.94	71.00	14.7	0.0	69		143.0	0	330			0	
MSD-1C	**M#211603**																					
MBMG	04/15/04	37.1	<0.5					<150	<50	<5	<150	34.3	<10	63		<10	<10	269			NA	
MBMG	05/18/06	37.8	<2.5					<50	<5	<5	<150	28.4	<10	105		241.0	<10	438			NA	
MBMG	06/26/07	36.9	<2.5					<150	<5	1.9	78.9	26.2	<0.5	75	11.7	88.5	<0.5	274	<0.5	<0.5	NA	1.77
MBMG	08/19/08	28.5	<0.5					7	<0.36	<0.89	51.7	24.3	<0.78	78	25.1	214.0	<0.34	447	<0.19	<0.34	NA	5.65
Fingerprint	4/18/2010	41.2	<0.25	<0.25	<0.15	2.64	<0.25	82.4	<0.5	0.77	71.4	13.90	<0.6	153.00	35.0	1,086.00	<0.5	1,603	<0.5	0.52	NR	12.80

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			MINOR AND TRACE METALS																		
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	Palladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE		DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
		(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
MF-07	**M#4617**																			
		4/20/2010	127.00	<0.9	<0.7	<0.4	23.70	<2.5	<0.6	<0.5	<0.5	1.06	<3.0	######	<2.5	2.83	<2.5	23.60	<0.6	3,519
	Mean		127.00	<0.9	<0.7	<0.4	23.70	<2.5	<0.6	<0.5	<0.5	1.06	<3.0	######	<2.5	2.83	<2.5	23.60	<0.6	3,519
	Max		127.00	<0.9	<0.7	<0.4	23.70	<2.5	<0.6	<0.5	<0.5	1.06	<3.0	######	<2.5	2.83	<2.5	23.60	<0.6	3,519
	Min		127.00	<0.9	<0.7	<0.4	23.70	<2.5	<0.6	<0.5	<0.5	1.06	<3.0	######	<2.5	2.83	<2.5	23.60	<0.6	3,519
MF-10																				
	MBMG	4/24/1988	56.00	<20			<10													560
	MBMG	5/9/1989						24.50						500.00						810
	Trec	12/1/2007						0.45												7,930
	Trec	10/2/2008						1.30												9,500
	Trec	10/7/2009						0.66												16,300
	Fingerprint	8/11/2010	27.20	2.79	<0.86	2.64	9.18	14.00	<2.53	<1.01	7.81	1.34	<1.01	657.00	<1.01	6.43	<1.01	2.87	<1.01	61,854
MSD-1A	**M#212801**																			
		05/17/06	89	<10			25	8.6				2.9		766				5.4		10,036
		04/24/07	83.2	<1	<0.1	9.2	19	16.4	2	2.7	1	1.2	<0.1	960	0.1	4	<0.1	4.1	<1.0	8,742
		08/20/08	43.6	<0.1	<0.03	11.4	16	3.3	1	3.5	0	0.7	<0.06	573	0.0	3	<0.04	4.1	<0.05	7,516
	Fingerprint	4/18/2010	60.90	<0.4	<0.7	8.58	24.70	5.84	<0.6	2.44	<0.5	<1.0	<3.0	738.00	<2.5	3.59	<2.5	4.86	<0.6	9,641
	Mean		69.2	#DIV/0!			20.9	8.5				1.6		759				4.6		8,984
	Max		89.0	0.0			24.7	16.4				2.9		960				5.4		10,036
	Min		43.6	0.0			15.9	3.3				0.7		573				4.1		7,516
MSD-1B	**M#211606**																			
		04/15/04	750	<100			437	31.4				11.7		4,183				<5		200,140
		05/18/06	633	<100			633	<20				<10		3,327				<5		108,987
		04/26/07	695	<10	<1.0	8.0	353	24.4	6	2.3	2	<5	<1.0	3,460	0.5	27	<1.0	4.2	<10.0	118,000
		08/20/08	499	<0.48	<0.16	10.3	275	13.6	5	3.4	2	<1.9	<0.30	2,557	<0.02	25	<0.22	2.1	<0.27	76,204
	Fingerprint	4/18/2010	209	3.56	<0.7	1.43	105.0	<2.5	1.28	0.90	13.4	<1.0	<3.0	3,551	<2.5	16.7	<2.5	3.66	<0.6	15,645
	Mean		557	3.56			361	23.1				11.7		3,416				3.3		103,795
	Max		750	3.56			633	31.4				11.7		4,183				4.2		200,140
	Min		209	3.56			105	13.6				11.7		2,557				2.1		15,645
MSD-1C	**M#211603**																			
	MBMG	04/15/04	174	<50			107	<10				<5		4,960				2.9		9,480
	MBMG	05/18/06	260	<50			147	<10				<5		4,300				<3		26,775
	MBMG	06/26/07	203	<5	<0.5	1	106	<1	5.33	<0.5	12.3	<2.5	<0.5	5,004	<0.25	15.2	<0.5	2.4	<5.0	15,438
	MBMG	08/19/08	170	2.25	<0.16	2	117	<2.81	6.68	<0.82	9.92	<1.9	<0.30	3,684	<0.02	21.3	<0.22	2.4	<0.27	19,974
	Fingerprint	4/18/2010	397	<0.4	<0.7	4.85	227.0	10.40	1.27	1.57	2.22	<1.0	<3.0	2,481	<2.5	18.1	<2.5	<3.0	<0.6	57,281

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		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
	Mean				5.78	2,872	10.94	303	5.28	2,696	1,854	27	49.2	25.8	9.3	1.1	0.0	96.6	508.8	141.9	97.4	14.0	15.2	55	30	0.0	47.2	2,162	2.40	
	Max				6.10	3,150	11.44	319	6.38	3,170	1,967	57	60.5	30.0	11.4	2.5	0.0	98.2	562.0	161.0	118.0	14.8	36.7	122	70	0.0	101.0	2,233	2.40	
	Min				5.49	2,600	10.23	278	3.49	1,090	1,634	0	27.1	24.3	6.4	0.0	0.0	94.2	389.0	133.0	64.6	13.1	0.2	30	0	0.0	18.9	2,070	2.40	
MSD-2A	**M#999030**																													
(M-14)	05/17/06	15:00	10.16	2	5.37	1,195	10.61	349	5.29	1,305	463	14	48.3	17.6	16.5	1.9	0.0	73.0	136.0	30.0	53.1	8.2	16.4	24	17	0.0	123	501	2.24	
MBMG	06/25/07	13:35	7.51	2	5.06	1,150	9.70	630	3.53	1,140	361	0	45.7	17.2	19.7	0.0	0.0	86.6	105.0	23.9	51.8	7.9	13.1	16	0	0.0	87	786	1.61	
MBMG	07/28/08	15:00	10.06	2	5.44	1,260	11.77	336	4.78	1,170	385	6	42.9	18.3	22.2	0.9	0.0	80.6	109.0	27.4	63.7	8.0	14.7	19	7	0.0	88	517	1.24	
Fingerprint	4/19/2010	15:45	8.95		5.32	638	8.03	335	4.85	769	177	4	40.08	17.44	25.58	1.43	0.00	67.94	49.3	13.0	36.1	5.3	6.50	9.69	5.5	0.0	66.1	205	1.17	182
	Mean				5.30	1,061	10.03	413	4.61	1,096	346	6	44.3	17.6	21.0	1.1	0.0	77.0	99.8	23.6	51.2	7.4	12.7	17	7	0.0	91	502	1.57	
	Max				5.44	1,260	11.77	630	5.29	1,305	463	14	48.3	18.3	25.6	1.9	0.0	86.6	136.0	30.0	63.7	8.2	16.4	24	17	0.0	123	786	2.24	
	Min				5.06	638	8.03	335	3.53	769	177	0	40.1	17.2	16.5	0.0	0.0	67.9	49.3	13.0	36.1	5.3	6.5	10	0	0.0	66	205	1.17	
MSD-2B	**M#215787**																													
MBMG	04/02/04	13:30			4.83	3,720	10.24		5.39	4,020	2,320	19	41.3	25.7	5.2	0.6	0.0	93.5	573.0	216.0	82.2	25.3	2.3	307	23	0.0	147	3,129	<2.5	
MBMG	05/17/06	13:40	8.11	2	4.32	4,900	10.10	425	4.37	4,910	2,373	0	35.3	22.9	5.4	0.0	0.0	86.2	576.0	227.0	102.0	23.9	145.0	307	0	0.0	438	3,709	<5	
MBMG	06/25/07	11:30	9.71	2	4.49	5,560	10.40	576	4.18	4,860	2,371	0	32.0	21.8	5.6	0.0	0.0	88.6	559.0	237.0	112.0	27.2	214.0	357	0	0.0	327	3,451	<5	
MBMG	07/28/08	14:30	10.03	2	4.25	5,660	11.69	395	3.46	5,180	2,100	0	26.8	20.4	6.3	0.0	0.0	90.4	475.0	222.0	128.0	24.6	317.0	368	0	0.0	399	4,152	2.31	
Fingerprint	4/18/2010	15:25	10.57		4.11	5,310	10.16	397	3.81	5,240	1,906	0	26.09	18.99	7.00	0.00	0.00	89.08	442	195	136	22.2	352.00	318.00	0.0	0.0	322.4	3,602	2.02	<250
	Mean				4.40	5,030	10.52	448	4.24	4,842	2,214	4	32.3	22.0	5.9	0.1	0.0	89.6	525.0	219.4	112.0	24.6	206.1	331.4	5	0.0	327	3,609	2.2	
	Max				4.83	5,660	11.69	576	5.39	5,240	2,373	19	41.3	25.7	7.0	0.6	0.0	93.5	576.0	237.0	136.0	27.2	352.0	368.0	23	0.0	438	4,152	2.3	
	Min				4.11	3,720	10.10	395	3.46	4,020	1,906	0	26.1	19.0	5.2	0.0	0.0	86.2	442.0	195.0	82.2	22.2	2.3	307.0	0	0.0	147	3,129	2.0	
MSD-3	**M#211593**																													
MBMG	05/09/04	15:00	7.91	NA	6.60	2,300	NR	NR	6.35	2,410	1,579	81	59.2	25.7	10.6	4.8	0.0	87.8	441.0	116.0	90.9	16.4	0.4	22	99	0.0	70	1,422	3.1	
MBMG	05/19/06	14:00	8.21	2	5.73	2,740	10.28	421	5.77	2,780	1,732	63	57.1	27.0	8.5	3.1	0.0	90.6	471.0	135.0	80.0	18.7	0.1	45	77	0.0	78	1,735	<1.0	
Duplicate	05/19/06	14:00	8.21	2	5.73	2,740	10.28	421	5.73	2,770	1,738	62	79.1	27.2	8.6	2.9	0.0	91.3	472.0	136.0	81.3	18.7	0.1	42	76	0.0	79	1,877	<1	
MBMG	07/26/06	14:00	7.93	2	5.85	2,740	10.40	400	5.68	2,790	1,777	102	58.6	27.5	8.4	4.7	0.0	89.5	484.0	138.0	79.2	18.8	0.0	31	124	0.0	80	1,864	<0.5	
MBMG	04/26/07	14:43	8.05	2	5.59	3,150	10.40	195	5.79	3,010	1,659	65	58.0	27.6	8.9	3.2	0.0	90.6	450.0	130.0	78.9	18.6	0.1	28	79	0.0	79	1,774	<2.5	
MBMG	07/29/08	12:00	8.20	2	5.86	3,170	11.20	347	6.02	2,920	1,784	66	60.9	26.1	7.8	3.0	0.0	90.2	500.0	130.0	73.9	14.9	<0.009	30	80	0.0	93	1,880	<0.5	
Fingerprint	4/18/2010	14:45	8.50		5.64	2,920	10.00	407	6.65	3,020	1,696	59	56.75	27.97	8.76	2.90	0.00	88.05	455	136	80.6	18.3	<0.006	38.10	71.9	0.0	119.2	1,717	0.428	<250
	Mean				5.86	2,823	10.43	365	6.00	2,814	1,709	71	61.4	27.0	8.8	3.5	0.0	89.7	467.6	131.6	80.7	17.8	0.1	34	87	0.0	85	1,753	1.8	
	Max				6.60	3,170	11.20	421	6.65	3,020	1,784	102	79.1	28.0	10.6	4.8	0.0	91.3	500.0	138.0	90.9	18.8	0.4	45	124	0.0	119	1,880	3.1	
	Min				5.59	2,300	10.00	195	5.68	2,410	1,579	59	56.8	25.7	7.8	2.9	0.0	87.8	441.0	116.0	73.9	14.9	0.0	22	72	0.0	70	1,422	0.4	
MSD-4	**M#215790**																													
	10/26/04	15:25			6.32	1,687	8.90		7.21	2,120	1,237	111	59.5	28.0	10.2	7.9	0.0	82.8	337.0	69.0	66.5	11.5	0.0	7.78	135	0.0	88	1,118	0.26	
	04/26/07	11:10	9.45		6.14	2,260	8.60	177	6.27	2,120	1,155	60	58.5	27.4	11.3	4.4	0.0	89.4	315.0	89.6	69.7	12.0	0.0	10.46	73	0.0	60	1,171	<1.0	
	08/20/08	10:20	10.07	2	6.46	1,790	9.17	432	6.48	1,845	1,139	68	59.3	27.4	10.6	5.7	0.0	88.7	312.0	87.5	64.5	10.6	0.0	10.90	83	0.0	46	1,052	<0.5	
Fingerprint	4/17/2010	12:00	9.69		6.11	1,625	9.61	418	6.99	1,918	857	67	55.38	28.77	12.58	6.34	0.00	87.62	226	71.2	58.9	10.5	<0.006	9.67	81.7	0.0	40.6	889	0.279	78
	Mean				6.26	1,841	9.07	342	6.74	2,001	1,097	76	58.2	27.9	11.2	6.1	0.0	87.1	297.5	79.3	64.9	11.2	0.0	9.70	93	0.0	58	1,058	0.27	
	Max				6.46	2,260	9.61	432	7.21	2,120	1,237	111	59.5	28.8	12.6	7.9	0.0	89.4	337.0	89.6	69.7	12.0	0.0	10.90	135	0.0	88	1,171	0.28	
	Min				6.11	1,625	8.60	177	6.27	1,845	857	60	55.4	27.4	10.2	4.4	0.0	82.8	226.0	69.0	58.9	10.5	0.0	7.78	73	0.0	41	889	0.26	

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		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Beryllium	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanum
SAMPLE SITE	DATE	SiO$_2$	NO$_3$-N	PO$_4$		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
	Mean	36.3	#DIV/0!					45	#DIV/0!	1.3	67.3	25.4	#DIV/0!	94.7		407.4	#DIV/0!	606			#DIV/0!	
	Max	41.2	0.00					82	0.0	1.9	78.9	34.3	0.0	153.0		1,086.0	0.0	1,603			0.0	
	Min	28.5	0.00					7	0.0	0.8	51.7	13.9	0.0	62.6		88.5	0.0	269			0.0	
MSD-2A	**M#999030**																					
(M-14)	05/17/06	53.3	<.5					675	<1	5.0	189	15.0	<2	102		111.0	<2	200			NA	
MBMG	06/25/07	52.6	<0.5					1,273	<1	9.3	160	15.8	0.4	88		64.9	<0.1	848			NA	
MBMG	07/28/08	48.9	<0.5					486	<0.5	8.5	218	14.5	<0.5	74	13.5	88.5	<0.5	146	<0.5	<0.5	NA	13
Fingerprint	4/19/2010	49.8	<0.05	<0.05	<0.03	2.22	<0.25	247	<0.1	1.96	123	18.10	0.27	33.70	0.34	42.20	<0.1	68	<0.1	<0.1	NR	0.20
	Mean	51.15	#DIV/0!					670	#DIV/0!	6.2	172.5	15.85	0.3	74		76.7	#DIV/0!	316			#DIV/0!	
	Max	53.3	0.00					1,273	0	9.3	218	18.1	0.4	102		111.0	0	848			0	
	Min	48.9	0.00					247	0	2.0	123	14.5	0.3	34		42.2	0	68			0	
MSD-2B	**M#215787**																					
MBMG	04/02/04	70.9	<2.5					3,350	<10	<10	<300	68.1	22.6	842		1,310.0	<20	43,639			NA	
MBMG	05/17/06	70.3	<5					5,413	<10	<10	<300	24.1	<20	1,193		2,324.0	<20	41,466			NA	
MBMG	06/25/07	77.8	<5					5,759	<100	<2	114	18.8	16.2	1,020	547	2,624.0	<1	44,221	<1.0	2.14	NA	105
MBMG	07/28/08	71.5	<0.5					4,953	10.6	<2	94.4	17.5	16.1	1,096	5,133	2,094.0	<0.5	40,460	<0.5	2.88	NA	2,123
Fingerprint	4/18/2010	68.6	<0.25	<0.25	<0.3	2.57	<0.25	6,208	11.60	<2.3	126	16.00	16.30	1,032.00	612	2,167.00	<2.0	33,641	<2.0	2.56	NR	143
	Mean	71.8	#DIV/0!					5,137	11.1	#DIV/0!	111.47	28.9	17.8	1,037		2,103.8	#DIV/0!	40,685			#DIV/0!	
	Max	77.8	0.0					6,208	11.6	0.00	126.00	68.1	22.6	1,193		2,624.0	0.0	44,221			0.00	
	Min	68.6	0.0					3,350	10.6	0.00	94.40	16.0	16.1	842		1,310.0	0.0	33,641			0.00	
MSD-3	**M#211593**																					
MBMG	05/09/04	47.2	5.29					150	<5	<5	189	74.8	<2	37		30.0	<10	403			NA	
MBMG	05/19/06	47	4.15					<30	<5	<5	<150	20.8	<2	79		<10	<10	2,013			NA	
Duplicate	05/19/06	46.2	4.13					<50	<5	<5	<150	21.1	<2	74		<10	<10	1,859			NA	
MBMG	07/26/06	43.7	4.05					<30	<1	3.0	123	20.2	<2	56		6.4	3.52	1,464			NA	
MBMG	04/26/07	45.8	4.08					8	<5	2.2	145	19.2	<0.5	51	1	5.8	<0.5	1,176	<0.5	<0.5	NA	<0.5
MBMG	07/29/08	43.3	<0.5					12	1.42	2.4	148	18.8	<1.0	55	9	6.9	<0.5	1,167	<0.5	<1.0	NA	<10
Fingerprint	4/18/2010	43.3	4.08	<0.25	<0.15	1.63	<0.25	10.8	1.62	2.09	131	18.80	<0.6	59.00	1.30	9.79	<0.5	1,813	<0.5	<0.5	NR	0.58
	Mean	45.2	4.30					45	2	2.4	147	27.7	#DIV/0!	59		11.8	3.52	1,414			#DIV/0!	
	Max	47.2	5.29					150	2	3.0	189	74.8	0.0	79		30.0	3.52	2,013			0.00	
	Min	43.3	4.05					8	1	2.1	123	18.8	0.0	37		5.8	3.52	403			0.00	
MSD-4	**M#215790**																					
	10/26/04	33.9	1.73					<30	<5	14.0	131	34.0	<2	8.2		<2	<10	<5			NA	
	04/26/07	35.8	<2.5					<5	<5	1.2	78	19.5	<0.5	9.0	<0.5	0.8	<0.5	6	<0.5	<0.5	NA	<0.5
	08/20/08	29.0	1.17					<4.76	<0.36	1.3	77	18.1	<0.78	9.2	<2.69	1.2	<0.34	7	<0.19	<0.34	NA	<4.26
Fingerprint	4/17/2010	34.8	1.65	<0.05	<0.03	1.67	<0.25	<4.2	<0.5	1.26	81.4	15.50	<0.6	7.26	0.63	0.54	<0.5	<3.0	<0.5	<0.5	NR	0.58
	Mean	33.4	1.52					#DIV/0!	#DIV/0!	4.5	92	21.8	#DIV/0!	8.4		0.8	#DIV/0!	7			#DIV/0!	
	Max	35.8	1.73					0	0.00	14.0	131	34.0	0.0	9.2		1.2	0.00	7			0	
	Min	29.0	1.17					0	0.00	1.2	77	15.5	0.0	7.3		0.5	0.00	6			0	

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			MINOR AND TRACE METALS																
		Lithium	Iolybdenu	Niobium	Ieodymiu	Nickel	Lead	alladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
	Mean	241	2.3			141	10.4				#DIV/0!		4,086				2.6		25,790
	Max	397	2.3			227	10.4				0.0		5,004				2.9		57,281
	Min	170	2.3			106	10.4				0.0		2,481				2.4		9,480
MSD-2A	**M#999030**																		
(M-14)	05/17/06	161	<10			48	3.7				2.7		812				0.9		13,147
MBMG	06/25/07	136	<1			28	2.7				0.9		646				1.2		10,746
MBMG	07/28/08	120	1.42	<0.5	1.18	34	<2	0.912	<1	0.745	<0.5	<0.5	661	<0.1	3.9	<0.2	0.5	<0.5	10,183
Fingerprint	4/19/2010	62	0.37	<0.1	0.11	14.5	<0.5	0.62	<0.1	0.36	0.64	<0.6	320	<0.5	1.26	<0.5	<0.6	<0.1	4,922
	Mean	119.675	0.897			31	3.2				1.4		610				0.8		9,750
	Max	161	1.42			48	3.7				2.7		812				1.2		13,147
	Min	61.7	0.374			15	2.7				0.6		320				0.5		4,922
MSD-2B	**M#215787**																		
MBMG	04/02/04	842	<100			408	21.1				<10		4,793				8.3		181,341
MBMG	05/17/06	939	<100			773	62.2				16.3		4,478				25.6		262,592
MBMG	06/25/07	1056	<10	<1.0	56	593	70.3	9.58	17	15.6	<5	<1.0	5,033	<0.50	37.1	<1.0	18.3	<10.0	250,502
MBMG	07/28/08	805	<1	<0.5	193	566	32.4	7.83	92	17.50	<3	<0.5	3,836	<0.1	30.50	<0.5	23.2	<0.5	254,766
Fingerprint	4/18/2010	722	<1.7	<2.7	77.0	562.0	24.70	6.78	27.1	17.1	4.01	<12.1	3,594	<10.1	29.8	<10.1	26.9	<2.5	248,767
	Mean	873	#DIV/0!			580	42.1				10.2		4,347				20.5		239,594
	Max	1,056	0			773	70.3				16.3		5,033				26.9		262,592
	Min	722	0			408	21.1				4.0		3,594				8.3		181,341
MSD-3	**M#211593**																		
MBMG	05/09/04	433	<10			100	<10				<5		3,660				2.4		9,700
MBMG	05/19/06	465	<10			132	<10				<5		4,396				<3		25,337
Duplicate	05/19/06	459	<10			123	<10				<5		4,319				<3		23,107
MBMG	07/26/06	455	<10			101	5.0				1.8		4,389				1.2		17,114
MBMG	04/26/07	479	<5	<0.5	<0.5	80	9.1	6.8	<0.5	11	<2.5	<0.5	4,778	0.4	17	<0.5	1.9	<5.0	15,445
MBMG	07/29/08	398	<1.0	<5	<2	83	<5.0	4.54	<1	11	<3.0	<1	4,041	<0.1	15	<0.5	1.1	<0.5	15,929
Fingerprint	4/18/2010	334	0.66	<0.7	<0.4	89.8	4.98	1.18	<0.5	11.7	0.98	<3.0	4,123	<2.5	13.3	<2.5	<3.0	<0.6	19,131
	Mean	432	1			101	6.4				1.4		4,244				1.6		17,966
	Max	479	1			132	9.1				1.8		4,778				2.4		25,337
	Min	334	1			80	5.0				1.0		3,660				1.1		9,700
MSD-4	**M#215790**																		
	10/26/04	106	<10			12.7	<10				<5		1,670				10.4		363
	04/26/07	165	<5	<0.5	<0.5	13.4	<1	2.44	<0.5	<0.5	<2.5	<0.5	1,737	<0.25	11.6	<0.5	4.3	<5.0	440
	08/20/08	129	2.9	<0.16	<1.09	14.0	<2.81	2.33	<0.82	0.30	<1.9	<0.30	1,271	<0.02	11.7	<0.22	3.0	<0.27	506
Fingerprint	4/17/2010	115.00	3.15	<0.7	0.72	10.10	<2.5	<0.6	0.67	<0.5	<1.0	<3.0	1,115	<2.5	8.03	<2.5	3.75	<0.6	401
	Mean	129	3.0			12.6	#DIV/0!				#DIV/0!		1,448				5.4		427
	Max	165	3.2			14.0	0.00				0.0		1,737				10.4		506
	Min	106	2.9			10.1	0.00				0.0		1,115				3.0		363

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		PHYSICAL AND CALCULATED PARAMETERS																	MAJOR CATIONS AND ANIONS											
		FIELD PARAMETERS							GENERAL LABORATORY PARAMETERS										CATIONS						ANIONS					
SAMPLE SITE	DATE	TIME	SWL	FLOW	pH	SC	TEMP	REDOX	pH	SC	HARDNESS	ALKALINITY	PERCENT MEQ/L						Ca	Mg	Na	K	Fe	Mn	HCO_3	CO_3	Cl	SO_4	F	Br
	(MM/DD/YR)	(HRS)	(FT)	(GPM)		(UMHOS)	(C)	(mv)		(UMHOS)	(MG/L)	(MG/L)	Ca	Mg	Na	HCO_3	CO_3	SO_4	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
MSD-5	**M#237726**																													
	08/17/07	12:30	10.61	2	5.63	2,930	9.29	450	5.72	3,010	1,867	89	55.0	28.3	7.8	3.9	0.0	87.8	494.0	154.0	80.6	22.4	0.1	43.6	109	0.0	113	1,924	2.85	
	07/29/08	10:45	10.15	2	5.66	3,460	9.73	325	5.92	3,200	1,891	59	54.8	28.2	7.8	2.5	0.0	88.8	500.0	156.0	81.8	23.2	1.9	44.7	72	0.0	133	2,042	0.52	
Fingerprint	4/17/2010	13:45	10.75		5.48	3,074	9.80	501	6.07	3,080	1,794	56	53.65	27.87	8.96	2.51	0.00	88.27	473	149	90.6	23.3	<0.006	48.40	68.3	0.0	130.6	1,891	0.575	<250
	Mean				5.59	3,155	9.61	425	5.90	3,097	1,851	68	54.5	28.1	8.2	3.0	0.0	88.3	489.0	153.0	84.3	23.0	1.0	45.6	83	0.0	125	1,952	1.32	
	Max				5.66	3,460	9.80	501	6.07	3,200	1,891	89	55.0	28.3	9.0	3.9	0.0	88.8	500.0	156.0	90.6	23.3	1.9	48.4	109	0.0	133	2,042	2.85	
	Min				5.48	2,930	9.29	325	5.72	3,010	1,794	56	53.7	27.9	7.8	2.5	0.0	87.8	473.0	149.0	80.6	22.4	0.1	43.6	68	0.0	113	1,891	0.52	
PW-01	**M#4669**																													
MBMG	08/18/09	9:40	20.71		4.58	1,790	8.80	359	4.20	1,695	696	0	52.8	10.3	9.8	0.0	0.0	87.2	233.0	27.7	49.5	12.2	44.5	20.30	0.00	0.00	98.90	1,005	1.95	
	Mean				4.58	1,790	8.80	359	4.20	1,695	696	0	52.8	10.3	9.8	0.0	0.0	87.2	233.0	27.7	49.5	12.2	44.5	20.30	0.00	0.00	98.90	1,005	1.95	
	Max				4.58	1,790	8.80	359	4.20	1,695	696	0	52.8	10.3	9.8	0.0	0.0	87.2	233.0	27.7	49.5	12.2	44.5	20.30	0.00	0.00	98.90	1,005	1.95	
	Min				4.58	1,790	8.80	359	4.20	1,695	696	0	52.8	10.3	9.8	0.0	0.0	87.2	233.0	27.7	49.5	12.2	44.5	20.30	0.00	0.00	98.90	1,005	1.95	
Whittier School	**M#4716**																													
	4/25/2010	12:20	50.99		7.18	355	10.64	211	7.09	389	132	116	47.99	22.75	27.55	59.95	0.00	22.57	35.8	10.3	23.6	1.9	0.21	0.03	141.0	0.0	12.9	42	0.236	110
	Mean	12:20	50.99		7.18	355	10.64	211	7.09	389	132	116	47.99	22.75	27.55	59.95	0.00	22.57	35.8	10.3	23.6	1.9	0.21	0.03	141.0	0.0	12.9	42	0.236	110
	Max	12:20	50.99		7.18	355	10.64	211	7.09	389	132	116	47.99	22.75	27.55	59.95	0.00	22.57	35.8	10.3	23.6	1.9	0.21	0.03	141.0	0.0	12.9	42	0.236	110
	Min	12:20	50.99		7.18	355	10.64	211	7.09	389	132	116	47.99	22.75	27.55	59.95	0.00	22.57	35.8	10.3	23.6	1.9	0.21	0.03	141.0	0.0	12.9	42	0.236	110

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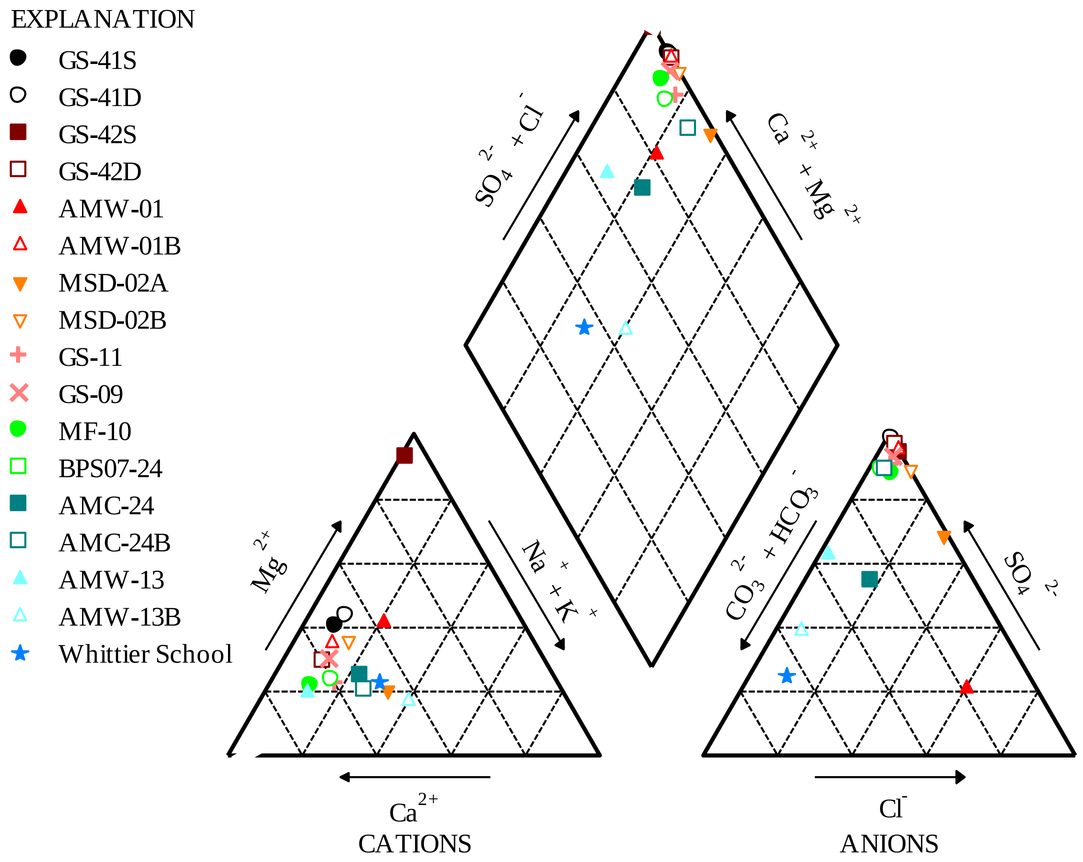
		NON-METALS						MINOR AND TRACE METALS														
		Silica	Nitrate	Ortho-Phosphate	Tot. Phosphate	Tot Organic	Diss. Organic	Aluminum	Silver	Arsenic	Boron	Barium	Berylliun	Cadmium	Cerium	Cobolt	Cromium	Copper	Cesium	Gallium	Mercury	Lanthanun
SAMPLE SITE	DATE	SiO_2	NO_3-N	PO_4		Carbon	Carbon	Al	Ag	As	B	Ba	Be	Cd	Ce	Co	Cr	Cu	Cs	Ga	Hg	La
	(MM/DD/YR)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
MSD-5	**M#237726**																					
	08/17/07	48.5	6.51					<10	<2.5	3.6	162	24.7	1.5	128.0	NR	2.7	<0.5	12,150	NR	NR	NA	NR
	07/29/08	45.4	5.69					26	1.1	3.7	160	22.4	1.7	127.0	16	2.5	<0.5	12,234	<0.5	<1.0	NA	13
Fingerprint	4/17/2010	50.7	5.58	<0.25	<0.15	2.01	<0.25	11.5	0.63	4.16	155	22.00	1.33	118.00	1.53	2.32	<0.5	12,745	<0.5	<0.5	NR	0.68
	Mean	48.2	5.93					19	0.8	3.8	159	23.0	1.5	124.3		2.5	#DIV/0!	12,376			#DIV/0!	
	Max	50.7	6.51					26	1.1	4.2	162	24.7	1.7	128.0		2.7	0.00	12,745			0.0	
	Min	45.4	5.58					12	0.6	3.6	155	22.0	1.3	118.0		2.3	0.00	12,150			0.0	
PW-01	**M#4669**																					
MBMG	08/18/09	54.00	2.63					7,492	0.56	2.51	71.40	10.50	4.50	255.00	133	163.0	0.32	20,826	<0.21	0.27	NR	51
	Mean	54.00	2.63					7,492	0.56	2.51	71.40	10.50	4.50	255.00		163.0	0.32	20,826			#DIV/0!	
	Max	54.00	2.63					7,492	0.56	2.51	71.40	10.50	4.50	255.00		163.0	0.32	20,826			0.00	
	Min	54.00	2.63					7,492	0.56	2.51	71.40	10.50	4.50	255.00		163.0	0.32	20,826			0.00	
Whittier School	**M#4716**																					
	4/25/2010	27.1	4.18	<0.05	<0.03	2.24	<0.25	<0.8	<0.1	0.67	9.62	73.30	<0.1	<0.1	<0.1	0.24	<0.1	<0.6	<0.1	<0.1	NR	<0.1
	Mean	27.1	4.18	<0.05	<0.03	2.24	<0.25	<0.8	<0.1	0.67	9.62	73.30	<0.1	<0.1	<0.1	0.24	<0.1	<0.6	<0.1	<0.1	NR	<0.1
	Max	27.1	4.18	<0.05	<0.03	2.24	<0.25	<0.8	<0.1	0.67	9.62	73.30	<0.1	<0.1	<0.1	0.24	<0.1	<0.6	<0.1	<0.1	NR	<0.1
	Min	27.1	4.18	<0.05	<0.03	2.24	<0.25	<0.8	<0.1	0.67	9.62	73.30	<0.1	<0.1	<0.1	0.24	<0.1	<0.6	<0.1	<0.1	NR	<0.1

Montana Bureau of Mines and Geology
Butte Priority Soils Groundwater-Quality Data

			MINOR AND TRACE METALS																	
		Lithium	olybdenu	Niobium	eodymiu	Nickel	Lead	Palladiun	raseodymiu	Rubidium	Selenium	Tin	trontiun	Thorium	Titanium	Thallium	Uranium	Tungsten	Zinc
SAMPLE SITE	DATE	Li	Mo	Nb	Nd	Ni	Pb	Pd	Pr	Rb	Se	Sn	Sr	Th	Ti	Tl	U	W	Zn
	(MM/DD/YR)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
MSD-5	**M#237726**																		
	08/17/07	595	<5	NR	NR	243.0	<1	NR	NR	NR	<2.5	NR	6,459	NR	9.4	<0.5	1.7	NR	42,076
	07/29/08	492	<1	<0.5	<2.0	248.0	<5	7	<1.0	33	<3	<1.0	5,532	<0.1	16.5	<0.5	1.6	<0.5	42,679
Fingerprint	4/17/2010	457	0.71	<0.7	<0.4	221.0	<2.5	1.37	<0.5	32.5	1.36	<3.0	5,588	<2.5	12.8	<2.5	<3.0	<0.6	42,007
	Mean	515	0.7			237.3	#DIV/0!				1.4		5,860				1.7		42,254
	Max	595	0.7			248.0	0.0				1.4		6,459				1.7		42,679
	Min	457	0.7			221.0	0.0				1.4		5,532				1.6		42,007
PW-01	**M#4669**																		
MBMG	08/18/09	159.00	<0.20	<0.20	33	89.40	5.10	2	9	6	1.53	<0.21	898	<0.12	11	<0.17	38.80	<0.25	33,024
	Mean	159.00	#DIV/0!			89.40	5.10				1.53		898				38.80		33,024
	Max	159.00	0.00			89.40	5.10				1.53		898				38.80		33,024
	Min	159.00	0.00			89.40	5.10				1.53		898				38.80		33,024
Whittier School	**M#4716**																		
	4/25/2010	2.52	0.82	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	0.12	0.79	<0.6	259	<0.5	0.35	<0.5	2.14	<0.1	<0.7
	Mean	2.52	0.82	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	0.12	0.79	<0.6	259	<0.5	0.35	<0.5	2.14	<0.1	<0.7
	Max	2.52	0.82	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	0.12	0.79	<0.6	259	<0.5	0.35	<0.5	2.14	<0.1	<0.7
	Min	2.52	0.82	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	0.12	0.79	<0.6	259	<0.5	0.35	<0.5	2.14	<0.1	<0.7

APPENDIX D PIPER DIAGRAM



Piper diagram showing the relationship of the SA and MA aquifers in mining impacted areas (from the Parrot Tailings area to Blacktail Creek) to background concentrations (Whittier School Well).

e

APPENDIX E: PHREEQC INPUT FILE FOR THE MA AQUIFER

```
TITLE Parrot Water GS-41D
SOLUTION 1  Parrot water GS-41D
units   ppm
TEMP    9.02
pH      3.93
pe      6.16
Ca      406
Mg      228
Na      85.1
K       17.4
Fe      1552
Mn      192
Si      77.9
Cl      83.9
S(6)    8294
F       18.98
Al      164.867
Ag      0.00277
As      0.0241
B       0.184
Ba      0.00736
Be      0.0495
Cd      3.516
Co      2.332
Cu      1062.86
Li      1.06
Ni      0.82
Pb      0.0221
Se      0.00796
Sr      2.867
U       0.613
Zn      624.272
PHASES
GreenrustSO4
        Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
        log_k               21.8
        delta_h   277  kJ
SAVE solution 1
SELECTED_OUTPUT
    -file         MAflowpathGR.sel
                -totals        Fe(2) Fe(3) Mn(2)
    -molalities     HCO3-
    -saturation_indices  siderite ferrihydrite lepidocrocite hematite magnetite maghemite gibbsite goethite
rhodochrosite malachite calcite manganite K-Jarosite Na-Jarosite Cuprousferrite Cupricferrite Smithsonite
Pyrochroite Pyrolusite Birnessite Bixbyite GreenrustSO4
END
TITLE GS-42D
SOLUTION 2  GS-42D Water
    units   ppm
                TEMP    9.63
                pH      4.03
                pe      8.07
                Ca      470
                Mg      140
                Na      81.7
                K       25.6
```

```
                Fe      0.061
                Mn      227
                Si      83.7
                Cl      62.95
                S(6)    2868
                N(5)    4.54
                F       12.34
                Al      28.594
                B       0.163
                Be      0.02
                Cd      0.942
                Co      0.612
                Cu      113.836
                Li      0.818
                Ni      0.457
                Sr      3.99
                U       0.0967
                Zn      204.915
                Br      0.258
PHASES
GreenrustSO4
        Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
        log_k           21.8
        delta_h  277  kJ
SAVE solution 2
END
TITLE AMW-1B
SOLUTION 3  AMW-1B Water
units   ppm
TEMP    12.8
pH      4.27
pe      8.65
Ca      444
Mg      173
Na      80.2
K       25.5
Fe      5.03
Mn      333
Si      77.5
Cl      101.7
S(6)    2954
N(5)    4.53
F       5.54
Al      13.153
As      0.0014
B       0.154
Ba      0.0116
Be      0.009
Cd      1.2
Co      0.538
Cu      102.087
Li      0.713
Ni      0.581
Pb      0.0122
Se      0.00328
Sr      4.621
```

```
U       0.0547
Zn      222.675
Br      0.263
PHASES
GreenrustSO4
        Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
        log_k           21.8
        delta_h  277  kJ
SAVE solution 3
END
TITLE MSD-2B
SOLUTION 4  MSD-2B Water
units   ppm
TEMP    10.16
pH      4.11
pe      7.06
Ca      442
Mg      195
Na      136
K       22.2
Fe      352
Mn      318
Si      68.6
Cl      322.4
S(6)    3602
F       2.02
Al      6.208
Ag      0.0116
B       0.126
Ba      0.016
Be      0.0163
Cd      1.032
Co      2.167
Cu      33.641
Li      0.722
Ni      0.562
Pb      0.0247
Se      0.00401
Sr      3.594
U       0.0269
Zn      248.767
PHASES
GreenrustSO4
        Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
        log_k           21.8
        delta_h  277  kJ
SAVE solution 4
END
TITLE GS-09
SOLUTION 5  GS-09 Water
units   ppm
TEMP    11.54
pH      5.59
pe      7.27
Ca      484
Mg      155
```

```
Na       102
K        23.3
Mn       30.5
Si       48.7
Alkalinity       64.3 as HCO3
Cl       77.99
S(6)     2096
N(5)     2.63
F        0.589
Al       0.0212
As       0.00322
B        0.13
Ba       0.0222
Be       0.00159
Cd       0.0971
Co       0.00181
Cu       9.997
Li       0.511
Mo       0.000702
Ni       0.205
Se       0.00103
Sr       6.515
Zn       37.55
PHASES
GreenrustSO4
         Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
         log_k              21.8
         delta_h  277  kJ
SAVE solution 5
END
TITLE BPS07-24
SOLUTION 6  BPS07-24 Water
units   ppm
TEMP     10
pH       6.27
pe       2.88
Ca       392
Mg       95.4
Na       107
K        23.6
Mn       0.468
Si       33.8
Alkalinity       148 as HCO3
Cl       38.59
S(6)     1396
N(5)     0.137
F        1.02
As       0.00414
B        0.0858
Ba       0.0428
Cd       0.0198
Cu       0.834
Li       0.398
Mo       0.00297
Ni       0.0214
Se       0.000987
```

```
Sr        6.27
U         0.0411
Zn        5.379
Br        0.137
PHASES
GreenrustSO4
          Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
          log_k             21.8
          delta_h  277  kJ
SAVE solution 6
END
TITLE AMC-24B
SOLUTION 7  AMC-24B Water
units   ppm
TEMP      10.79
pH        6.23
pe        6.21
Ca        183
Mg        43.1
Na        95.1
K         14.1
Mn        0.002
Si        37.7
Alkalinity          70.8 as HCO3
Cl        28.04
S(6)      775.1
N(5)      1.09
F         0.639
As        0.00409
B         0.0792
Ba        0.0185
Cd        0.00707
Cu        0.158
Li        0.206
Mo        0.00196
Ni        0.00469
Sr        2.191
Zn        1.568
Br        0.073
PHASES
GreenrustSO4
          Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
          log_k             21.8
          delta_h  277  kJ
SAVE solution 7
END
TITLE AMW-13B
SOLUTION 8  AMW-13B Water
units   ppm
TEMP      9.87
pH        7.09
pe        4.27
Ca        26.9
Mg        6.43
Na        26.7
K         3.25
```

```
Fe      0.009
Mn      0.001
Si      33.7
Alkalinity      108.3 as HCO3
Cl      7.17
S(6)    60.35
N(5)    0.428
F       1.22
Al      0.0014
As      0.00328
B       0.0283
Ba      0.0282
Cd      0.000253
Cr      0.000426
Cu      0.00124
Li      0.00904
Mo      0.0283
Se      0.000301
Sr      0.196
U       0.00348
Zn      0.0238
Br      0.055
PHASES
GreenrustSO4
        Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
        log_k           21.8
        delta_h 277  kJ
SAVE solution 8
END
```

PHREEQC input file for the SA aquifer.

```
TITLE GS-41S
SOLUTION 1  Parrot water GS-41S
units   ppm
TEMP    8.93
pH      4.04
pe      6.36
Ca      429
Mg      204
Na      74.2
K       14.9
Fe      1636
Mn      87.6
Si      86.9
Cl      174.4
S(6)    7919
F       15.64
Al      156.869
As      0.0716
B       0.187
Ba      0.007
Be      0.0365
Cd      4.231
Co      1.213
Cr      0.0108
Cu      986.507
Li      0.6
Ni      0.708
Pb      0.0584
Se      0.00699
Sr      2.746
U       0.581
Zn      525.85
Br      0.304
SAVE solution 1
PHASES
GreenrustSO4
        Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
        log_k                21.8
        delta_h   277  kJ
SELECTED_OUTPUT
    -file          SAflowpathGR.sel
                        -totals        Fe(2) Fe(3) Mn(2)
    -molalities     HCO3-
    -saturation_indices  siderite ferrihydrite lepidocrocite hematite magnetite maghemite gibbsite goethite
rhodochrosite malachite calcite manganite K-Jarosite Na-Jarosite Cuprousferrite Cupricferrite Smithsonite
Pyrochroite Pyrolusite Birnessite Bixbyite GreenrustSO4
END
TITLE GS-42S
SOLUTION 2  GS-42S Water
    units   ppm
TEMP    9.39
pH      3.84
pe      7.61
Ca      439
```

```
Mg      4123
Na      93
K       17.9
Fe      1178
Mn      34.9
Si      83.7
Cl      232.7
S(6)    4911
N(5)    8.81
F       10.08
Al      98.436
B       0.057
Ba      0.00986
Be      0.0337
Cd      0.768
Co      0.358
Cr      0.00136
Cu      331.406
Li      0.541
Ni      0.251
Se      0.00337
Sr      2.125
U       0.145
Zn      208.033
Br      0.421
PHASES
GreenrustSO4
        Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
        log_k           21.8
        delta_h   277  kJ
SAVE solution 2
END
TITLE AMW-1A
SOLUTION 3  AMW-1A Water
units   ppm
TEMP    9.6
pH      6.43
pe      4.49
Ca      59.9
Mg      40.2
Na      34.8
K       6.48
Fe      21.2
Mn      2.4
Si      26.2
Alkalinity      103.1 as HCO3
Cl      185.6
S(6)    87.92
N(5)    0.148
F       1.95
Al      0.0428
As      0.056
B       0.46
Ba      0.0818
Cd      0.000128
Co      0.0104
```

```
Cu      0.00224
Li      0.324
Mo      0.00783
Ni      0.00669
Se      0.00222
Sr      0.285
U       0.0016
Zn      2.697
Br      0.93
PHASES
GreenrustSO4
        Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
        log_k           21.8
        delta_h  277  kJ
SAVE solution 3
END
TITLE MSD-2A
SOLUTION 4  MSD-2A Water
units   ppm
TEMP    8.03
pH      5.32
pe      6.00
Ca      49.3
Mg      13
Na      36.1
K       5.32
Fe      6.5
Mn      9.69
Si      49.8
Alkalinity      5.49 as HCO3
Cl      66.11
S(6)    205.2
F       1.17
Al      0.247
As      0.00196
B       0.123
Ba      0.0181
Be      0.000274
Cd      0.0337
Co      0.0422
Cu      0.0683
Li      0.0617
Mo      0.000374
Ni      0.0145
Se      0.000638
Sr      0.32
Zn      4.922
Br      0.182
PHASES
GreenrustSO4
        Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
        log_k           21.8
        delta_h  277  kJ
SAVE solution 4
END
TITLE GS-11
```

```
SOLUTION 5  GS-11 Water
units   ppm
TEMP    11.75
pH      6.19
pe      7.28
Ca      328
Mg      73.8
Na      98.6
K       23.4
Fe      0.049
Mn      23.2
Si      20.4
Alkalinity      87.8 as HCO3
Cl      67.76
S(6)    1475
F       0.742
Al      0.0511
As      0.00203
B       4.86
Ba      0.0136
Be      0.000961
Cd      0.455
Co      0.0314
Cu      31.72
Li      0.167
Mo      0.00154
Ni      0.0274
Pb      0.212
Se      0.00182
Sr      2.724
U       0.0302
Zn      126.757
Br      0.266
PHASES
GreenrustSO4
        Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
        log_k           21.8
        delta_h   277  kJ
SAVE solution 5
END
TITLE MF-10
SOLUTION 6  MF-10 Water
units   ppm
TEMP    16.29
pH      4.9
pe      8.58
Ca      164
Mg      32.3
Na      23.9
K       14
Fe      19.6
Mn      7.79
Si      23.4
Alkalinity      54.1 as HCO3
Cl      38.39
S(6)    663
```

```
F        1.74
Al       0.223
Ag       0.00219
As       0.0527
B        0.209
Ba       0.0246
Cd       0.481
Co       0.00975
Cu       6.42
Li       0.0272
Mo       0.00279
Ni       0.00918
Pb       0.014
Se       0.00134
Sr       0.657
U        0.00287
Zn       61.854
PHASES
GreenrustSO4
         Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
         log_k             21.8
         delta_h   277  kJ
SAVE solution 6
END
TITLE AMC-24A
SOLUTION 7  AMC-24A Water
units   ppm
TEMP     12.83
pH       6.37
pe       3.43
Ca       46.1
Mg       13.2
Na       20
K        5.26
Fe       4.96
Mn       0.552
Si       32.3
Alkalinity         71 as HCO3
Cl       25.32
S(6)     108.4
N(5)     5.09
F        0.482
As       0.00598
B        0.0771
Ba       0.026
Li       0.0396
Ni       0.000693
Sr       0.313
Zn       0.0696
Br       0.081
PHASES
GreenrustSO4
         Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
         log_k             21.8
         delta_h   277  kJ
SAVE solution 7
```

```
END
TITLE AMW-13A
SOLUTION 8  AMW-13A Water
units   ppm
TEMP    12.1
pH      6.47
pe      2.45
Ca      388
Mg      68.5
Na      46.6
K       41.8
Fe      46.6
Mn      1.36
Si      21.3
Alkalinity      662.5 as HCO3
Cl      22.26
S(6)    934.7
F       0.285
As      0.00659
B       1.606
Ba      0.0385
Cd      0.000582
Co      0.00108
Cu      0.00365
Li      0.0769
Mo      0.00186
Sr      3.205
Zn      0.19
PHASES
GreenrustSO4
        Fe6(OH)12(SO4) + 12H+ = 4Fe+2 + 2Fe+3 + 12H2O + SO4-2
        log_k           21.8
        delta_h   277  kJ
SAVE solution 8
END
```

APPENDIX F MBMG RESPONSE TO EPA COMMENTS

Response to EPA's Technical Review Comments
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The Montana Bureau of Mines and Geology (MBMG) response is in two sections; first we respond to the Environmental Protection Agency's (EPA's) general comments then we provide a line-item response to EPA's 64 specific comments. Prior to each response, we quote EPA's comment for context.

1.0 General Comments

Environmental Protection Agency (EPA): general comments

"The document is based on data collected 2 years ago (April 2010), including groundwater data from a nested well set that was improperly installed (GS-08/GS-09/GS-11). Much of the report focuses on the attenuation mechanism(s) downgradient of the Parrot tailings area. The findings, such as the conclusion that the main attenuation mechanism is adsorption, do not consider all available data and may not be supported by the existing information. The current attenuation/geochemical testing investigation being conducted by the Atlantic Richfield Company (AR) is designed to address significant data gaps related to the attenuation processes taking place within the aquifer. Drawing conclusions on very little information when a large dataset designed to answer these very questions is months away could result in incomplete or misleading information.

Because the well set referenced above was improperly installed, any references to well triplet GS-08/GS-09/GS-11 should be removed, or, if used, should be properly qualified. The lithologic logs for these wells lack detail in the critical depths near the middle gravel and the geology that was reported does not correlate well with other wells in the area. The nearby MSD-05 has a significantly better log. The well construction in GS-08 and GS-09 (and other "GS" wells below 15) is substandard with continuous gravel pack making cross-connection between water-bearing zones possible. The well construction at MSD-05 is better. This report should use MSD-05 for data presentation and discussions because of the questionable nature of GS-08/GS-09/GS-11. Additionally, these three wells have recently been replaced by Montana Bureau of Mines and Geology (MBMG), indicating, we believe, that MBMG recognized the substandard quality of these wells.

In general, the report at times draws conclusions based on incomplete or unsupported arguments, using a selective set of the available data without explaining why other data were not considered in the analysis."

MBMG Response to EPA General Comments

The EPA suggests numerous times that the authors selectively reported data, did not consider all available data, used the wrong data, and only used data that supports their conclusions. In actuality, the authors considered all data available as of 10/01/2010 which was the cut-off date for inclusion. To address some of the data-usage questions the authors have in some instances modified the report to clarify why some data were or were not used; in other cases the authors address data usage here.

The authors anticipate the results of the geochemical attenuation studies being performed by AR but we are confident that our assessment that adsorption onto MA sediments, and to a lesser degree dilution, are the most important attenuation mechanisms for the contaminants of concern (COC's). The authors disagree with EPA that our assessment is "incomplete or unsupported". Furthermore, we believe that lithologic data obtained during the 2011/2012 anoxic drilling program will confirm our hypothesis that attenuation of dissolved Fe in the MA Parrot Plume results from 'green rust' formation.

We strongly disagree with EPA's suggestion that wells GS-08, -09, and -11 are compromised and it is a mischaracterization of MBMG's lengthy and documented discussion with EPA regarding these wells for EPA to state that, *"…indicating, we believe, that MBMG recognized the substandard quality of these wells"*. MBMG verbally disagreed with EPA officials on this issue during construction meetings held in April and May 2011 and further documented its position in an email (dated 4/14/2011) sent by Ted Duaime (dated 4/14/11) to EPA and DEQ. EPA argues that the wells were improperly installed, noting that pea gravel was used from 3' – to 54' below ground surface. While the construction at GS-09 is not to the normally accepted methods for new monitoring wells, EPA fails to acknowledge 4-foot bentonite seal placed above the sand pack and screened interval that separates the pea gravel from the well completion. EPA also fails to recognize that an aquifer test performed at the GS-08, -09, and -11 site (Multi-Tech, 1987) did not demonstrate any hydrogeologic connection between these nested wells. A comparison of groundwater chemistry between well GS-09 (MA unit) and nearby well MSD-05 (MA unit) show similar analyte concentrations, indicating that water quality at GS-09 is not being impacted by water from the SA or DA units. For these reasons, we disagree with EPA about the consequence of the 'non-standard' completion at GS-09 relative to the present discussion. Well GS-09 is the only MA site down gradient of the Parrot Tailings that has a historic pre-1990's water-quality record, and the authors believe that it would be irresponsible not to consider data from GS-09.

Some EPA comments (21, 22, 28, 40, 48 51, and 62) appear to be inconsistent with previously held EPA positions. For example, EPA has often argued that aquifer material that has hosted contaminated groundwater plumes may well serve as secondary contamination sources, and that contaminants sorbed onto these aquifer materials can and will desorb for centuries (EPA, 2006). EPA has consistently used this argument as reasons to leave primary sources in place (Parrot, Diggings East, and Northside Tailings). When presented with data in this report that indicates groundwater COC concentrations resulting from the desorption process may decrease to acceptable concentrations faster than originally assumed, EPA's now suggests that groundwater flow paths have changed as a result of water management practices. The authors agree that flow paths have most likely changed during the past 30 years. However, a specific monitoring well within a 'contaminated' aquifer cannot change locations and water must still flow through that contaminated aquifer to reach that specific well.

2.0 MBMG Response to EPA's Specific Comments

EPA comment 1: (Pg. 3. Section 1.0): The characterization of data collection for this report as "a comprehensive groundwater/surface water monitoring investigation" is overstated. It is more accurately characterized as a single synoptic groundwater sampling event for most monitoring wells east of Montana Street and a single synoptic surface water sampling event from Harrison Avenue to Montana Street with analysis for an extended suite of analytes.

> **MBMG Response:** The language throughout the document has been changed to reflect the synoptic nature of the investigation.

EPA Comment 2: The stated objective of this document is "to determine if geochemical signatures (fingerprints) were identifiable and could be used to track individual contaminant plumes in the Silver Bow Creek/Metro Storm Drain (MSD) corridor." The only place in the document that this single stated objective was addressed was a single paragraph in Section 3.2.3 on page 17. Instead, the document presents and discusses broad information on the metals plume outside the stated objective. The document should either make an effort to meet the single objective by presenting and discussing fingerprinting data and remove other analysis or re-state its objectives to more clearly indicate what is intended.

> **MBMG Response:** The objective of this work was to link contaminated groundwater at different depths in the alluvial aquifer to the various contaminate sources in the Upper Silver Bow Creek/Metro Storm Drain (SBC/MSD) corridor. The language in the document has been modified to more clearly state the objective.

EPA Comment 3: (Pg. 4, Section 1.2, and Section 3.2.3.2): EPA does not think all factors regarding this event were included in this analysis. A discharge into upper MSD of the magnitude described in these sections of the report into a losing stream would create a groundwater divide. The groundwater flow direction would be away from this divide. Once the discharge ceased, the divide would dissipate and a significant change in flow direction would occur. Specifically for wells south and southeast of the upper MSD channel including AMC-12 and GS-44S/D, the change in flow vectors would change the source of water flowing to the wells. Currently, the water flowing toward these wells is from the east or upgradient of major source areas. While the mine discharge into MSD was occurring, the local flow direction would be away from the channel and possibly toward these wells. In summary, the trends seen in these wells are not exclusively due to a change in source loading, but more likely due to a change in groundwater flow directions.

> **MBMG Response:** The authors agree with EPA's assessment regarding the groundwater divide. The primary source of contamination to the area south of the Parrot Tailings was the mine discharge to Silver Bow Creek, which ceased in 1982. Since that time, desorption from aquifer materials has been dominant contaminant source south of the Parrot Tailings; changes in groundwater flow direction will have little impact on desorption from the aquifer material.

EPA Comment 4: (Pg. 4, Section 2, last sentence): This sentence fails to recognize the many secondary sources of contamination within the aquifer.

> **MBMG Response**: The sentence has been modified from "source" to "primary source"

EPA Comment 5: (Pg. 6, Section 1.4): The statement that groundwater in the shallow alluvium in the MSD corridor discharges to MSD and Blacktail Creek needs clarification. Clearly, shallow groundwater along and close to the MSD subdrain discharges to the subdrain. The extent of the capture zone has not been defined. The source of groundwater discharging to Blacktail Creek should be a subject of the fingerprinting analysis and should not be presumed in the introductory section of the report. Unfortunately, no actual fingerprinting analysis was presented.

> **MBMG Response:** It is clear from potentiometric surface maps that shallow groundwater discharges to the MSD and Blacktail Creek. The groundwater divide in the shallow aquifer between these groundwater discharge receptors could be delineated by a capture zone analysis, which was not performed for this report. It is not possible to clarify the statement further because the capture zones have not been defined.

EPA Comment 6: Figure 2 does not demonstrate that the surface aquifer (SA) groundwater flows to Blacktail Creek.

> **MBMG Response:** Figure 2 has been modified to show an approximate groundwater divide. The divide is represented by a dashed line to demonstrate that no one has performed a capture zone analysis on the MSD and that the zone's precise boundary has yet to be defined.

EPA Comments 7: (Pg. l0, Section 1.4.3, second paragraph): What evidence is there for contaminant loading into the deep alluvial (DA) aquifer? The last four analyses from GS-50, which was completed to 268 feet, (collected in 1997) have copper and zinc ranges of 2-4 micrograms per liter (ug/L) and 39-89 ug/L, respectively. In contrast, the data collected in the 1989-90 timeframe had ranges of 4-13 ug/L and 211-799 ug/L, for copper and zinc, respectively. However, it is safe to say that well AMC-5 (bottom of screen at 87 feet) has been significantly impacted, with recent (June 2010) copper and zinc concentrations of 10,000 and 43,000 ug/L for copper and zinc, respectively. Deep wells GS-07 (160 feet) and GS-010A (no feet) cannot be relied upon as they were among the improperly-installed wells from the 1980s (all GS wells below GS-15 were improperly installed). Given the conflicting data from the one properly installed deep well, making a statement that the Parrot is loading to the DA without the proper qualifications, assumptions, and discussion is potentially misleading.

> **MBMG Response:** Wells AMW-01B, MSD-01B, GS-08, and AMC-24C are all down gradient of the Parrot Tailings and all show elevated COC concentrations. Well GS-50 is most likely not downgradient of the Parrot Tailings plume, and COC concentrations in water from GS-50 are very similar to concentrations in water from nearby bedrock Well F, and should not be used as a counter-argument. Well AMC-05 is a part of the Berkeley Pit drainage and is irrelevant to this discussion.

EPA Comment 8: (Pg. 6-II, Section 1.4, and Table 1): The definition of the three aquifer zones is applicable to a limited area from the Parrot tailings to the MSD-05/GS-09 area. Extrapolation beyond this area requires further interpretation and explanation. Important to this report is the area downgradient of MSD-05/GS-09 and extension of the middle gravel monitored by MSD-05, MSD-03, etc. This layer is less distinct west of MSD-05/GS-09, but, assuming that it is continuous, it would be encountered at the screened depths in wells BPS07-24, AMW 24C, AMC-13C, and BPS07-21C. Although not included in this report, drilling in 2011-12 confirmed these findings. For this layer to be encountered above these depths would require the water that deposited these sediments to flow uphill, or significant structural uplift at this location since deposition, which presumably is Pleistocene or Holocene. Placement of three of these wells in the deeper alluvium is incorrect based on our current understanding of the stratigraphy and aforementioned physical constraints. Given that further investigation has been conducted in this area, the new data should be evaluated before extrapolating the stratigraphic units beyond MSD-05/GS-09. A more appropriate definition of the middle aquifer west of MSD-05 would be that it fingers out to multiple transmissive layers and becomes less distinct.

> **MBMG Response:** The authors have not attempted to define the stratigraphy west of well GS-09 in this report. However, the well log for MSD-05 shows the top of the MA gravel layer at an elevation of 5,402 feet above mean sea level; the bottom of this gravel unit is unknown at this location. The well log for AMC-24C (presents a better lithologic description than that of AMC-24B), describes sand and gravel starting at an elevation of 5,410 feet. While the logfor AMC-24C does place the downgradient MA sand and gravel higher in elevation, eight feet does not represent "significant structural uplift". We do not necessarily disagree with EPA's interpretation and state throughout the document that the stratigraphic correlations become less certain to the west as represented by dashed red lines in figure 5. To address this comment, figure 5 has been further modified.

EPA Comment 9: (Pg. 13, first paragraph): Where are the Eh-pH diagrams referred to? Why discuss if they are not included?

> **MBMG Response:** A few reviewers suggested that Eh-pH diagrams would be useful but in attempting to use them the authors found that the system could not be adequately visualized using this tool. However, that the tool was considered, found not useful, and then discarded is pertinent.

EPA Comment 10: (Pg. 13, second paragraph): Well GS-9 was improperly installed and the data are suspect. All of the analysis that relies on this well or any of the other improperly installed wells should be removed or properly qualified.

> **MBMG Response:** We address the propriety of using data from well GS-09 in the third paragraph of the general comments above.

EPA Comment 11: (Pg. 13, last paragraph): Evaluation of the iron system requires an accurate Eh value. Often, the Eh measured using a platinum electrode is a mixed potential resulting from multiple redox couples. An evaluation should be made of the Eh equilibrium (or disequilibrium) of the system by calculating the Eh resulting from each of the known redox couples and comparing to the Eh measured using the platinum electrode.

> **MBMG Response:** The authors agree. MBMG did not evaluate speciation of the known redox couples. However, redox couple speciation was evaluated in later sampling performed by AR. It is unfortunate that the AR speciation data are not yet released.

EPA Comment 12: (Pg. 13, last paragraph): The variety of sulfate green rust presented is one of many possible stoichiometries each of which has different thermodynamic data. A sampling of thermodynamic data is presented in the table below. (The table containing 12 green rust formulas has been deleted to save space; we will provide this table upon request)

> **MBMG Response:** The authors suggest that sulfate green rust minerals are likely to be the most dominant in this system because sulfate is the system's dominant anion.

EPA Comment 13: (Pg. 14, first paragraph): The use of free energy data (as opposed to direct solubility data) requires the use of a consistent set of G_f values that agree with those used in the specific literature source in which the free energy for the green rust phase was obtained.

> **MBMG Response:** Free energy data were used in the modeling because that is the input data required for the model. Geochemical models of this type do not utilize direct solubility data. The free energies of formation from Bard et al (1985) for iron and sulfate were used by Genin et al (1998) and the MINTEQ database and are therefore internally consistent.

EPA Comment 14: (Pg. 14, Section 3.1 first sentence): Change "figure 3" to "figure 4."

> **MBMG Response:** This change has been made.

EPA Comment 15: (Pg. 17, Section 3.2.3, second paragraph, last sentence) The wells south of the Parrot tailings are currently outside a direct flow path through the Parrot tailings, but this does not mean that the current flow regime was in place historically. During active release of water into the Clear Water ditch, a local groundwater mound would have been in place that would have resulted in flow from the Parrot to the south through wells AMC-12. U.S. Geological Survey (USGS) flow data suggest that water was present in this ditch long after 1982 (see comment #51 for reference).

> **MBMG Response:** We agree. The groundwater mound referred to by comment 15 would have resulted in a groundwater divide. The vast majority of the Parrot Tailings source material would have been to the north of this divide and the divide would have prevented Parrot Tailings groundwater from moving south. This is exactly the point made in the report's text. EPA is correct that surface water was present in the upper SBC channel after MR's mining operations went to a zero discharge. This surface water was a combination of water discharged through the Clear Water Ditch system and storm drains along Continental Drive.

EPA Comment 16: (Pg. 17, Section 3.2.3, third paragraph, second sentence): The statement that “The most significant source of contamination impacting the SA is the Parrot Tailings” is not true of the entire unit, only the area in the vicinity of the Parrot tailings. The main source of contamination in the GS-11 area is undoubtedly the Diggings East tailings as presented in the 2004 EPA Focused Feasibility Study (FFS).

> **MBMG Response:** The COC concentrations observed in groundwater in well GS-11 are orders of magnitude lower than COC concentrations in groundwater observed in GS-41S (Parrot Tailings area). The report acknowledges the contamination to the SA in the Diggings East area. The Parrot Tailings is the most significant source of SA contamination based on the volume of in-place source material and concentrations in SA groundwater.

EPA Comment 17: (Pg. 18, Figure 5): The first three bullets on page 7 make a case that the uppermost and middle gravels are connected in the Parrot tailings area; however, Figure 5 shows a thick confining unit between these permeable units in the same area. These are conflicting characterizations that need to be resolved.

> **MBMG Response:** Figure 5 has been modified to show connection. All suggested recommendations provided in this comment have been accepted.

EPA Comment 18: (Pg. 20, third paragraph): The interpretation of the zinc data is influenced by differential attenuation (copper adsorbs more readily than zinc) and the presence of isolated slag deposits, which contain a higher fraction of zinc than the tailings. Slag has been noted in the boring logs for several wells and an isolated deposit between AMW-1B and AMW-02B is possible.

> **MBMG Response:** The authors are unfamiliar with well AMW-02B and assume the commenter is referring to well MSD-02B. This comment demonstrates a lack of understanding of the hydrogeologic environment between AMW-1B and MSD-02B. It is impossible for contamination from near-surface sources (slag) to enter the MA unit in this area because there is an upward vertical gradient that supports groundwater flow from the MA to the SA.

EPA Comment 19: (Pg. 20, fourth paragraph): Sulfate cannot always be considered conservative, as stated here, especially in this case where sulfate rich waters are flowing into aquifer materials containing calcite (based on AR fizz testing) and/or mixing with high calcium groundwaters. The reaction between acidic sulfate-bearing water and calcite within the aquifer would be as follows: 2 (aq) + FI~(aq) + CaCO3 (s) + 2H20 = Ca504 2HaO (s) + HCO3 (aq) Unless gypsum can be shown to be undersaturated, the assumption of sulfate as a conservative parameter is not valid. In addition, if sulfate-green rust is forming, as suggested later in the document, then sulfate cannot be considered conservative.

> **MBMG Response:** No dissolved element or compound is totally conservative and the text was modified to make this clear. However, the formation of significant amounts of gypsum is unlikely because the changes in Lithium and SO_4 concentrations down downgradient from the Parrot area were similar. If large quantities of gypsum were forming in the aquifer, SO_4 concentrations should decrease to a much greater extent than do Lithium concentrations.

EPA Comment 20: (Pg. 26, Section 3.2.3.1, last sentence): As mentioned in a previous comment, the elevated copper and zinc south of the Parrot is likely due to mounding caused by discharge of water into the Clear Water Ditch, which would have produced some flow lines from the Parrot tailings to the south and east.

> **MBMG Response:** The vast majority of the Parrot Tailings source material is to the west of the Clear Water Ditch and north of the SBC channel. The resulting mound would have acted as a groundwater divide, hydraulically separating the Parrot source material from the alluvial aquifer south of the Parrot Tailings area.

EPA Comment 21: (Pg. 26, Section 3.2.3.2): The discussion of temporal trends should be clearly divided into SA and MA wells (i.e., separate subsections). The temporal trends are often erratic, moving in a zig-zag pattern, or go up for a while and then down, etc. Such behavior suggests that the changes in chemistry are due to changes in the flow regime as opposed to changes in the source loading.

The trend observed for GS-41S appears to correlate with changes in water management described in the 2010 groundwater data analysis report (U.S. Environmental Protection Agency [EPA] 2012). Two events occurred in 2003: Montana Resources resumed operations and began filling the Ecology Ponds; and dewatering for MSD construction started. As EPA showed in water level graphs in 2012, these operational changes affected water levels in the vicinity of the Parrot tailings by lowering the water table. This change is expected to affect the direction of groundwater flow around the MSD subdrain and Ecology Ponds. Based on the concentration chart for GS-41S on Plate i, metals concentrations changed from 2003 to 2005, and then remained somewhat stable since that time with the exception of a single sampling event in 2009. This pattern is more clearly shown in EPA 2012 where more data were presented. The concentration chart for GS-41D shows a similar pattern except that the increases occurred from 2003 to 2008 before leveling off. Since this is a deeper well, it is expected that changes in flow would manifest slower. While this section does not present a cause of the observed trends, it fails to list other trends in the vicinity of the Parrot tailings. For example, metals concentrations in GS-42S are lower in the 2006 to 2010 data than in the 1997 quarterly data. No data were collected between these periods. This reduction in metals concentrations does not indicate a worsening of water quality and cannot easily be explained by evolving geochemical conditions in the plume. More simply, the direction of groundwater flow around the well has changed because of water management changed made in 2003. This change is manifested as a reduction in metals concentrations from before to after the management change, but no trends in the 2006 to 2010 data are observed that could be attributed to geochemical changes.

> **MBMG Response:** The concentrations of COC’s in wells GS-41 S and D have remained consistently elevated (more than 2x) above their pre-2004 levels. This is not a zig-zag pattern. While we agree with EPA that these concentration changes are most likely the result of changes in water management, the authors do not agree that it is only a matter of changed flow direction. The concentration increases observed in MA Well GS-09, the only frequently monitored MA well downgradient of the Parrot Tailings, would suggest that these changes are observed in the plume as a whole, and not be simply a result of

changes in flow regime. Well GS-42 was not monitored during the period where changes in the plume were observed, and has too short of a record to depict any kind of observable trend.

EPA Comment 22: (Pg. 26, Section 3.2.3.2): The zinc concentrations in AMC-12 do not show a trend from 1982 to 1995. There are considerable fluctuations in the concentrations, but no clear trend is evident. A downward trend is observable from 1995 to 2010. Copper is similar with considerable fluctuations in the early data. GS-44D no longer shows a trend from 2007 to 2010. This section fails to present data from GS-44S which shows a decreasing trend in metals concentrations from 1990 to 2004, then an increasing trend in metals concentrations since 2004. This cannot be explained by a change in source loading to MSD in 1982. These trends are more easily explained by changes in water management in 2003 causing a change in the directions of groundwater flow.

MBMG Response: The authors do not agree that decreasing concentration trends that have been observed since the 1990's (AMC-06, AMC-12, and GS-44D) can be correlated to a change in water management in 2003.

Well GS-44S was not used in the temporal trend analysis because prior to 2008 its well-head was a flush-mount vault at land surface in a topographically low area. The well was often covered by thick sheets of ice in the winter and spring months, and obvious surface-water infiltration occurred during snow melt and precipitation events. Observation of unreasonable field parameters during water-quality sampling (specific conductance = 100 us/cm) prior to 2008 supported the conclusion that the well was often contaminated (diluted) by precipitation and meltwater. This was not the case for Well GS-44D, because the well was always protected by a surface mounted steel container which housed a water-level recorder. To prevent surface water infiltration, a protective outer casing which extended two-feet above ground surface was added to GS-44S in October-2008,.This explanation has been added in the body of the report.

EPA Comment 23: (Pg. 26, Section 1.2.1.2, last paragraph): Again, the trends noted here are likely due to changes in flow regime over time.

MBMG Response: We are aware of no documentation to support this claim.

EPA Comment 24: (Pages 26 and 31, Section 3.2.3.2): This section presents data for copper and zinc in ground water and declares that certain trends are present. Identifying trends appears to rely on the charts presented on Plate I. This method may be adequate for a general discussion of water quality, but this document relies on the existence of these trends in the more detailed discussion in Section 4.2.2. In order to rely on these trends for further discussion, a trend analysis should be conducted to determine if any statistically significant trends exist.

The first step in the trend analysis is to select appropriate data. For wells possibly influenced by the MSD subdrain, data should be separated into groups prior to and after installation of the subdrain in 2003-2004. This activity changed the hydrologic conditions and induced a change in ground water conditions and these conditions need to be analyzed separately. For the area east and south of the Parrot tailings, the MSD subdrain may not have significantly influenced this area, but the change in water management in 1982 likely would have. Therefore, analysis of wells in this area should be limited to data collected after 1982.

The Mann-Kendall test is used to determine if a trend exists and its direction. The program MAROS (AFCEE 2003 htto://www.gsi-net.com/en/software/free software/maros.html) was used to run the test and the outputs are attached. Possible outcomes of the test include no trend, stable, probably increasing, probably decreasing, increasing, and decreasing.

For the purposes of this review, selected wells were subjected to the Mann Kendall Test. For wells in the Parrot tailings, GS-41S, GS-41D, GS42S, and GS42D were selected and cadmium, copper, and zinc data collected since 2004 were subjected to the test. The cadmium data indicated either no trend or stable in all four wells. The copper data indicated no trend in three wells and increasing in GS-41D. The zinc data indicated no trend or stable in all four wells. Therefore, for wells in the Parrot tailings, the only trend detected was an increasing trend in copper in well GS-41D.

Wells in the middle gravel downgradient from the Parrot tailings were also subjected to the Mann-Kendal test. Data since 2004 was used from wells AMW-01B, MSD-01B, MSD 02B, MSD-03, MSD-04, MSD-05, GS-09, and two wells potentially at the edge of the plume AMC-24B and AMC-24C. The results of the test are attached. For cadmium, three wells showed a decreasing trend (AMW-01B, MSD-01B, and AMC-24B) and one was probably decreasing (MSD-04). The remaining wells showed no trend or stable. No wells were increasing or probably increasing for cadmium. For copper, two wells were decreasing (MSD-01B and MSD-02B) and one was probably decreasing (AMC-24B). The rest were 8 stable or had no trend. For zinc, two wells were decreasing (MSD-01 and AMC-24B) and one was probably decreasing (GS-09). The rest were stable or had no trend. Overall for wells in the middle gravel, none had increasing or probably increasing trends for cadmium, copper and zinc, but several had decreasing or probably decreasing trends.

Shallow wells in the Digging East area include MF-10 and GS-11. GS-11 is suspect due to the adjacent wells being improperly constructed. Both of these wells are expected to be affected by installation of the MSD subdrain, so data after 2003 are used. Based on the Mann-Kendall test, MF-10 shows no trend for cadmium and copper and an increasing trend for zinc. No trend is the result due to low confidence in the trend due to highly variable concentrations. Section 3.2.2 indicates that concentrations have increased and the data show this increase, but further monitoring is needed to identify a trend. GS-u does show an increasing trend.

Wells east and south of the Parrot tailings were subjected to the Mann-Kendal test using data since 1983. Since no ground water data are available prior to 1983, this represents all available data. Wells included AMC-06, AMC-12, AMC-13, AMW-09 (although only one recent sample has been collected), BMF-05-01, GS-44DR, GS-445, GS-46D, and GS-46S. Most of these wells showed a decreasing trend for cadmium, copper and zinc confirming the presentation in Section 3.2.2. However, these need to be parsed more to draw conclusions. AMW-09 does not show a trend although this well is very near upper MSD and should have responded to ceasing of discharge in 1982. GS-44S shows a clear change around 2004. Using data prior to 2004, deep well GS-44DA shows a stable trend for cadmium, copper, and zinc while shallow well GS-44S shows a decreasing trend. Using data after 2003, deep well GS-44DR shows a decreasing trend for cadmium and zinc and a stable trend for copper while shallow wells GS-44S shows and increasing trend for all three metals. The timing of the change in trend in the shallow well suggests that this installation of the MSD subdrain may have influenced this well. Overall, the document discusses trends without conducting a trend analysis and the results of the trend analysis conducted for this review found some of the discussions are unsupported by a trend analysis.

> **MBMG Response:** All language discussing trend analysis has been removed from the report. The authors believe that it is appropriate to note where concentrations have increased or decreased over time, and we have done so in the report with no attempt to determine the cause for the increases or decreases.
>
> We are unfamiliar with historical data from GS-44DA. Our records indicate that GS-44DA was abandoned shortly after it was drilled and we have no water-quality data for that well. The concentrations of Cu and Zn in GS-44DR from 1989 to 2004 decrease by factors of roughly 3 to 4. It is unclear how the EPA's analysis suggests this is a stable trend.
>
> When using trend analysis, it is important to consider the quantity and distribution of the data. For instance, well AMW-09 has been monitored twice since it was drilled, and should not even be included in a statistical trend analysis discussion. The inappropriateness of using well GS-44S data has already been discussed. The data distribution and lack of monitoring between 1990 and 2000 greatly aids the EPA in the argument above. Concentrations in samples from GS-44D prior to 2005 were consistently elevated above the DEQ-7 drinking water standard, and have consistently remained below the standard since 2005. Furthermore, concentrations have decreased since monitoring started and continue to decrease. The largest decreases in GS-44D occurred prior to the year 2000 where Cu concentrations decreased from 4,500 ug/L to less than 2,000 ug/L and Zn concentrations decreased from 25,000 ug/L to less than 10,000 ug/L. We do not believe the installation of the MSD Subdrain greatly impacted wells AMC-06, AMC-12, or GS-44D.

EPA Comment 25: (Pg.31, Section 3.2.3.2): GS-09 was sampled six times from 1985 to 1990 and the metals data showed considerable fluctuation. Sampling from 2004 to 2010 also shows fluctuation with the highest metals concentrations in 2004 and the lowest in 2007. A trend in the metals concentration data since 2004 is not evident at GS-09. The difference between the 1980s data and the post-2003 data is most likely due to the installation of MSD subdrain beginning in 2003. Although the hydraulic connection between GS-09 and the MSD is not clear, the timing of the change in concentrations coincides with the change in water management causing changes in the direction of groundwater flow in the area.

> **MBMG Response:** While there is some degree of fluctuation, there is a clear and consistent metals concentration increase across the entire period of record for well GS-09. The comment above seems to agree with this assessment.

EPA Comment 26: Well MF-10 is relatively close to the MSD subdrain and is expected to be influenced by its operation. Based on water level data contained in GWIC, Well MF-10 showed a clear response to installation of the MSD subdrain with a 2-foot drop in the water table between August and September 2003. This water management modification is expected to result in a change in water quality following an adjustment in the direction of groundwater flow and possibly by exposing more tailings or mixed waste to air. The current upward trend in metals concentrations should be continually monitored. It is expected that the metals concentrations will stabilize if no further water management modifications are made. Diggings East shallow well GS-11 (which, as noted above, was improperly installed) also shows upward trends in metals concentrations following installation of the MSD subdrain. The most recent data suggest that the trend may be tapering off.

> **MBMG Response:** The authors have presented no assessment regarding causes for COC concentration increases in MF-10. Furthermore, the lack of consistent water-quality monitoring prior to 2004 makes it impossible to determine the subdrain's impact on the shallow groundwater system. COC concentrations in wells AMC-23 and AMC-24 have consistently decreased since monitoring began in the 1980's, which doesn't support EPA's assessment that the MSD subdrain is causing all the COC concentration decreases in this area. Also, water-levels in wells AMC-23, AMC-24, and MF-10 were impacted by the installation of the MSD-Subdrain, but at that time there was not a corresponding change in water quality.

EPA Comments 27: (Pg.31, first paragraph): If the observed decrease in aqueous copper and zinc concentrations in AMC-12 is due to desorption of copper and zinc from the aquifer (which is far from certain), then the decrease in concentrations would not "continue on the same downward trend." Numerous pump-and-treat investigations at Superfund sites have shown that cleanup times are not linear, as suggested in the first sentence, but instead reach a point of diminishing returns in which concentrations form a long "tail" as maximum contaminant levels (MCLs) are approached.

In the early 1990's various researchers began to evaluate the effectiveness of pump-and treat systems in restoring groundwater quality to drinking water standards (MCLs). The first study was by Doty and Travis (C.B. Doty and C.C. Travis, 1991, Oak Ridge National Laboratory, ORNL/TM-11866). Doty and Travis evaluated the results from i6 sites. Soon after this, EPA also performed an evaluation on 24 sites (EPA, 1992, Evaluation of Ground-water Extraction Remedies: Phase II, Publications 9355.4-05 and 9355.4-05A). Other evaluations followed, including API (13 sites), Air Force (10 sites), California RWQCB (45 sites), and the NRC/NAS (75 sites). The NRC/NAS study (Alternatives for Ground Water Cleanup, 1994, National Academy of Sciences) provided the most definitive study. All studies showed that during pump-and-treat remediation:

- Concentrations in groundwater decrease rapidly but leveled off ("tailing"). In most cases, the leveling off was above MCLs.

- Some reports concluded that aquifer restoration to MCLs is not technically feasible. The NRC/NAS report provided a table (table 3-2, pg 85) titled the “Relative Ease of Cleaning Up of Contaminated Aquifers as a Function of Contaminant Chemistry and Hydrogeology.” This table indicates that sites with heterogeneous and multiple layers with strongly sorbed contaminants rate a score (on a scale of 1 - 4 from easiest to most difficult to clean up). These conditions are similar to the MSD aquifer.

Because of the difficulty in restoring aquifers to MCLs by pump-and-treat methods, the percentage of National Priorities List records of decision selecting pump-and-treat 10 dropped from over 90 percent in 1986 to 30 percent in 1999 (EPA, 2003, Report No. 2003- P-000006). EPA reviewed 30 percent of the Superfund financed pump-and-treat systems and concluded that 65 percent of these sites should consider alternate technologies to replace pump-and-treat (Office of Inspector General/EPA, Memorandum Report, Improving Nationwide Effectiveness of Pump-and—Treat Remedies Requires Sustained and Focused Action to Realize Benefits, March 27, 2003, Report No. 2003-P-000006). The use of pump-and-treat (and other forms of groundwater capture) is an excellent control on plume migration but is generally not effective in cleaning up an aquifer to the point of meeting standards such as MCLs.

Some of the reasons given for the limited success of pump-and-treat remediation include the following:

- Heterogeneous aquifers with low permeability zones. Pumping causes preferential flow in areas of higher permeability. Tailing results from the slow diffusion of contaminants from the low permeability zones into the preferential flow paths.
- Slow desorption kinetics. A portion of the contaminant is released very slowly resulting in a tailing effect.
- Zones of immobile water exist within the soil grains (e.g., in micropores or fractures). In such cases, contaminant release is controlled by the slow diffusion from the immobile to the mobile zone.
- Some portion of the chemical is adsorbed more strongly or has become more resistant to desorption with time.
- Difficult to achieve 100 percent source removal. Missed source material can act as a continuous source that would greatly increase the predicted aquifer cleanup time.

The MSD aquifer has been evaluated in terms of the problematic conditions stated above in the following sections.

Heterogeneous Aquifers with Low Permeability Zones

The aquifer in the vicinity of the Parrot tailings and the MSD has been repeatedly described as heterogeneous in reports produced by a number of entities including MBMG. The presence of numerous clay/silt units is also well established and characteristic of the aquifer as a whole. The results of the column tests conducted by MBMG in 2004 showed the typically observed tailing effect indicating control of concentrations by diffusion from lower permeable materials.

Slow desorption kinetics

The results of the 2004 column test on the CCE boring materials suggests that the diffusion or desorption kinetics from the iron oxide coated sand were quite slow. In fact, after about 38 pore volumes had been passed through the column, cadmium concentrations were still above the WQB-7 criteria of 5 ug/[. and the trend was leveling off (i.e., tailing). The figure below shows the data for column CCE for the first i8 pore volumes along with the projected cleanup time to reach the MCL of 5 ug/L Cd of 83 pore volumes.

Zones of Immobile Water Exist Within the Soil Grains.
The Parrot tailings have been in place for approximately 100 years, allowing contaminated water to penetrate deeply into the lithology of the underlying aquifer. Even the most tortuous flow paths could have been penetrated over such a long period of time. To suggest that the contaminated water could be flushed out quickly should the Parrot tailings be removed is overly optimistic. Without direct contact flushing, the contamination in the immobile water zones will only be removed by slow diffusion processes.

Why Metals are More Difficult to Clean Up
Most of the above studies evaluated aquifers with organic contamination. Typically the organic chemicals (especially volatile organic compounds) are uncharged species that are very mobile in groundwater (little retardation). A few of the evaluated aquifers did have 12 metals, but these were typically chromium and arsenic. Chromium (chromium VI) and arsenic usually exist as anions or uncharged species in the groundwater and are, therefore, relatively mobile. In contrast, cadmium, zinc, and copper usually exist as cations in the groundwater. Because of this, they adsorb to aquifer materials and are more highly attenuated (especially copper). As a result, aquifers contaminated with such base metals are even more difficult to clean up than aquifers contaminated with volatile organic compounds, chromium, or arsenic.

MBMG Response to Comment 27:

1) This lengthy comment seems to contradict itself. The EPA argues that the aquifer is heterogeneous in nature, and then references site-specific case studies from various other organic contaminant sites as evidence of support. If the aquifer is truly heterogeneous as the EPA argues, then only case studies specific to BPSOU should apply (Metesh and Madison, 2004).
2) We are not advocating a pump and treat system. One of the reasons pump and treat systems often fail is because the advection from pumping exceeds the desorption rate resulting in low COC concentrations while pumping that increase when pumping stops and advection slows down. In the area south of the Parrot Tailings, natural advection is occurring and COC concentrations are decreasing as a result of desorption and natural advection, which is not analogous to a pump and treat system.
3) If COC's decrease to acceptable concentrations in water from the aquifer, is it relevant to discuss whether the concentrations will ever stabilize? The authors agree that it is unlikely the aquifer will ever be completely 'pristine' and it will continue to desorb metals. However, if the metals concentrations drop below the level of concern, they would no longer be an issue.
4) While it is true that the Parrot Tailings have been in place for more than 100 years, the current flow paths within the aquifer have only been established since 1982. Moreover, recent changes in water management (as described by EPA in this review) most likely changed flow directions yet since. During a period of 100 years, flow paths throughout the aquifer have been changed at least three times as a result of water management

practices. It is a mischaracterization to suggest that the same portions of the aquifer have been subjected to the same point sources for over 100 years. It is inconsistent to argue for consistent flow paths here and then suggest the frequent changes of flow paths in other parts of this review (as the reviewers have in comments 3, 15, 20, 21, 22, 23, 24, 25, and 26).

5) The sorption of anions and cations onto sediments are not only media specific, but also highly pH dependent. To make the generalization that cationic contaminants are more highly attenuated than anions or organics without a thorough review of the characteristics of the aquifer is presumptuous. None of the reports sited by EPA are analogous to the metal contaminated alluvial aquifer in Butte because the sited studies deal with organic or anionic contamination. In fact, the only two site-specific data sets currently available (Metesh and Madison, 2004 and the trend analysis presented in the current report) suggest that the desorption process is much faster than previously assumed in the TI (centuries; EPA, 2006).

EPA Comment 28: (Pg. 31, first paragraph, first sentence): COCs have increased in shallow well MF-10. There is no evidence that concentrations of COCs are increasing within the MA aquifer, as the data from well GS-09 are invalid and inconclusive. This sentence should be modified to say that COC concentrations are increasing in well MF-10, and all reference to GS-09 and the MA needs to be removed or heavily qualified. Again, increases in MF-10 are likely due to changes in flow regime (installation of the MSD subdrain) and not plume expansion. This should be made clear.

> **MBMG Response:** It is most unfortunate that the only MA well completed prior to 2004 and located downgradient of the Parrot Tailings was well GS-09. It is also unfortunate that after 25 years of monitoring the integrity of this well is now called into question. The authors agree that well GS-09 construction is not what would be installed today, but suggest that data collected during aquifer tests and water-quality results show that the well performs as if it had been installed with modern construction techniques. The authors find data from well GS-09 to be valid for the purposes of this study and all references to well GS-09 will remain in the report.

EPA Comment 29: (Pg. 31, Section 3.3): Please provide the input and output files from the PHREEQC modeling runs so that the modeling can be evaluated. In the interpretation of the results, phases that are actively forming tend to be at or very near saturation. Some crystalline minerals formed at high pressures and/or temperatures within the Earth's crust, even if present within the aquifer may not be at saturation due to kinetic inhibitions. Such minerals are often supersaturated, but it does not mean that they will precipitate if given enough time. Minerals can be supersaturated for a variety of reasons, only one of which is kinetic inhibition on precipitation. Some minerals do not precipitate from solution directly. For instance, goethite typically forms from either crystallization of previously formed amorphous ferric oxyhydroxide or from weathering of ferro-magnesian minerals. The jarosite minerals presented in Table 6 are rarely if ever present as pure phase minerals. Most of the time, the actual phase that forms has numerous substitutions, such as aluminum or lead for iron, and arsenate or hydroxide for sulfate (such as with Schwertmannite). This needs to be made clear in the text.

MBMG Response: The input files have been added to the appendices. The output files are voluminous, and will be provided on request.

EPA Comment 30: (Pg. 31, Section 3.3, third sentence): The prediction of Fe3+ as the dominant species in MF-10 is determined by the pe used in the model (as acknowledged in the text). If the Eh is a mixed potential then the iron speciation will be incorrect (see previous comment). A model run should be conducted using alternate means of establishing the pe (i.e. use of the $N0_3/N0_2$ or S/SO_4 couples if available).

MBMG Response: The authors agree but speciation was not performed during the analysis for this project.

EPA Comment 31: (Pg. 31, Section 3.3, first paragraph, last sentence): The fact that green rust was supersaturated is strong evidence that this phase (with the specific stoichiometry used) is not forming. The bench-scale tests showed that the green-colored phase forms readily and there are little or no kinetic inhibitions. Therefore, either green rust is not forming or a green rust with a different stoichiometry is forming downgradient of GS-42S. A full analysis on the solution from one or more of the bench tests and an x-ray diffraction identification of the green rust phase that formed would allow for a specific solubility product constant to be determined (using PHREEQC).

MBMG Response: If green rust is supersaturated it would be evidence that the mineral could be precipitating.

EPA Comment 32: (Pg. 31, Section 3.3, second paragraph, first sentence): The important information within Table 6 is that calcite is at saturation within well AMW-13, indicating that calcite is likely present within the aquifer sediments. This could be an important part of the attenuation mechanism.

MBMG Response: AMW-13 is adjacent to Blacktail Creek and most likely produces groundwater mixed with surface water .However, it is possible that calcite in the aquifer is contributing to acid neutralization.

EPA Comment 33: (Pg. 31, Section 3.3, last paragraph, last full sentence): Ferrihydrite was at saturation (within the standard ±0.5 SI units) for MSD-2A (6.50 mg/L iron on April 19, 2010) and AMW 1B (5.03 mg/L iron on April 22, 2010) according to Table 6. This phase should not be dismissed as unimportant.

MBMG Response: The authors disagree. Ferrihydrite cannot precipitate in an anoxic aquifer regardless of what the modeling suggests.

EPA Comment 34: (Pg. 32, Section 3.3, last paragraph): If the Eh-pH diagrams were not to be included in the report then they should not be discussed.

MBMG Response: A few reviewers suggested that Eh-pH diagrams would be useful but in attempting to use them the authors found that the system could not be adequately visualized with this tool. However, that the tool was considered, found not useful, and then discarded is pertinent.

EPA Comment 35: (Pg. 36, Section 3.4): The observation of a green color is suggestive, but is far from an identification of green rust. Green rust is semi-crystalline to crystalline and can be identified by x-ray diffraction techniques.

> **MBMG Response:** Identification of the green material was beyond the scope of this study but the identification should be a part of AR's geochemical attenuation studies. The authors suggest that review of lithologic samples from the 2011 BPS-UAO drilling investigation and AR's geochemical studies will validate this hypothesis.

EPA Comment 36: (Pg. 37, Section 4.1, first bullet): The Clark tailings are subject to state regulation and control as a solid waste management unit, and are not included currently within the Butte Priority Soils Operable Unit remedial action requirements.

> **MBMG Response:** Noted. This report was a scientific investigation funded by restoration dollars. The authors desired to list all potential sources.

EPA Comment 37: (Pg. 37, Section 4.1, third bullet): On pg. 1, second bullet, you state, " However, determining whether or not the MSD Subdrain captures these SA plumes was beyond the scope of this investigation." If an analysis of MSD capture was not made then to suggest that 'significant contamination" is not being captured is speculation.

> **MBMG Response:** This is not a speculative comment; it is a list of possibilities. If an analysis of MSD capture zone has not been defined, as EPA has previously confirmed, then there are three possibilities for the fate of the plume; although all are listed, none have been singled out.

EPA Comment 38: (Pg. 37, Section 4.2, last sentence): It should be made clear that this increase occurred in wells MF-10 and invalid well GS-11 and that the increase corresponded with the beginning of operation of the MSD subdrain.

> **MBMG Response:** The increase in concentration in well MF-10 does not correspond with the beginning of MSD subdrain operation . Zn concentrations have been increasing since 2007 and a rapid increase in Cu was noted in 2010. We do not believe well GS-11 is an invalid well for the same reasons given for well GS-09 above.

EPA Comment 39: (Pg. 37, Section 4.1): AR and MBMG each have collected additional data in this area in 2011 and these should be considered when discussing the April 2010 data.

> **MBMG Response:** The authors have added text to the document that acknowledges the additional studies since 2010.

EPA Comment 40: (P. 37, Section 4.2, last sentence): The document fails to recognize all trends and seems to select only trends that support the conclusions.

MBMG Response: This statement is false. The authors considered all available data when evaluating for temporal trends. Wells drilled after January 2004 (AMW-01, MSD-01, MSD-02, MSD-03, MSD-04, MSD-05, and the BPS-07 series wells) were of little relevance when determining long-term water quality trends. Many of these sites had only been sampled three times. Other wells (GS-42, GS-45, AMW-09, MF-series wells) were monitored too infrequently to be of use. We have added text to the report to clarify our data usage.

EPA Comment 41: (Pg. 38, Section 4.2.1, first paragraph): Again, if a capture analysis was not performed it is not appropriate to speculate.

MBMG Response: Noted

EPA Comment 42: (Pg. 38, Section 4.2.1): Although not a part of this document, it should be noted that additional wells have recently been installed in this area in part to provide additional data to delineate a capture zone.

MBMG Response: The authors have clarified the text to inform the reader that additional wells have been drilled.

EPA Comment 43: (Pg. 38, Section 4.2.1): Before excavation of the Berkeley Pit, tailings ponds and mine waste were present across the bottom of the former Silver Bow Creek valley for more than 2 miles upstream and upgradient of the Parrot tailings. These are also potential sources that were noted in Section 1.2.

MBMG Response: Noted

EPA Comment 44: (Pg.39, Section 4.2.1, second paragraph, second to last sentence): Again (as noted above), unless gypsum and sulfate green rust can be shown to be undersaturated, sulfate is not conservative.

MBMG Response: See response to EPA Comment 19.

EPA Comment 45: (Pg.39, Section 4.2.1): The last sentence in the first paragraph needs further explanation and qualification. No data have been presented or discussed to show that the portion of the plume in the middle gravel has or ever will reach the water table.

MBMG Response: Section 4.2.1 describes a groundwater discharge area in which a significant upward vertical gradient exists. The authors believe that water in a discharge area with significant upward vertical gradient will move upward towards shallow aquifers and the land surface. .

EPA Comment 46: (Pg. 39, Section 4.2.1): Change “The width of the Parrot tailings plume in the MA is unknown.” to “The width of the Parrot tailings plume in the MA is not precisely known, but is bounded on the south at well MSD-04, which is not contaminated and bounded on the north by bedrock." Additionally, reword the sentence beginning "The dimensions of the plume to the north are unknown to reflect that the northern extent of the plume must be limited by the absence of alluvium. This is not unknown.

> **MBMG Response:** The precise location of the bedrock-alluvial contact to the north is unknown, but it is somewhere north of Front Street. We are not suggesting that the plume extends that far north. We suggest that the plume is relatively narrow and do not see need for further clarification.

EPA Comment 47: (Pg. 40, first full paragraph, last sentence): The statement "Therefore, it seems likely that the contamination increases observed in GS-09 is [sic] due to downgradient movement of highly contaminated Parrot tailings water." is unsubstantiated, because no trend is evident at GS-09 and the trends at GS-41 S and GS-41D have not been determined to be caused by an overall increase in contaminant load in the plume, but can be attributed to a change in water management resulting in adjusted groundwater flow directions. The "parallel increases" between an invalid well and one well near the Parrot that happened to go up is very poorly supported at best.

> **MBMG Response:** The authors agree that the historic water-quality time series data are weak historic water-quality record in existence for BPSOU. Undoubtedly, there was a significant increase in Cd, Cu, and Zn concentrations in GS-41S and GS-41D in 2003 relative to previous years. Hydrographs of these wells (GS-41 S & D) show no change in water-levels between 2003 – 2005, and cannot be attributed to changes in flow direction or regime. Well GS-09 was sampled in 2004, and COC concentrations had increased since last monitored during the RI. Unfortunately this is the only long-term record for deeper wells downgradient of the Parrot. This data combined presents a credible hypothesis that water quality in the MA Parrot Plume degraded between 2003-2004. It is very unfortunate that data collection wasn't considered a priority from 1990 to 2007, but the lack of data is not a credible argument against our hypothesis.

EPA Comment 48: (Pg. 40, Section 4.2.2): The statement "concentrations increased starting in 2004" ignored data from GS-42S and GS-42d, which do not show an increasing trend. The document should consider all of the data, not just those that support the conclusions.

> **MBMG Response:** Unlike GS-41S and D which have long historic records that are fairly complete, GS-42 S and D were not sampled in 2003, 2004, or 2005 (the years concentration increases in the plume were observed). Monitoring for these wells is incredibly sparse, and for this reason the data were not included in the analysis. The authors have modified the text to clarify how and why data were used.

EPA Comment 49: (Pg. 40, Section 4.2.2): The travel time for water was estimated at 1 to 3 years in the referenced document. This is not the same as the travel time for contaminants.

> **MBMG Response:** Noted

EPA Comment 50: (Pg. 40, Section 4.2.2): Insufficient data have been presented to conclude that overall plume concentrations have increased. Generally, EPA disagrees with the first full paragraph on page 40 in its entirety as unsupported by the available data. If the MBMG wants to measure if the mass of the plume is increasing, a mass flux measurement should be conducted periodically.

> **MBMG Response:** Noted. The authors stand by our conclusion and believe that we have sufficient supporting evidence. Preliminary results from current and ongoing studies suggest additional support will be forthcoming.

EPA Comment 51: (Pg. 40, Section 4.2.2, second full paragraph): The discussion of the plume south of the MSD ignores the trends in metals concentrations observed in well GS-44D. This paragraph should be revised to recognize that some wells in this vicinity do not show the trends used to support the conclusion that mine discharge is the source of the plume. Additionally, waste deposits upgradient of the Parrot tailings are potential sources that existed before excavation of the Berkeley pit. This conclusion needs further analysis and supporting data.

> **MBMG Response:** We present all the data we have for GS-44D in the figure on Plate I, which shows consistently decreasing concentrations. See response to EPA Comment 24. Furthermore, wells MSD-01B, BPS07-11B, and AMC-13 south of the Parrot Tailings area all show decreasing concentration trends and if added to the data set in the report, would strengthen our hypothesis that this area's contamination source was the mine operation discharge. The decreasing trends in all of these wells would further strengthen the hypothesis that the desorption process is much faster than originally assumed. However, these data were not included because historic time-series data were inadequate. Too few samples were collected. The robustness of the historic record was the only factor that determined the inclusion or exclusion of a site.

EPA Comment 52: (Pg. 40, second full paragraph): Between 1977 and 1979, zinc and copper concentrations within the Anaconda Minerals Company (AMC) discharge water were often quite low. Periodic discharge violations occurred in which concentrations of copper and zinc reached values of 300 mg/L and 435 mg/L, respectively. The distribution of the data (in mg/L) is presented in the form of box plots below (chart available upon request).

With the exception of the periodic spikes, the concentrations are not high enough to be responsible for concentrations of copper and zinc to reach values of 5 and 100 mg/L, respectively in well AMC-12 in April 1994, particularly once the Clear Water ditch discharge is mixed with groundwater and diluted. A much more likely explanation for the trends in AMC-12, AMC-06, and GS-44D is that the groundwater mound created by the Clear Water Ditch discharge has flattened over time, resulting in a change in groundwater flow direction. USGS flow data indicate that water was present within the Clear Water Ditch well after 1982. http://nwis.waterdata.usgs.gov/mt/nwis/nwisman/?site_no=12323170&agency_cd=USGS

> **MBMG Response:** The EPA summarizes 1977 to 1979 water-quality data from the clear water ditch, but the link provided in the comment is for Silver Bow Creek; the 1977 to 1979 water-quality data is not available on the site listed.

This comment is conjecture and completely unsupported by the available data. The mine discharge was treated after 1972 and the water quality prior to lime treatment was likely much worse than it was between 1977 and 1979. Also, water levels in wells AMC-06, AMC-12 have been monitored since 1983 by the MBMG and there is no correlation between decreasing water-levels and water quality. A much more likely hypothesis is that historic mine-water discharge to Silver Bow Creek served as a point source to the aquifer. Since monitoring began in the 1980's, concentrations have been decreasing in wells to the south of the Parrot Tailings. The EPA's argument is also irrelevant because the contaminated groundwater was a primary point source to the aquifer surrounding these wells. The aquifer material is the secondary source, and the flushing/desorption process is much faster than previously assumed in the TI.

EPA Comment 53: (Pg. 41, second paragraph): Amorphous co-precipitates are quite likely to be controlling metals concentrations. Very rarely are pure-phase metal-bearing minerals formed. This question will be answered during the upcoming Electron Microprobe (EMP) analyses and other tests to be conducted by AR.

MBMG Response: Noted

EPA Comment 54: (Pg. 41, third paragraph): Supersaturation of iron oxides can mean different things for different minerals, for goethite this is common, as this mineral usually forms from crystallization of amorphous ferric oxyhydroxide. For ferrihydrite, which usually forms rapidly from solution it may be due to the presence of ferrihydrite colloids, which are smaller than the filter size, that one or more iron complexes are present that are not accounted for, or that the groundwater is not in redox equilibrium. For magnetite, this is due to the fact that the thermodynamic data within the MINTEQ database is for crystalline magnetite which does not precipitate directly from solution. Sedimentary magnetite is possible, particularly within biological systems, but this phase would have different thermodynamic data. So, to say that iron oxides may be precipitating from solution, because they are supersaturated is misleading. Saturation of ferrihydrite (SI=0 ±0.5) would be a much stronger argument that this phase is forming.

MBMG Response: This comment seems to agree with the cited paragraph.

EPA Comment 55: (Pg. 42, first full paragraph): Oxygen is not the only potential oxidant of ferrous iron; nitrate can also oxidize Fe+2

MBMG Response: Concentrations of nitrate in groundwater samples from well MSD-02B are below detection and concentrations of dissolved Fe are 300 mg/L. The oxidation of ferrous iron by nitrate in the MA unit seems even more unlikely than the oxidation of ferrous iron by oxygen.

EPA Comment 56: (Pg. 42, last paragraph): The argument that iron oxides are not precipitating, because there is no pH decrease is very weak. pH is generally controlled by the aquifer matrix, which has a tremendous buffering capacity, especially when carbonate minerals are present.

> **MBMG Response:** We agree. However, it is one more factor in a long list of factors that argue against the formation of iron oxides within the MA. Furthermore, the preliminary data from the 2011 UAO drilling project also strongly support this hypothesis.

EPA Comment 57: (Pg.44, first full paragraph): There is no evidence that sorption of metals is the main attenuation mechanism. To use a process of elimination when all other possibilities have not been conclusively ruled out is not a valid approach. The upcoming geochemical analyses planned by AR are designed to answer this very question, and to draw such a conclusion now, based on limited evidence is potentially misleading.

> **MBMG Response:** The authors disagree and believe that there is adequate evidence presented to support the conclusion that sorption is the main attenuation mechanism.

EPA Comment 58: (Pg.44, first full paragraph): Again, sulfate has not been shown to be conservative.

> **MBMG Response:** See our response to EPA Comment 19.

EPA Comment 59: (Pg. 45, first full paragraph, last sentence): Assuming that a decaying secondary source is the cause for the trend, which has not been adequately demonstrated (see comment #51), projecting the current trend in a linear fashion to attain an estimated cleanup time is an invalid approach (see comment #26).

> **MBMG Response:** We are not estimating a cleanup time for the aquifer, which would have a significant 'tailing' of the concentration data as the concentrations approach zero. We are estimating a time to acceptable groundwater concentrations, which may occur before the 'tailing' of the concentration data.

EPA Comment 60: (Pg. 45-46, Section 5): Since determination of the subdrain capture is not a part of this report, it should not be mentioned as a conclusion. Delete the portion of the last full sentence on page 45 containing "which may be an indication that the MSD Subdrain is effectively capturing the SA plumes." Also delete the entire sentence beginning "However, determining..."

> **MBMG Response**: We disagree with this comment. The statement is not based on capture zone analysis but on water quality data from nearby wells.

EPA Comment 61: (Pg. 46, Section 5, first bullet): The middle gravel portion of the plume is clearly significant in size, but the water table portion of the plume is significantly larger extending throughout Lower Area One. The statement of doubling the known extent of the Parrot plume appears to suggest that this extent was unknown until this report was written. Investigation of the plumes at BPSOU is the result of an iterative process conducted within the CERCLA process representing many past studies and analysis.

> **MBMG Response:** Given the truncated list of chemical analytes currently being monitored for BPSOU, it would have been impossible to trace the Parrot Tailings plume in the MA unit to Kaw Avenue (AMC-24B). Furthermore, until the 72-hour aquifer test performed in 2010, the hydrogeologic understanding of the aquifer was not adequate to trace the Parrot Tailings plume downgradient of MSD-02B. Therefore, prior to this investigation, the Parrot Tailings plume had not fully been characterized. Even now and after this investigation, the Parrot Tailings plume is still not fully characterized. Prior to this investigation, it was not known that the contamination in the MA and DA can be traced back to the Parrot Tailings. This investigation has doubled the known extent of the MA Parrot Plume.

EPA Comment 62: (Pg. 46, Section 5, fifth bullet): The document fails to present all trend data including those with a downward trend or no trend. Additional middle gravel wells within the plume include: AMW-01B, MSD-01B, MSD-02B, MSD-03, and MSD-05. Of these, four show no trends and one (MSD-01B) shows a downward trend in metals concentrations. Additionally, AMC-24B lies at the downgradient edge of the plume and may represent an upward excursion from the middle gravel. The metals data for this well appear to show a downward trend. This conclusion needs to be altered to recognize that downward trends exist as well as upward trends.

> **MBMG Response:** The increases in the MA Parrot Plume discussed in this report occurred between 2003 and 2004. Wells AMW-01B, MSD-01B, MSD-02B, MSD-03B were installed in 2004, and MSD-05 was installed in 2005. All of these wells were drilled after the increases in concentrations were observed in the MA Parrot Plume. Additionally, in 2010 (the cut off for data to be included in this report), few monitoring points were available for any of these sites, making determination of trends suspect.
>
> We agree with EPA that well MSD-01B shows decreasing concentrations. We believe this site to be a part of the area south of the Parrot Tailings that received contamination from historic mine discharge to the SBC-MSD channel, and since 1982, concentrations in this area have been decreasing as a result of the cessation of the mine-water primary source and subsequent degradation of a secondary source. The limited times-series data for this site supported our conclusion, but we excluded the data from the report for the reasons mentioned above.
>
> Well AMC-24B was drilled on 12/4/2007, and at the time of this report only three sets of sampling results were available. There is not enough data to reliably determine a trend. Furthermore, when drilled in 2007, the 2-inch casing was crimped approximately 2-feet above the static water level. As a result, conventional groundwater sampling pumps are unable to be used for monitoring activities. This well must be sampled with a peristaltic pump which requires purging a 40-foot water column at a flow rate of around 0.2 gallons per minute. An attempt should be made at this site to repair this well, so that proper purging activities can be performed.

EPA Comment 63: (Pg. 46, Section 5, sixth bullet): This conclusion needs additional analysis. This conclusion does not recognize that the direction of groundwater flow has changed which is expected to result in declining concentrations. The last two sentences are not supported by data or analysis.

> **MBMG Response:** This comment is similar to at least three other comments made in this review. Every well completed in the MA to the south of the Parrot Tailings area (AMC-06, AMC-13, GS-44D, BPS11-11B, and MSD-01B) all show decreasing trends for COC's. This evidence is strongly supportive of our conclusion. Please see previous responses.

EPA Comment 64: (Appendix C): Well AMC-05 was sampled during the synoptic round, but the data were not presented in Appendix C.

> **MBMG Response:** Well AMC-05 is a Butte Mine Flooding Operable Unit well, and was not sampled as a part of this analysis. Furthermore, the portion of the alluvial aquifer surrounding well AMC-05 is a part of the Berkeley Pit drainage basin, and not relevant to these discussions.

APPENDIX G MBMG RESPONSE TO BP/ARCO COMMENTS

Response to Atlantic Richfield Company's Technical Review Comments
By N.J. Tucci and G.A. Icopini

Comments of the Atlantic Richfield Company (AR) on Montana Bureau of Mines and Geology (MBMG) Draft Report – Geochemical and Hydrogeologic Investigation of Groundwater Impacted by Wastes Left in Place in the Butte Priority Soils Operable Unit, Butte, MT

Overarching Comments

1) Recent efforts have provided significant additional information that might support or even modify the basis provided in this report. It is suggested therefore that the issuance of this report is premature. The characterizations presented in the report would be better refined if information from the new monitoring wells installed in late 2011/early 2012 was considered. This would eliminate the need to state "*to define the extent of the MA Parrot Plume west of Kaw Avenue and north of the MSD, additional monitoring points are necessary*." In addition, the findings of recent work conducted to assess potential groundwater inflow to Blacktail Creek (thermal imaging and radon work) should be incorporated to provide a comprehensive evaluation. Finally, detailed geochemical evaluations of argon-preserved core samples will be implemented soon, and the data generated as part of those evaluations would significantly inform the authors' general statements regarding attenuation mechanisms in the alluvial aquifer. AR recommends that MBMG postpone public release of the report until the new data can be evaluated and appropriately incorporated.

   MBMG Response: The authors have added text acknowledging the efforts of AR, the Environmental Protection Agency (EPA), and the State of Montana to further characterize the deep flow systems. We have also added text that acknowledges the up-coming geochemical attenuation studies by AR. The authors assert that issuance of this report is not premature because new data may potentially refine our findings. Any project is subject to this caveat and if adhered to, reports would never be completed.

2) The report indicates that the "*the objective of this study was to determine if geochemical signatures (fingerprints) were identifiable and could be used to track individual contaminant plumes in the Silver Bow Creek/Metro Storm Drain (SBC/MSD) corridor.*" However, the report provides far more analysis than an evaluation of the "fingerprinting" data collected in 2010, and in the end, very little of the discussion contained in the report is related to this objective, concluding that "*…a unique chemical signature for each plume could not be identified.*"

   MBMG Response: The objective was to link contaminated groundwater at different depths in the alluvial aquifer(s) to contaminant sources in the Upper Silver Bow Creek/Metro Storm Drain (SBC/MSD) corridor. The authors have added language to clearly state the objective. We have shown that groundwater contamination in the SA, MA, and DA zones are linked to the left-in-place Parrott

Tailings. MBMG used several approaches, one of which has been noted above. We found that true statistical fingerprinting methods such as factor or cluster analysis are not appropriate here because these methods do not account for geochemical evolution in groundwater as it moves downgradient from each source area. Instead, we used a combination of methods, including a strong understanding of the hydrogeology, spatial and temporal groundwater-quality trends, an evaluation of the geochemical attenuation mechanisms, and an understanding of each aquifer's geochemistry to trace each individual plume.

3) Overall, the report:

   a) avoids discussion of the demonstrated effectiveness of the groundwater remedy, as evidenced by the significant improvements in surface water quality over the past several years, and

      MBMG Response: The authors assume AR is referring to the MSD subdrain. A capture-zone analysis would be required to demonstrate the effectiveness of the subdrain as a groundwater remedy.

   b) emphasizes and attempts to interpret selected data that would imply that certain of the wastes left in place are problematic for groundwater (e.g., noting wells with increasing concentrations while not acknowledging those with decreasing concentrations; noting that adsorption is a finite mechanism and not considering that dilution is an infinite mechanism, not considering previous fingerprinting efforts, and not considering all the known geochemical processes in the aquifer that affect sorption processes.

      MBMG Response: The authors considered all data available as of 10/01/2010, which was the cut-off date for inclusion in this report. We have clarified the report language to better explain why we selected sites with long-term records over sites with short records or insufficient sampling frequencies. We have provided a more thorough and detailed explanation about which sites and data we selected in our response to EPA comments found in Appendix F.

6) The conclusion that there is a source of Cu and Zn loading to Blacktail Creek between Oregon Avenue and SS-05A appears to be based on the results of a single surface water sampling event that was not representative of typical sampling results. This single event does not appear to be reproducible in several other data sets that have been collected before and after this event.

   MBMG Response: Although the data are not included here because they exist outside of the time frame used in this report, elevated Cu and Zn concentrations in Blacktail Creek water have been observed in several AR monthly monitoring events between sites SS-01 and SS-04.

7) The report makes no mention of the Technical Impracticability (TI) Zone for groundwater in the BPSOU and compares groundwater concentrations to State human health standards. A more logical comparison might be a comparison of these concentrations to DEQ 7 surface water standards.

   MBMG Response: This document is a scientific study funded by restoration dollars. Discussion of a TI zone is not relevant.

8) The report uses both Metro Storm Drain and upper Silver Bow Creek terminology interchangeably to describe the surface water drainage between Continental Drive and Montana Street. The accepted terminology is Metro Storm Drain.

   MBMG Response: MBMG has been instructed by the State of Montana to refer to this stream reach as Upper Silver Bow Creek/Metro Storm Drain

9) The reviewers focused primarily on major points and discussions in this paper, but numerous editorial issues and misspellings were noted. It was suggested that a sound technical editorial review of the final document be conducted prior to release or publication of this paper. Although we recognize that this suggestion is not pertinent to the technical value of this report, we would be remiss if we did not make this recommendation.

   MBMG Response: The authors will have a technical editor recheck the final draft.

Hydrological/Hydrogeological Comment Themes

10) AR believes that the available data confirm that the MSD Sub-Drain effectively captures groundwater impacted by wastes left in place and appreciates that the authors recognize this as a possible mechanism for controlling the down gradient extent of the plume. However, the report is entitled **“***Geochemical and Hydrogeologic Investigation of Groundwater Impacted by Wastes Left in Place in the Butte Priority Soils Operable Unit, Butte, MT*.” The MSD Sub-Drain was specifically installed to collect “groundwater impacted by wastes left in place” for treatment before it can adversely affect surface water quality in Silver Bow Creek. As such, the MSD Sub-Drain, and its operation and effectiveness, are central to the very topic that the report was prepared to address. For this reason, it is unclear why the authors assert that “*determining whether or not the MSD Subdrain captures these SA plumes was beyond the scope of this investigation*.” It appears that the authors did not consider this important aspect of the evaluation.

    MBMG Response: At the time this document was written, too few wells existed in the deep flow units to determine an adequate capture zone. The 2011 Upper Area One (UAO) drilling project most likely corrected this problem.

11) The authors indicate that dilution of groundwater affected by the wastes left in place in the Metro Storm Drain corridor is a less important mechanism for reducing groundwater concentrations relative to a single attenuation mechanism (adsorption), yet no basis is

provided for this. The authors have abundant information that can be used to assess dilution, such as lithium concentrations in groundwater. The authors also did not note the geochemical impact of diluting waters on the attenuation of metals and the impact of attenuation capacity provided through precipitation of iron oxides.

> **MBMG Response**: We compared Li concentrations in water from MA wells (figure 6) to Cu and Zn concentrations in MA wells (figure 7) to support our hypothesis. Between GS-41 (the center of the plume) and AMC-24B (the known tail of the plume), Li concentrations decrease by less than an order of magnitude while Cu and Zn concentrations in MA wells decrease by 3-4 orders of magnitude. Furthermore, data portrayed in figure 8 strongly suggests that dilution is not the major attenuation mechanism impacting the concentrations of COC's in the MA unit.

12) The authors initially describe the MA as a leaky confined unit, and have characterized the MA in this way in earlier publications. However, the authors characterize the MA throughout the remainder of the document as fully confined. Additionally, the A.R. report on the pumping test did further analyses of drawdown based on derivatives and differentiated the aquifer as "unconfined with delayed yield" (Atlantic Richfield, 2010). One line of supporting evidence for confined conditions in the MA erroneously cited in the report is the presence of upward gradients toward the SA. Upward gradients occur in response to boundary conditions (e.g., discharge areas) and in no way signify the presence of confining conditions. The alluvial deposits in the BPSOU are highly heterogeneous. Although confining conditions might locally exist (e.g., GS-11), they are probably not laterally extensive, as shown by the 2010 pumping test responses. Consequently, the authors' statement *"…and contaminants entering the MA unit from the Parrot Tailings are vertically confined in the MA unit down gradient to well GS-09*" might be modified to *"…and contaminants entering the MA unit from the Parrot Tailings appear to be vertically confined in portions of the MA unit downgradient to well GS-09.*

> **MBMG Response:** The statement that: *'Upward gradients…in no way signify the presence of confining conditions.'* appears to contradict basic hydrogeologic concepts. We also disagree with the assessment the aquifer is "unconfined with delayed yield". We believe that the data support the MA being semi-confined to locally confined.

13) The report characterizes continuous thick silt and clay horizons as confining zones between the SA and MA and also characterizes the SA and MA as continuous, thick sand and gravel horizons. These types of deposits are not consistent with the depositional history and models for fluvial systems characteristic of Silver Bow Creek. In reality, the confining zones appear to be laterally and vertically discontinuous units of predominantly silts and/or clays, while the SA, and MA appear to be laterally and vertically discontinuous units of predominantly sands and/or gravels. The discontinuous fine grained units are the likely source of the "delayed yield" portion of the "unconfined with delayed yield" aquifer characterization, and perhaps locally transitions to leaky confined or even confined conditions.

MBMG Response: The report acknowledges lateral and vertical discontinuity in the confining and gravel units. The statement that upward gradients in no way signify the presence of confining conditions appears to contradict the basic hydrogeologic concept of a confined aquifer. We also disagree with the assessment the aquifer is "unconfined with delayed yield". We believe that the data supports our hydrogeologic concept of the confining nature of the MA by breaking the MA into three distal areas (above Harrison Ave, between Harrison Ave and well GS-09, and below GS-09) and believe that no further clarification is necessary. The report acknowledges the lateral and vertical discontinuity of the confining units and the gravel units.

Geochemical Comment Themes

14) Much of the report references the "Parrot plume." In reality, the Parrot tailings is one of several discrete deposits of mine wastes left in place, and these are in addition to numerous other dispersed mine wastes both on the valley floor and on Butte Hill. The report (including the title) tends to convey the message that that by simply removing the Parrot tailings, the single source of metals to groundwater within the BPSOU would be removed and the aquifer would clean up. Other sources of metals to the alluvial aquifer remain that will degrade water quality for decades, or possibly centuries.

    MBMG Response: The single remaining primary source area to the MA and DA units is the Parrot Tailings. The report acknowledges the various other source areas to the SA aquifer throughout the study area.

15) Historical impacts to the aquifer: if there is a connection between the SA and MA near the Parrot tailings, why would discharge prior to 1982 from AMC operations to Silver Bow Creek upstream of the Parrot tailings also not contribute metals to the MA and DA? In addition, impounded water on historic tailings ponds was not discussed. The radial flow from these areas of impounded water is responsible for some of the contaminant distribution.

    MBMG Response: We agree and believe the report considers the potential impact of mine discharge on the MA and DA.

16) Metals flushed into the alluvial aquifer to the southeast of the Parrot tailings (likely sourced to AMC operations) historically migrated to the area of GS-44 and -66. The report characterizes the MA as anoxic because DO measurements are typically <2.0 mg/L DO. USGS defines anoxic as "ground water that has no dissolved oxygen or a very low concentration of dissolved oxygen (that is, less than 0.5 mg/L) from: *The Quality of our Nation's Waters—Volatile Organic Compounds in the Nation's Ground Water and Drinking-Water Supply Wells. US Geological Survey. Circular 1292.* The MA should more appropriately be characterized as weakly oxidizing.

MBMG Response: Agreed. Most of the wells sampled in the MA unit have DO concentrations <0.5 mg/L, and therefore the anoxic terminology still applies. Analytical results with DO concentrations > 0.5 mg/L were sampled without flow-through instrument-cells, which potentially allowed contact between the sample and the atmosphere that would bias the samples. More recent MBMG samples of MSD-02B, MSD-01B, and AMC-24B all contained DO concentrations <0.5 mg/L; AMC-24B, as a result of well construction issues, must be sampled with a peristaltic pump and DO concentrations in water from this well are not reliable. Based on preliminary data, we anticipate the release of AR's follow-up investigation during which DO measurements in groundwater from MA wells were more precisely measured.

17) Although data show a non-linear relation between sulfate and COC concentrations, it does not mean that dilution does not play a significant role in reduction of metals concentrations within the MA. In addition to dilution, it is likely other geochemical attenuation mechanisms are active in the system, including precipitation and adsorption.

MBMG Response: The authors agree that dilution may play a role in metals reductions, but believe the report has thoroughly and satisfactorily exhausted the other attenuation mechanisms listed above as possibilities.

18) The progression of Fe and Mn decreasing trends with distance down gradient is consistent with mixing of low-ORP and high-ORP ground water (i.e., impacted groundwater and Summit Valley groundwater, respectively). This is analogous to uranium roll-front deposits formed at the boundary between oxidized and reduced groundwater. In addition, acidity is attenuated through inflow of more alkaline waters and encountering more alkaline sediments down gradient. This theory should be evaluated and discussed along with green-rust as potential attenuation mechanisms for iron.

MBMG Response: While MBMG has not interpreted the 2011 drilling or water-quality data for this report, the authors have not observed the 'boundary' evidence for these mixing zones. There are no historic data in the Summit Valley to suggest that the formation of ORP roll-fronts. There is simply no data, historic or current, to support this hypothesis. Furthermore, groundwater flow is laminar, and does not mix like surface waters do.

19) GS-09 COC increases might not be evidence of plume migration from the Parrot tailings or other wastes left in place. GS-09 was constructed with an inadequate seal (pea gravel) and the annulus could allow COCs to migrate from the SA to the MA. This is why GS- 09, and other wells in its vicinity, were recently replaced. Any use of data from GS-09 should be provided with the appropriate caveats regarding improper well construction.

MBMG Response: We disagree with this assessment and refer the reader to our response regarding the GS- series wells to EPA comments in Appendix F. There is no evidence to suggest that a hydraulic connection exists between GS-11 and GS-09. There is however, evidence to suggest that a connection does not exist.

20) The authors indicate that there is little iron staining in the MA. Based on observations during drilling, iron staining is widespread down gradient of the Parrot tailings within the MA. This is also evidenced in the down gradient distribution of Fe in solution. The authors have not considered new data gathered during the latest monitor well installation. Moreover, the MA contains significant amounts of silts and clays that are in contact with the sand and gravel layers that can also contribute a substantial amount of sorption sites. It is possible that silts and clays play a significant role with respect to attenuation of metals.

MBMG Response: We believe the reviewers are unintentionally biased by the choice of drilling locations. Only three sites (<10%) were drilled up-gradient of well GS-09, while roughly 90% of the drilling locations were below well GS-09. While iron staining in the SA is widespread downgradient of well GS-09, little to no iron staining was observed below the SA aquifer in cuttings for wells GS-09R, BPS11-17, and BPS11-18. This is a very important distinction, because in areas of the MA and DA where elevated dissolved Fe in groundwater is detected, little to no Fe-staining was observed in MA and DA cuttings. The lack of staining is further evidence that Fe oxides are not forming in the MA or the DA aquifers.

21) A possible driver for iron and manganese oxidation in the MA is mixing with regional groundwater containing DO. Though present, DO concentrations are low in the MA, likely because it is consumed upon mixing. Furthermore, the H^+ produced during the oxidation reaction is likely buffered by alkalinity in regional groundwater. Concentrations of relatively conservative tracers, such as Li, provide support for this mixing and dispersion of waters.

MBMG Response: The authors discuss this idea extensively in section 4.2.3.

22) The possibility exists for multiple attenuation mechanisms to be present and active within the aquifer system, and many mechanisms can be active concurrently. The authors do not convey this coexistence. For instance, although mixing cannot completely explain the reduction in iron concentrations, it can explain a portion of the decrease. Ruling out the mechanism of iron oxidation via mixing can’t explain all of the iron attenuation because it does not appear to be a logical conclusion.

MBMG Response: The authors have discussed and evaluated all apparent attenuation mechanisms. Based on the evidence and data, iron oxidation, mixing, or iron oxidation via mixing does not appear to be important in these systems.

23) On Manganese as an indicator for reduced conditions: Manganese is slower to oxidize than Fe and will likely precipitate as it is oxidized along the flow path. The existence of dissolved manganese does not definitively indicate reduced conditions.

MBMG Response: The authors agree that dissolved manganese <u>may</u> not definitively indicate reduced conditions, but in this case and when considered with the other geochemical characteristics of these groundwater flow systems, we believe it does.

24) Groundwater mixing through advection and hydrodynamic dispersion: Based on the most recent monitoring well installation, the entire alluvial aquifer system is a fluvial depositional environment consisting of a series of repeating gravels, sands, silts, clays. The non-continuous nature of these types of sediment deposits would likely enhance dispersion and mixing of groundwaters. "*Subterranean void spaces*," as indicated in MBMG's report, are not the only way to induce mixing. Dominico and Schwartz (1990 p. 484), Drever (1997, p.361), Fetter (1994 p. 455), and Montana DEQ (Circular DEQ 4) all consider mixing (through advection and hydrodynamic dispersion) to be a significant and documentable mechanism within an aquifer. **MBMG Response**: We do not argue that groundwater doesn't mix; actually we say that it does. However, we also demonstrate that mixing cannot be the dominant attenuation mechanism in the MA unit.

25) Relying on green rust precipitation to solely control iron concentrations based on the limited thermodynamic data does not account for other possible mechanisms, See general comment #21.

MBMG Response: There is other supportive evidence to suggest the green rust Suggesting that Fe oxide formation as a possibility after drilling two locations where green sediments (BPS11-17 &18; downgradient of MSD-02B) were observed at the contact of the MA unit is further supportive evidence that the formation of green rust is the mechanism controlling iron concentrations.

Specific Comments

Executive Summary

1. (Pg. 1, 3rd bullet): Define characteristic of plume by contaminants concentration. What metals concentrations in groundwater define the maximum extent of the plume? To what plume is the doubling referring to? The elevated concentrations of contaminants at AMC-24 have been known for many years, and to portray this as extending the plume implies significant plume movement, which we believe is not the author's intention

MBMG Response: While it is true that elevated concentrations in AMC-24B have been known for many years, current limited BPSOU analyte lists would make it impossible to trace the Parrot Tailings plume in the MA unit as far west as Kaw Avenue (AMC-24B). Furthermore, until the 72-hour aquifer test performed in 2010, hydrogeologic understanding of the aquifer was not adequate to trace the Parrot Tailings plume downgradient of MSD-02B. Prior to this investigation, it was not known that contaminates in the MA and DA had the Parrott Tailings as their single source. This investigation has doubled the known extent of the MA Parrot Plume.

2) (Pg. 1, 4th bullet, 3): Parrot Plume “is, or will be discharging to Blacktail Creek or Silver Bow Creek” is asserted, but not supported by available data. Please state basis for this assertion. Data from new wells that would decrease the uncertainty have been installed recently and the report should indicate the new information available.

   MBMG Response: The authors list three possibilities for the ultimate fate of the MA Parrot Plume but do not prefer any one possibility. We have added language to the text to clarify our lack of preference.

3) (Pg. 2, 5th bullet): Use of the term COC should refer to a fixed list of contaminant metals and/or metalloids. Please specify that COC list here, and be consistent with its use throughout the document.

   MBMG Response: COC’s in this report refer to Cd, Cu, and Zn. We have clarified the reference in the text.

4) (Pg. 2. 6th bullet): Precipitation of ferric iron from oxidation of soluble ferrous iron also should be mentioned as an attenuation mechanism, which would continue to establish new sorption sites for metals. The small amount oxygen might limit precipitation of ferric oxides, but the oxygen that does enter likely is utilized to oxidize and precipitate iron. Also, please refer to potential attenuation of COC metals by the green rust deposition.

   MBMG Response: There is no evidence to suggest that oxygen enters the MA unit.

5) (Pg. 2 Bullet 3.) Please identify which wells. Changes in some of these wells likely result from lowering of water tables and oxidation as a result of the capture system. Also, please consider indicating wells where the COC concentrations are decreasing.

   MBMG Response: This level of detail is not appropriate in an executive summary. We refer readers to the report body and its illustrations to become familiar with well locations and decreasing COC trends.

6) (Pg. 2, 8th bullet): Well pairs GS-44 and GS-46 are decreasing in concentration. The rates of desorption are not specified and the “previously assumed” numbers are not referenced. Furthermore, it is suggested that this rate be outlined and that it is significantly slower than desorption rates estimated from the 2004 column studies. While interesting, these studies assume that Drinking Water Limits are the target for groundwater remediation. Groundwater within most of the area is protected by a TI zone, and discharge to surface water is likely the most limiting regulatory parameter and could require much lower groundwater concentrations. The authors might consider presenting this as bullet 4 following the MA discussion of the Parrot Plume.

MBMG Response: Language has been added to the report referencing the "previously assumed" numbers. This report is a scientific study funded by restoration dollars and referencing the TI zone is not appropriate.

1.0 Introduction

7) (Pg. 3, 1.1): Please characterize here the chemical nature of the deicing chemicals and other possible sources of COCs in the Parrot Tailings area.

MBMG Response: The chemical nature of the deicing chemicals were not determined for this report.

8) (Pg. 3, 1.1, last sentence): Sentence is confusing, please clarify connection between geochemical signature and fate and transport of COCs.

MBMG Response: This section has been modified.

9) (Pg. 4, 3rd paragraph): The Parrott tailings pond also held water at one time that likely caused a groundwater mound, enhancing transport to a greater extent than during later years.

MBMG Response: The exact year the ponds were in existence is unknown. The ponds were most likely in existence up until the great depression era, when the channel was re-designed as a CCC project. From 1930 – 1982, there was no ponding in this area.

1.4 Hydrogeology

10) (Pg. 6, 1st paragraph): A continuous silt/clay later over the entire area is not consistent with deposition in a high energy stream system, see general comment #11. It is likely that finer textured strata are not laterally continuous.

MBMG Response: The authors note that the referenced paragraph refers to these units as discontinuous, not continuous.

11) (Pg. 6, 1.3): The last sentence refers to the upper alluvial aquifer of <150 feet as one unit with a hydrogeologic framework containing three separate alluvial aquifers. This nomenclature is contradictory and confusing. Is there one aquifer with three separate water-bearing subunits shallow, middle, and deep that comprise the aquifer or are there three aquifers in the <150 feet profile of the Silver Bow Alluvium? Please clarify in this discussion. Furthermore, this aquifer was further characterized in 2011 and 2012, indicating that this report would likely benefit from the incorporation of recently collected data.

MBMG Response: The nomenclature has been clarified to 'aquifer units'.

12) (Pg. 6, 1.4): What evidence and data show that the DA is highly transmissive? Please state reference here.

MBMG Response: The 2010 aquifer test (Tucci and Icopini, 2010) has been referenced.

13) (Pg. 7, 2nd paragraph): Consider changing "*the following aquifer test data suggests that the MA unit is confined*" to "*the following aquifer test data suggests that the MA unit is locally confined*".

MBMG Response: This change has been made.

14) (Pg. 7, 2nd paragraph, Bullet 2): Please consider refining the statement of "thick confining beds of silt and clay" to "thick, laterally discontinuous beds of silt and clay", as evidenced by the aquifer characterization of "unconfined with delayed yield" (A.R., 2010).

MBMG Response: We disagree with the assessment that the aquifer is "unconfined with delayed yield" as evidenced by the widespread lateral degree of response in all the MA wells available at the time. This sentence is not appropriate between Harrison Ave and GS-09 as well log data show that confining beds are continuous between these locations.

15) (Pg. 7, 3rd paragraph): Please consider defining conditions in the MA as "unconfined with delayed yield" instead of "confining conditions of the MA unit are less apparent."

MBMG Response: The aquifer test results of cannot be extrapolated that far downgradient of the pumped well, but we agree that this area of the aquifer is most likely unconfined.

1.4.2 Lithology

16) (Pg. 9, 1st paragraph): Figure 3 shows one sample as a polished section, smoothed trench face, or different scale (A) and the second one is grains of a disturbed sample (B). The second describes more coatings on grains, but is likely a function of the sample type. It is clear that there is more staining near the surface, but there are also significant ferric iron oxides in the MA.

MBMG Response: The argument that the differences in iron staining between the two images in the report are a function of sample disturbance is not logical. Regardless of how much you crumble an iron oxide stained aquifer (A), all the particles are still going to be iron-oxide stained.

1.4.3 Vertical Hydrologic Gradients

17) (Pg. 10, 2.0): -- What about acidified samples? Sample methods, field methods, bottle types, filter media, etc. are incomplete. Please provide the complete description of well sampling protocols.

MBMG Response: All of these procedures are covered in sections 2.1 and 2.2, which immediately follow this section.

2.3 Geochemical Diagrams and Modeling Methods

18) (Pg. 12, 2.3): Please insert original reference to Stiff diagrams.

MBMG Response: The Stiff diagrams were referenced to the software program used to generate them.

19) (Pg. 13): Use and application of field Eh data should be characterized prior to this discussion. Field measured ORP is not an analytical equivalent of Eh. The USGS National Field Manual states in Ch. 6.5 "In contrast to other field measurements, the determination of the reduction-oxidation potential of water (referred to as redox) should not be considered a routine determination. Measurement of redox potential, described here as Eh measurement, is not recommended in general because of the difficulties inherent in its theoretical concept and its practical measurement." "Eh measurement may show qualitative trends but generally cannot be interpreted as equilibrium values." "Concentrations of redox species can be determined by direct chemical analysis instead of using the electrode method (Baedecker and Cozzarelli, 1992)."

MBMG Response: We agree with this comment.

20) (Pg.14, 2nd paragraph after the bullets):The researchers isolated ferrous iron in solution and titrated with NaOH. It will precipitate ferrous iron compounds, unless it is oxidized. This does not mean that ferric iron compounds have not precipitated in the MA. Virtually all iron converted to ferric iron is precipitated at the pH values present in the MA at this location. Ferric iron will not remain in solution; therefore, the collected solution contains the iron that has not been attenuated at that location. This experiment does not mean that a significant amount of ferric iron has not already been precipitated along the reaction path. The amount of iron precipitation along the path is likely oxygen limited, but occurring.

MBMG Response: This is exactly the argument we have made for the MA unit, ferrous compounds will precipitate in the MA unit unless it is oxidized. There is no oxidant available in the MA unit as it is an anoxic N-limited system.

3.1 Surface Water

21) (Pg. 15 Tables 2 and 3): Please include dates on the tables. Also, a map of these surface water monitor locations is needed.

MBMG Response: The map of the surface-water sites is located in Figure 1 of the report.

22) (Pg. 15): Tables 2 and 3 show BTC and SBC meet virtually all surface water criteria. Most of the data do not show significant loading between SS-4 and SS-5a. Please explain? Also note that surface tailings are known to be adjacent to BTC between Oregon Avenue and SS-4. Any COC metals migration is more likely from the adjacent tailings than from Parrott tailings in that reach.

> **MBMG Response:** There is no mention of loading between SS-4 and SS-5a. The BTC Berm is listed as a potential point source in the report.

3.2.1 Background Groundwater Quality

23) (Table 4): pH of 6.09 is not neutral but could be indicative of background pH from a mineralized area.

> **MBMG Response:** Noted

3.2.2 General Groundwater Quality Along the SBC/MSD Corridor

24) (Pg. 16, 3.2.2): Figure 5 shows stratigraphy that is not consistent with a depositional model for a fluvial depositional environment like that of Silver Bow Creek. A cross-section containing a great deal of interpretation was used for this discussion. Is there a reference for this cross-section? What borehole logs were used, and, have these correlations been reviewed? Are there transverse cross-sections to this cross-section? A "generic graphical representation" of the complex lithology of the alluvial water-bearing zones should be derived and simplified as needed from a cross-section constructed from borehole logs and/or geophysics. A large number of hydrogeological and geochemical interpretations of data depend on the most accurate framework of this complex alluvial system available. Sufficient shallow subsurface data are available from Superfund (with more coming in) and other investigations to construct a reasonable set of longitudinal and transverse cross sections that characterize the geologic framework of the Silver Bow Alluvial Aquifer system that could be used in this paper.

> **MBMG Response:** Noted. We considered all lithologic data available at the time of the report. Figure 5 was constructed from lithologic logs for the few deep alluvial wells in existence at the time of the writing. As noted in the report, we are quite confident in its interpretation between the Parrot Tailings and Well GS-09. Downgradient of GS-09, the lithologic correlations were not comparable.

25. p. 16, last paragraph--The low Cu and Zn concentrations in the two wells down gradient from the Parrott tailings are also associated with lower sulfate concentrations and likely represent a difference in hydrology and groundwater source. The higher pH values might indicate a carbonate or other neutralizing reactions in those sediments Figure 5 does not contribute to an understanding of the chemistry of groundwater from these wells.

> **MBMG Response:** Noted. The over-arching intent of this figure is to show the continuous nature in chemistry in the MA unit, as opposed to the discontinuous nature in the SA. We believe we have accomplished this goal.

3.2.3 GW Quality Relative to Contaminant Source Areas

26. p. 17, 3.2.3— If the authors were unable to conduct fingerprinting as a result of a lack of data, why mention this process at all as it is not relevant to the discussions in the paper? None of the ratios used would be expected to yield a good tracer, as they are all affected by attenuation. Jim Chatham, AR, provided a good tracer study using Li and other fairly conservative ions, but it was not cited.

> **MBMG Response:** We are unfamiliar with the public release of Jim Chatham's work, and therefore it was unable to be referenced. The last iteration of this work that was previewed by MBMG showed Well MSD-02B as the tail end of the Parrot Plume. Wells MSD-05, GS-09, BPS07-24, and AMC-24B were labeled as second tails, which makes no sense given the upward gradients in the area. Factor analysis does not take factors such as dilution and sorption into account.

27. p. 17, 2nd paragraph--Waters in GS- 42S&D are connected. The concentrations are less in both of the GS-42 wells, indicating attenuation at both depths, although attenuation might not be exactly the same for both wells.

> **MBMG Response:** Clearly, GS-42S & D are connected, but they are less connected vertically than GS-41 S & D. This is the only point we were trying to make.

28. p. 17, 2nd paragraph--The wells south of the GS-44 S&D are not currently down gradient of the Parrott tailings, but were at one time. Both are on a declining concentration trend as the source is no longer up gradient. These wells have likely not been down gradient since the head was removed from the ponds that contained the Parrott tailings. The flushing process has been on-going for many decades already and many more decades will be required before the groundwater approaches concentrations consistent with surface water criteria. The drawdown of the MSD Sub-drain has also contributed to the flushing at GS- 44S&D by affecting hydraulic gradients.

> **MBMG Response:** This is an incomplete assessment. The head discussed above was in existence until AMC converted to a zero-discharge facility (1982). The creek would have served as a discharge point for the Parrot Tailings (north of the creek bed); the source to this area was most likely surface water discharges from the mine operations, not the Parrot Tailings. There is no correlation between the installation of the MSD Sub-drain (2004), and concentrations in well GS-44D.

29. p. 17, 3.2.3, 3rd paragraph— A significant source of loading to the aquifer is the Parrott area tailings; however, there are many other sources of COC metals along the flow path. This distribution of sources throughout the area supports the TI waiver of groundwater

performance standards at BPSOU. Source removal sufficient to meet the separate surface water standards (or groundwater performance standards) is not technically practicable and effective capture of metals would be required even if additional source removals were implemented. Have tailings in different locations been chemically analyzed for possible COC differences? If so, discuss here.

> **MBMG Response:** We are unfamiliar with primary source areas outside of the Parrot, Northside, and Diggings East Tailings areas. The referenced paragraph discusses the SA, and mentions that the SA unit receives loading from the three known source areas. The MA and DA units do not currently receive source loading from any other primary source area than the Parrot Tailings. Again, this is a scientific study funded by restoration dollars and the mention of a TI waiver does not apply.

30. p. 17, 3.2.3, 4th paragraph— Waters containing 2 mg/L dissolved oxygen are not anoxic. Anoxic means without oxygen, or as a practical matter the USGS (2010,http://toxics.usgs.gov/definitions/anoxic.html) uses <0.5 mg/L oxygen as depleted 10 with respect to oxygen. Many attenuation processes for organic and inorganic compounds that require oxygen can occur at dissolved oxygen concentrations of 2 mg/L. Concentrations of all oxygen sensitive species also decrease in concentration (e.g., dissolved Fe) which precipitates and provides the attenuation capacity for Cu and Zn as well. These COC concentrations beyond Kaw avenue are primarily below Drinking Water Standards, but above concentrations that would meet surface Water Criteria or could affect surface water criteria as suggested in Section 3.1 of this report.

> **MBMG Response:** Noted. All waters in the MA unit sampled with a flow-through cell contained concentrations of DO <0.5 mg/L. Subsequent sampling of Wells MSD-02B, and MSD-01B using a flow-through cell showed that these wells had concentrations of DO < 0.5 mg/L. Well AMC-24B as a crimp in the 2-inch casing, preventing the use of a traditional pump. This well has to be sampled with a peristaltic pump, and DO results are most likely biased as a result. We are confident in its assessment that the MA unit is anoxic.

31. p. 17 5th paragraph--The report suggests that the Cd, Cu, and Zn health standards are exceeded in the MA. These standards are not applicable to the MA, as there is a TI waiver in place and engineering and institutional controls are in place to prevent exposure.

> **MBMG Response:** This report is a scientific study funded by restoration dollars and therefore discussion of a TI waiver is not relevant.

32. Figure 5—It is unclear what "break down" jargon means in terms of lithologic logs. Please revise and clarify.

> **MBMG Response:** The language has been modified.

33. p. 20, 2nd paragraph--Drinking water standards are not applicable to SA or MA units within BPSOU TI zone. The limiting and critical criterion for groundwater is discharge to surface waters. Because there are dispersed wastes in close proximity to MSD throughout the areas, the waters of the SA and MA have little effect on meeting the surface water remediation goal (total metals concentrations in surface water).

> **MBMG Response:** The document is a scientific study funded by restoration dollars. Comparison of groundwater concentrations to groundwater standards is applicable.

34. p 20, 3rd paragraph--Water in AMC-24 has been significantly affected by pumping from the MSD. Concentrations of sulfate (and some other constituents) have decreased substantially following startup of the system.

> **MBMG Response:** Concentrations of Cu and Zn have been decreasing in water samples from AMC-24 since 1989, but they have never been observed to be as elevated as they are in well AMC-24B.

35. p. 20, 4th paragraph--Cu and Zn can adsorb to aquifer sediments or onto oxides precipitated from solution in the SA and MA. Li occurs at concentrations of 1-2 μg/L (Table 4) and is a good tracer for the tailings leachate input to the water bearing units. Li in the MA decreases consistently from the Parrott tailings and down gradient, as water enters the MA causing dilution, dispersion, and chemical reactions that precipitate Fe oxides and other redox sensitive species. These materials also form adsorption sites for metals such as Cu and Zn. This was explained in the conceptual site model submittal.

> **MBMG Response:** We disagree that Fe oxides are forming in the MA unit.

36. p. 20, 4th paragraph, last sentence--The variability of Li and sulfate in SA waters reflects the dispersed occurrence of sulfide-containing minerals in the sediments and the rationale for the TI waiver at BPSOU.

> **MBMG Response:** Noted.

37. p. 20, 5th paragraph--Potentiometric mapping indicates that the MSD Sub-drain is likely affecting AMW-13 wells also. Low concentrations reflect lack of contaminants reaching the well and containment from groundwater capture by the MSD.

> **MBMG Response:** Noted

38. p. 20, 6th paragraph--The ratios listed are affected by attenuation processes. The statement that something other than dilution is responsible is partially true. The addition of water from other sources to the MA does cause some dilution, but also introduces reactants that cause precipitation of oxygen sensitive species, which in turn cause adsorption of Cu and Zn. The oxidation/precipitation and adsorption reactions cause decline in these metals concentrations that exceed simple dilution. This mechanism was explained in the Conceptual Site Model submitted by AR.

> **MBMG Response:** There is no evidence to suggest that oxide rich waters are mixing with the MA plume, not even with the new 2011 BPS-UAO drilling. We are quite confident that Fe oxide formation is not a main attenuation mechanism.

39. p. 23, 1st paragraph--AMW-13 might be in close proximity to bank tailings along Blacktail Creek. Distribution of Fe and Mn in water in the SA reflects the dispersed nature of contaminants throughout the shallow aquifer.

> **MBMG Response:** The primary author of this report has drilled two of the wells at the AMW-13 site; there is no indication of so-called bank tailings in this area.

40. p. 23, 2nd paragraph--Fe concentrations in groundwater decrease down gradient and then increase again at MSD-2. This pattern in part shows the highly variable physical nature of the alluvium in the MSD and could be representative of additional source materials that were noted in the studies that support the TI waiver for groundwater at BPSOU. If all data were plotted, the variability would likely be even greater.

> **MBMG Response:** This pattern could be the result of a number of different possible factors, but we do not believe that it is the variable physical nature of the alluvium in the MSD. Between the Parrot Tailings and at least well GS-09, we are confident in our assessment of the continuous nature of the aquifer.

41. p. 23, 3rd paragraph--Fe concentrations decrease more rapidly down gradient because the solubility of ferric compounds is partly controlled by pH. Precipitation of ferric compounds is sensitive to introduction of oxygen and alkalinity from waters that are introduced to the MA along the groundwater flow path. The dilution of Li in the MA shows only 20% of the Li concentrations at AMC-24 as were present in the area of contamination near the Parrot tailings. This indicates that 80% of the water in the MA at AMC-24 originated from near the Parrot tailings. The attenuation of Fe as ferric oxide precipitate, provides sorption capacity for other metals, is continually precipitated as long as the source exists. Other metals (e.g., Cu and Zn) extend farther down gradient because of the adsorption behavior of Cu and Zn as a function of pH.

> **MBMG Response:** The solubility of ferrous compounds is also partly controlled by pH. The discussion of Fe is only relevant between the Parrot Tailings and GS-09, because there is no dissolved Fe left in the plume upgradient of GS-09. A good discussion of this can be found in section 4.2.3 of the report, where essentially this hypothesis is effectively dismissed. Furthermore, the presence of green silty clay in lithologic logs from the new drilling investigation is further evidence that the attenuation mechanism controlling Fe concentrations in the MA Parrot Plume is green rust.

42. p. 31, 3.3—Here it is suggested that the authors should state that the PHREEQC model has many features, but was used as a static model with the MINTEQ thermodynamic database to determine mineral/water interactions at each well location.

> **MBMG Response:** We disagree.

43. p. 31, 3.3, 2nd paragraph---- Here and elsewhere, how were predictions established? From modeling or other means? The static PHREEQC model does not actually predict a mineral status, only assesses the saturation state, indicating precipitation or dissolution potential, as the authors stated previously in Section 2.3. Please revise and clarify.

> **MBMG Response:** We do not say the minerals were predicted to form or not form. We say the model predicted the mineral to be supersaturated or undersaturated, which is consistent with the statements in Section 2.3.

44. p. 32, 3.3, last paragraph-- The greater problem would be that Eh data obtained from field measurements are likely to not be accurate, and the diagrams should be constructed based on a calculated Eh from redox pairs. If no data interpretations are to be presented using Eh-pH diagrams, why mention this at all?

> **MBMG Response:** This issue is covered satisfactorily in the discussion.

45. p. 33, Table 6 footnote-- Also, near zero SI indicates that a mineral might be dissolving or precipitating in the system, such as for calcite at AMW-13.

> **MBMG Response:** Agreed.

46. p. 36, 3.4—Were precipitates transferred and left to equilibrate as a slurry or was the liquid decanted? Please clarify.

> **MBMG Response:** The language has been clarified. The solution was left to equilibrate as a slurry.

47. p. 37, 4.1-- There are data available that are being analyzed by AR from the Spring 2011 base flow sampling in Blacktail and Silver Bow creeks that the authors might consider.

> **MBMG Response:** The cut-off data for this work is 2010, but there will be a follow up report to this investigation covering surface water in Blacktail and Silver Bow Creeks.

48. p. 37, 4.2 first sentence--This statement has no purpose or significance as there are large datasets for both, allowing some good understanding of water quality of both; suggest revising the sentence.

> **MBMG Response:** The language has been modified.

49. p. 37, 4.2--"geographically constrained" is not clear. Please elaborate and clarify.

> **MBMG Response:** We believe this language is appropriate.

50. p. 37, 4.2—Are the trends spatial or temporal or both?

> **MBMG Response:** Temporal.

51. p. 39, 4.2.2, 3rd paragraph—Please the contaminants that are large concentrations.

> **MBMG Response:** This comment is an incomplete sentence.

52. p. 41, 4.2.3, 3rd paragraph—good cogent comments on Eh that could be used earlier.

> **MBMG Response:** Agreed

53. p. 45, 4.2.3 2nd paragraph—Statement not fully correct. Dispersion process should not result in retardation of dissolved COCs, but rather dilution; whereas diffusion is undefined here. Diffusion of dissolved metals into finer-grained sediment surfaces followed by diffusion-limited release of metals could be a retarding mechanism, but that has not been clearly stated. Please elaborate.

> **MBMG Response:** Arguing dispersion versus dilution is semantic, because dispersion is how groundwater is mixed and diluted. Diffusion into fine-grained sediments is unlikely to be a primary attenuation mechanism.

54. p. 45, 4.2, 2nd paragraph—Plate 1 is not referenced as an attachment in an appendix or the table of contents. The assertion that "cessation of loading to the aquifer in other areas would likely result in similar decreases in metals concentrations ", implying faster desorption than predicted is an assertion that is not supported by other data analyses.

> **MBMG Response:** The plate has been added to the table of contents. We disagree that our assertion isn't fully supported by the data.

55. p. 46, 5.0, 4th bullet—This statement ignores any effects from multiple source areas known to exist along the creeks contradictory to those mentioned in bullet 2. Please revise and clarify.

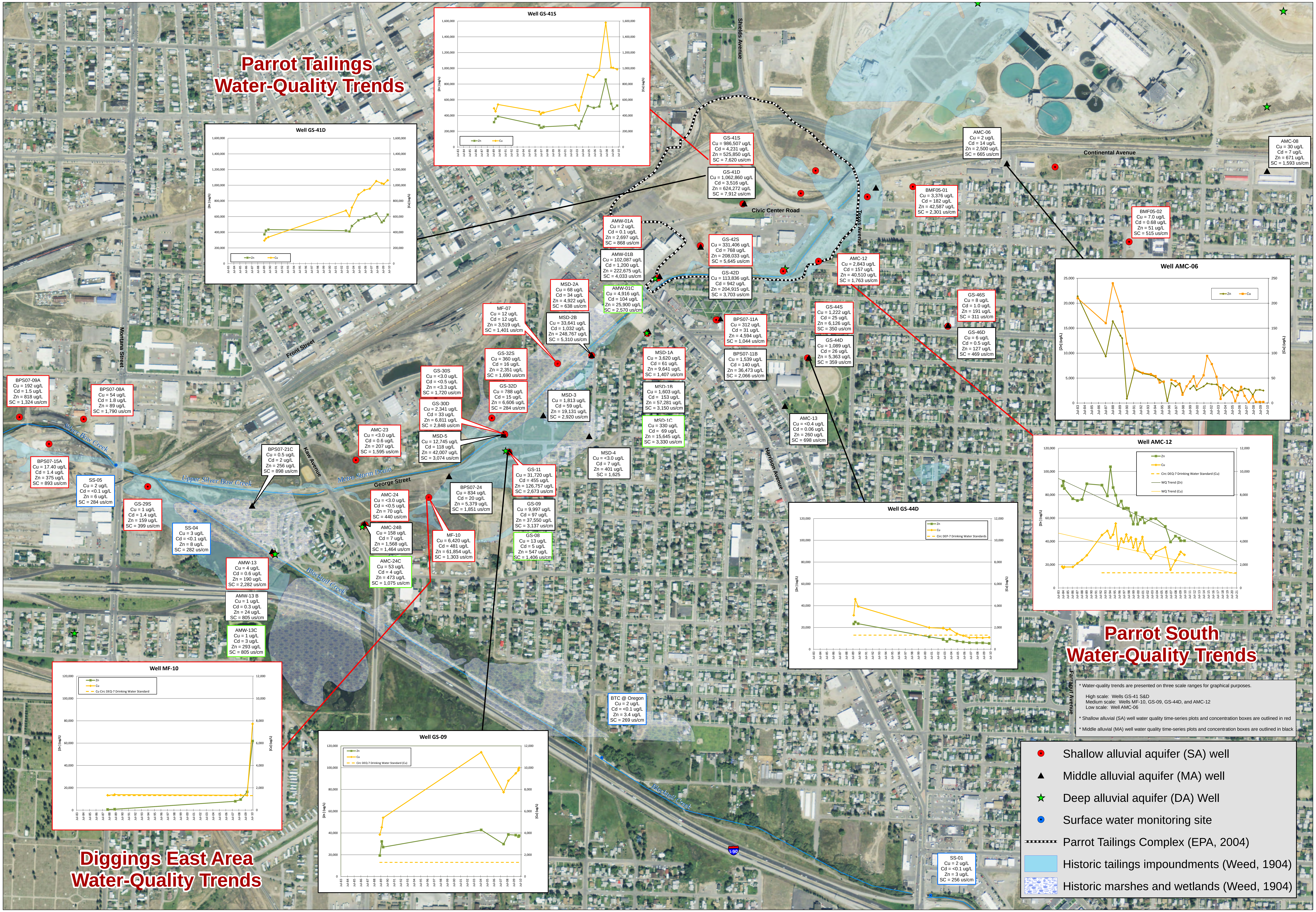
> **MBMG Response:** The fourth bulleted item on this page deals with the MA unit. There is only one source area to the MA and the DA unit, which is the Parrot Tailings.

56. p. 46, 5.0, 5th bullet—This statement ignores the precipitation of iron oxide surfaces in the aquifer as groundwater migrates, forming precipitates and fresh sorption surfaces (infinite sorption capacity) such as the green rust precipitation discussed in the next bullet.

> **MBMG Response:** We believe we have sufficiently dismissed the formation of iron oxides as a likely scenario in the MA unit.

57. p. 46, 5.0, 8th bullet—This assertion is not supported by all field data and other temporal trend analyses. Please revise statement.

> **MBMG Response:** This assertion has been fully supported by all relevant temporal trend analyses. For a more detailed and thorough discussion, please see our responses to EPA's comments.



* Water-quality trends are presented on three scale ranges for graphical purposes.

High scale: Wells GS-41 S&D
Medium scale: Wells MF-10, GS-09, GS-44D, and AMC-12
Low scale: Well AMC-06

* Shallow alluvial (SA) well water quality time-series plots and concentration boxes are outlined in red

* Middle alluvial (MA) well water quality time-series plots and concentration boxes are outlined in black

Montana Bureau of Mines and Geology
Earth Science Information

Plate I: Upper Silver Bow/Blacktail Creek Surface- and Groundwater Quality Temporal Trends and Dissolved Concentrations for Selected Contaminants

* Individual water-quality data collected during Spring 2010 MBMG sampling events
* Data available at www.mbmggwic.mtech.edu and Appendix B

Survey Source Data: MBMG/Pioneer/Trec
Imagery: 2009 NAIP, Silver Bow County
Projection: State Plane
Zone: Montana
Datum: NAD 83
Units: Feet