GROUNDWATER / SURFACE WATER REMEDIAL INVESTIGATION REPORT

EUREKA MILLS SUPERFUND SITE OPERABLE UNIT 4
Eureka, Utah

Prepared By:
HDR Engineering, Inc.
8404 Indian Hills Drive
Omaha, Nebraska 68114

Contract Number W912DQ-06-D-0010
Task Order DK01

June 2010

This page intentionally left blank to facilitate double sided printing

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

Al	Aluminum
Ag	Silver
As	Arsenic
Ba	Barium
Be	Beryllium
BHHRA	Baseline Human Health Risk Assessment
Ca	Calcium
CLP	Contract Laboratory Program
Cd	Cadmium
Co	Cobalt
COPC	Chemical of Potential Concern
Cr	Chromium
CSM	Conceptual Site Model
Cu	Copper
DQO(s)	Data Quality Objective(s)
EPA	United States Environmental Protection Agency
EPC	Exposure Point Concentration
°F	Degrees Fahrenheit
Fe	Iron
ft	feet
GWQS	Groundwater Quality Standards
GW/SW RI	Groundwater /Surface Water Remedial Investigation
HDR	HDR Engineering, Inc.
Hg	Mercury
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectroscopy
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
K	Potassium
K	Hydraulic Conductivity
L	Liter
MCL	Maximum Contaminant Level
Mg	Magnesium
Mn	Manganese
Na	Sodium
Ni	Nickel
OU	Operable Unit
Pb	Lead
PRG(s)	Preliminary Remediation Goal(s)

ACRONYMS AND ABBREVIATIONS (Con't)

QAPP	Quality Assurance Project Plan
2002 RI	Eureka Mills Superfund Site Remedial Investigation Report for Operable Units 1-4
RI	Remedial Investigation
ROD	Record of Decision
Sb	Antimony
SI	Site Inspection
Se	Selenium
TAL	Target Analyte List
Tl	Thallium
µg/dL	Micrograms per deciliter
µg/L	Micrograms per Liter
UAC	Utah Administrative Code
UDEQ	Utah Department of Environmental Quality
V	Vanadium
WRCC	Western Regional Climate Center
Zn	Zinc

EXECUTIVE SUMMARY

This Groundwater/Surface Water Remedial Investigation (GW/SW RI) was conducted to investigate whether contamination from historic mining activities at the Eureka Mills Superfund Site (Site) is present in surface water and/or groundwater at concentrations potentially unacceptable to human health. The Site consists of residential areas of Eureka, Utah and adjacent mining areas located within and in the vicinity of Eureka. Activities completed for the GW/SW RI included collection and review of available data on Site geology, hydrology, hydrogeology, and existing wells. In addition, sampling and analysis was conducted on surface water and groundwater collected from existing wells and installed monitoring wells. Samples collected were analyzed for total Target Analyte List (TAL) metals by EPA's Contract Laboratory Program (CLP) using Method ILM05.3. Data results were compared with human health screening criteria.

Groundwater

Groundwater samples were collected in 2007, 2008, 2009, and 2010 from existing wells and monitoring wells. Table ES-1 presents a summary of groundwater samples found to have metal concentrations which exceed screening criteria. The screening criteria are the Maximum Contaminant Levels (MCLs) or Action Levels established in the National Primary Drinking Water Standards. For metals without a MCL or Action Level, the Environmental Protection Agency (EPA) Region 9 Preliminary Remediation Goals (PRGS) for tap water (EPA, 2004a) were used for screening.

Table ES-1
Chemicals Exceeding Screening Criteria – Groundwater

Metals	Minimum Detected Concentration Above Screening Criteria	Maximum Detected Concentration Above Screening Criteria	Samples Detected Above Screening Criteria	Screening Criteria
Arsenic	19.7 µg/L	19.7 µg/L	1 of 56	**10 µg/L**[1]
Lead	19.2 µg/L	230 µg/L	2 of 56	15 µg/L[2]
Manganese	1,120 µg/L	1,930 µg/L	6 of 56	880 µg/L[3]
Iron	15,200 µg/L	20,700 µg/L	3 of 56	11,000 µg/L[3]
Zinc	33,400 µg/L	47,900 µg/L	3 of 56	11,000 µg/L[3]

Notes:

[1] Screening criteria is the National Primary Drinking Water Standards MCL

[2] Screening criteria is the National Primary Drinking Water Standards Action Level

[3] Screening criteria is the Preliminary Remediation Goal

µg/L = micrograms per liter

Based on results of the groundwater analytical data and the spatial distribution of the chemicals detected above the screening criteria, it does not appear that a defined plume of contaminants exists at the Site. Two of the three detections above the MCL/Action Level were found in one sample. Subsequent samples collected from this well did not have analytical results above the MCL/Action Level. No additional groundwater data collection is recommended for the GW/SW RI.

Surface Water

To investigate whether other surface water bodies are present following a precipitation event monitoring stations were established within the Site where surface water was most likely to be present. Eight of the stations were established in Eureka Gulch and one station was located in each of the Knightsville Sedimentation Ponds. Between May and September 2007, the stations were monitored within 24-48 hours following a rain event for the presence of surface water. Surface water was rarely present at the monitoring stations except for one monitoring station located downstream of the City of Eureka. Further investigation revealed that this location was receiving drainage from the daily discharge of several thousands of gallons of decontamination water from the remedial action project that is ongoing at the Site. Based on the monitoring observations it was concluded that Knight's Spring Pond is the only permanent water body located within the Site boundary. The pond is approximately 24 feet in diameter is located adjacent to Knightsville Road on the east side of the Site.

Surface water samples were collected from Knight's Spring Pond and from monitoring stations when surface water was present. Samples were analyzed for TAL metals and compared to State of Utah criteria that apply to Tanner Creek and its tributaries (Eureka Gulch is tributary to Tanner Creek) under Rule R317-2 of the Utah Administrative Code (UAC). Use designations listed in UAC for Tanner Creek and tributaries include 2B (recreation), 3E (severely habitat-limited waters) and 4 (agricultural). Of these designations, only the agricultural use code lists numeric criteria for metals. None of the surface water samples analyzed exceeded the applicable State of Utah surface water criteria for dissolved metals.

The criteria for recreational use is $6.5<pH<9.0$. During April and May, 2009 the monitoring stations were inspected for the presence of surface water following precipitation events. Surface water was found only at Knight's Spring Pond. Samples for field measurement of pH were collected from two locations within Knight's Spring Pond. At each location, 5 samples were collected during each event. Table ES-2 presents average pHs levels measured at Knight's Spring Pond.

Table ES-2
Surface Water pH Levels at Knight's Spring Pond

Date	Sample Location		Average
	K1	K2	
4/10/2009	6.04	6.49	6.27
4/25/2009	6.53	6.76	6.65
5/1/2009	6.52	6.64	6.58
Average	6.36	6.63	6.50

Based on these results, the pH in the pond is slightly acidic, and may not be suitable for human recreation. There was no evidence of recreational use of the pond and, given its size, recreational use is unlikely.

Based on the surface water monitoring completed, naturally occurring surface water is typically only present immediately following rainfall events within the Site, with the exception of Knight's Spring Pond.

This page intentionally left blank to facilitate double sided printing

1.0 INTRODUCTION

1.1 Purpose

This GW/SW RI was conducted to investigate whether contamination from historic mining activities at the Site is present in surface water and groundwater at concentrations potentially unacceptable to human health. The general location of the Site is depicted on Figure 1-1. Investigation activities included collection of surface water samples, installation of monitoring wells, and collection of groundwater samples from private wells and the newly installed monitoring wells. The surface and groundwater data collected were compared with applicable human health criteria to assess potential impact to human health. Investigation of environmental effects of the chemical releases at the Site is not addressed in this GW/SW RI, as comparison to ecological criteria and any impacts to the environment are discussed in the Baseline Ecological Risk Assessment for the Eureka Mills Site (SRC, 2009). This GW/SW RI was prepared in accordance with Guidance for Conducting Remedial Investigations and Feasibility Studies under Comprehensive Environmental Response, Compensation, and Liability Act (EPA, 1988).

1.2 Basis for Concern

Mining and milling operations at Eureka released various types of waste materials that contain elevated concentrations of metals. Mine waste is found throughout Eureka as a result of mining activities, milling operations, construction use, and by wind and water erosion (EPA 2006). A tailings impoundment failure below the Eureka Hill area also resulted in mill tailings being distributed across the lower portion of the western part of the valley, below Eureka (WGI 2002). Leaching from surface and subsurface sources could result in an increase in the concentration of metals in groundwater and surface water, which could migrate off-Site. In addition, surface water and sediments could be impacted.

1.3 History of Environmental Studies and Remedial Actions

The State of Utah discovered elevated metal concentration in soil and mine waste materials at the Site when conducting a Site Inspection (SI) in July, 2000. The SI consisted of the collection of a number of mine waste and residential soil samples for analysis. All of the mine waste and soil samples indicated levels of lead and arsenic above health-based levels. Concurrently, the Central Utah Public Health Department conducted blood lead testing on 18 children in Eureka. Eleven of the 18 children had blood lead levels above the health-based level of concern established by the United States Centers for Disease Control (10 µg/L).

Elevated levels of lead and arsenic in soil, combined with elevated blood lead levels in children living in Eureka led to time critical soil removal action at the Site in 2001 and 2002. Remediation was completed at 71 residential properties within the town of Eureka. In 2002, the EPA completed a Remedial Investigation (2002 RI) for OUs 1-4, which included a Baseline Human Health Risk Assessment (BHHRA). The scope of the 2002 RI and BHHRA included soils and other likely sources of human exposure to metal contamination, including tap water, air, residential interior and exterior paint, and other residential indoor sources. Groundwater and surface water were not included in the scope of the 2002 RI or BHHRA. As a result of the findings of the 2002 RI and BHHRA, the Site was listed on the National Priority List in September 2002.

Remedial Design for the Site was completed in 2003 and Remedial Action to remediate 15 mine waste areas (piles and mill sites) and approximately 700 residential properties was initiated in August 2003. Remedial Action is expected to continue until 2011. Figure 1-2 provides a plan of the response action structures that are planned or already constructed at the Site, and displays the Site Boundaries.

In 2007, an Ecological Risk Assessment was completed to describe the likelihood, nature, and extent of adverse effects to ecological receptors resulting from post-remedy Site conditions. This information, along with other relevant information, will be used by risk managers to decide whether further remedial actions are needed to protect the ecological receptors and habitat from Site-related releases.

1.4 Site Identification

The Site consists of five Residential and Adjacent Mining Areas OUs; designated 00 through 04 (note that the OU numbering has been revised since the completion of the 2002 RI). A description of each OU is provided below:

- OU 00: Site-wide, including the residential and commercial portions of Eureka.
- OU 01: Mining areas located to the east of Eureka, including Godiva Shaft, Godiva Tunnel, and May Day Shaft.
- OU 02: Mining areas located on the western edge of Eureka, including Gemini Mine, Bullion Beck Mine and Bullion Beck Mill.
- OU 03: Central Eureka, including Chief Consolidated Mining Company properties and non-residential area sites.
- OU 04: Surface and groundwater elements, and ecological risk.

The 2002 RI focused on the nature and extent of contaminants in mine waste, soils, outdoor air, and other potential sources of heavy metal contamination. This GW/SW RI has been prepared to address surface and groundwater elements of OU 04 and support a screening-level assessment of potential risks to human health.

1.5 Remedial Investigation Report Organization

This GW/SW RI Report is organized in sections by the following major topics:

- Section 1.0 Introduction
- Section 2.0 Site History and Characteristics
- Section 3.0 Investigation Approach
- Section 4.0 GW/SW Remedial Investigation Field Activities
- Section 5.0 Analytical Results
- Section 6.0 Summary of Findings
- Section 7.0 References

A list of subsections is provided in the Table of Contents for this GW/SW RI.

2.0 SITE HISTORY AND CHARACTERISTICS

This GW/SW RI pertains only to surface and groundwater; therefore, the summary of Site characteristics provided in this Section is limited to climate, geology, hydrogeology, and hydrology. A discussion of site soil characteristics is included in the 2002 RI.

2.1 Site Setting

Eureka is situated in a southwest trending valley on the west side of the East Tintic Mountains in northeast Juab County about 80 miles southwest of Salt Lake City, Utah. Elevations range from 6,700 feet to 6,300 feet above mean sea level. The town has a population of 766, as of the 2000 census.

2.2 Site History

The town of Eureka is part of Utah's historic Tintic Mining District. Eureka was founded in 1870, upon the discovery of a high-grade mineralized outcrop containing silver and lead, as well as other minerals including gold, copper, and arsenic. The area was extensively mined until 1958, and has experienced sporadic mining activity since that time (EPA 2006). Most of the mining activity since 1958 has occurred in the East Tintic Mining District, a few miles to the east and south of the town of Eureka. Mines near Eureka were developed on large replacement ore bodies in the Paleozoic limestone and quartzite. The ores consisted of native silver, gold, and sulfides and sulpho-salts of silver, lead, copper, iron, zinc, cadmium, and bismuth associated with jasperiod, barite, quartz, calcite, dolomite, and ankerite (UDEQ 2000).

There are several significant historical mines located within the Site, including: Bullion Beck Mine, Eureka Hill Mine, Gemini Mine, Chief Mine #1, Chief Mine #2, Eagle Blue Bell Mine, Godiva Mine and May Day Mine. Mines on the east side of Eureka, May Day and Godiva Mines, are located on the Godiva Ore Zone. The Chief No.1 and Blue Bell mining areas are located on the Mammoth Chief Ore Zone that runs under the center of town. Mines on the west side of town, Bullion Beck, Eureka Hill, Gemini, and the Eureka Centennial mines, are located on the Gemini Ore Zone (WGI 2002).

Due to the high transportation costs in the early stages of mining, only the richest ores were mined and shipped for milling and smelting, whereas the lesser quality ("second class") ores were stockpiled on the mine dumps. To concentrate second class ores and make them more profitable for shipping, a number of mills were constructed in and around Eureka. Up to 11 historic mill sites may have been present in Eureka. Early mills utilized the mercury amalgamation process, and amalgamation mills were built at the Bullion Beck and Eureka Hill Mines after the depression of 1893 (UDEQ 2000). The process had limited success due to the abundance of antimony in the ore which caused the mercury to "flour" (produce very small droplets of mercury that are no longer viable for amalgamating metals).

There are no current mining activities in the Tintic Mining District. However, at least two entities have recently conducted mining feasibility studies in the Tintic Mining District, which indicates that there is a potential for mining activities to resume in the future.

2.3 Site Topography

The Site is typical of the west desert portion of Utah's Basin and Range country. The town of Eureka sits in a low mountain saddle, between the ridgelines of the surrounding peaks of the Tintic Mountains to the south and the foothills to the north. Much of this topography is very rugged, with steep, rocky mountainsides and ridges, deep gullies and drainages throughout, and dry, rocky shrub-steppe vegetation. The Site is comprised of a range of elevations and habitats, including: sagebrush and pinyon-juniper stands, thick mountain scrublands and wooded areas of deciduous and mixed coniferous trees. However, some parts of the Site have been recently disturbed by removal of mining debris, contouring, removal of contaminated soils and covering with clean rock (riprap). Other reclaimed sites have had the mining debris removed, contoured and revegetated with native species.

2.4 Site Climate

The mountains that flank the Eureka valley greatly affect local climatic conditions. The climate at the Site is temperate and semiarid, typified by warm summers and cold winters. Average monthly temperatures vary from a high of approximately 86°F in July to a low of about 16°F in January. Average diurnal temperature variation is 31.2°F and 20.3°F during summer and winter, respectively (WRCC, 2001a).

The annual average total precipitation is approximately 17 inches. Annual average total snowfall is 120.3 inches, and average snow depth is eight inches during January and February (WRCC, 2001a). According to the Western Regional Climate Center (WRCC), the prevailing wind direction in Provo, Utah (approximately 40 miles northeast of Eureka) is from the southeast with a secondary direction from the northwest. WRCC reports there is no wind data for Eureka or the surrounding area (WRCC, 2001b).

2.5 Regional Geology

Quaternary deposits consisting of semi-consolidated, poorly sorted alluvial deposits of sand and gravel mantle most of the populated areas of Eureka. Bedrock formations at the Site belong to two distinct groups, Paleozoic limestone and quartzite and Tertiary age igneous rocks. Both groups have been subjected to prolonged weathering and erosion. The Paleozoic limestone and quartzite outcrop on the western end of the Site and on higher elevations to the north and south. Igneous rock (lavas) of Tertiary age invaded the lower elevations, including nearly the entire valley in which Eureka is situated. Packard Peak is believed to be the center of an eruption from which a relatively gentle outwelling of viscous lava occurred approximately 32 million years ago. The primary volcanic rock associated with this formation is the Packard Rhyolite.

Description of the regional geology is based primarily on the "United States Geological Survey Water Supply Paper 277" (Meinzer, 1911), "Geological Survey Bulletin 1142-K, Geology of the Eureka Quadrangle, Utah and Juab Counties, Utah" (Morris, 1964), and "Geological Survey Professional Paper 1024" (Morris, Lovering, 1979).

2.5.1 Site Specific Geology

As part of the GW/SW RI activities, four monitoring wells designated MW-1 through MW-4 were installed to depths ranging from 46 to 85.5 feet bgs to further characterize the Site-specific geology. Bedrock was encountered at varying depths ranging from 15 to 75 feet bgs. Sandstone was encountered at MW-1 and laitite (volcanic rock with large grained crystals) was encountered at MW-2, MW-3 and MW-4.

Historically, numerous wells have been installed in Eureka. The availability of boring logs for wells in Eureka was investigated via the State of Utah Division of Water Rights database. A total of six well logs were reviewed. The stratigraphy encountered during drilling activities was consistent with the geologic descriptions in the available literature and historical boring logs. A summary of information contained in the well logs is provided in Table 2-1. Available information for other wells sampled as part of this GW/SW RI is also included in Table 2-1. Copies of the historic well logs and installed monitoring wells are located in Appendices A and B.6, respectively. Figure 2-1 presents the location of monitoring wells and residential wells in Eureka.

Table 2-1
Summary of Well Logs, Eureka, Utah

Owner Name	Location	Depth (ft)	Well Log		Well Log Remarks	Well Screen Interval (ft bgs)	Other Available Information
			Depth Interval (ft)	Formation Description			
EPA	MW-1	63	0-10	Sandy Silt	Med. Dense Grayish Brown	52-62	Depth to water = 34.37
			10-40	Silty Sand	Med. Dense Dark Yellow Brown		
			40-63	Sandstone	Med. Dense Yellow Brown		

Table 2-1
Summary of Well Logs, Eureka, Utah (Con't)

Owner Name	Location	Depth (ft)	Well Log: Depth Interval (ft)	Well Log: Formation Description	Well Log Remarks	Well Screen Interval (ft bgs)	Other Available Information
EPA	MW-2	85	0-5	Sandy Clay	Soft Pale Yellow Brown	74.5-84.5	Water not encountered – see further discussion Section 4.2.2
			5-35	Silty Sand	Medium Dense Moderate Yellow Brown		
			35-50	Sandy Clay	Firm Moderate Yellow Brown		
			50-75	Silty Sand	Medium Dense Moderate Yellow Brown		
			75-85	Laitite	Dense Grayish Orange		
EPA	MW-3	46	0-5	Silty Sand	Medium Dense Brownish Black	36-46	Depth to water = 26.06'
			5-15	Silty Sand	Medium Dense Yellow Brown		
			15-46	Laitite	Dense Grayish Orange		
EPA	MW-4	85.5	0-7	Sandy Clay	Firm Brownish Black	75-85	Depth to water = 61.34'
			7-10	Clayey Sand	Medium Dense Moderate Brown		
			10-25	Silty, Sandy Clay	Firm Moderate Brown		
			25-85.5	Laitite	Dense Grayish Orange		
Ted Haynes	52 Iron & O'Connor	200	0-52	Clay, Boulders	Hard	60-75	None
			52-75	Bedrock	Solid Yellow Porphyry		
			75-200	Bedrock	Solid Blue Porphyry		
Edward Snell	151 East Godiva	200	0-4	Silt, Sand, Gravel	Brown Top Soil	Unknown	None
			4-62	Bedrock	Yellow Porphyry		
			62-200	Bedrock	Blue Porphyry		
Bill B. Riley	197 North Butler Road	270	0-170	Other	Porphyry - Hard	173-193, 233-263	Depth to water = 35'
			170-180	Clay, Other	Porphyry - Soft at Spots		
			180-195	NA	Porphyry - Streaks of Clay		
			195-256	NA	Porphyry - Hard		
			256-259	NA	Porphyry - Soft at Spots		
			259-270	NA	Porphyry		

Table 2-1
Summary of Well Logs, Eureka, Utah (Con't)

Owner Name	Location	Depth (Feet)	Well Log: Depth Interval (ft)	Well Log: Formation Description	Well Log Remarks	Well Screen Interval (ft bgs)	Other Available Information
Bill B. Riley	330 East Main	340	0-40	Clay, Silt, Sand with Volcanic Clasts	NA	40-200	None
			40-160	Gray and Pink Phoryphic Laitite	NA		
			160-200	Gray and Green-Gray Phoryphic Laitite	NA		
			200-320	Gray and Green-Gray Phoryphic Laitite	NA		
			320-340	Gray Phoryphic Laitite	NA		
Julie Ann Sorenson	97 Iron & O'Connor	156	0-6	NA	Top Soil	120-150	Depth to water = 64'
			6-104	Clay, Hardpan	Grayish Brown Hardpan Clay		
			104-130	Gravel, Boulders	Big Lime Boulders and Gravel Zone		
			130-156	Bedrock	Blue Porphyry		
Latter-Day Saints (LDS) Church	70 East Main	290	0-4	Clay	Dark Brown	50-60	Water encountered at 50'-60'
			4-60	Bedrock	Porphyry - coarse, loosely cemented		
			60-290	Bedrock	Porphyry - gray		
Cleo Judge	514 East Main	165	NA	NA	NA	NA	No well log available
Betty Robinson	40 N Spring	80	NA	NA	NA	NA	No well log available
John Miedell	63 East Arlington	18.5	NA	NA	NA	NA	No well log available
Elysabeth L. Franke	144 West Main	20	NA	NA	NA	NA	No well log available
Max Garbett	110 West Main	83	NA	NA	NA	NA	No well log available
Max Berry	110 West Arlington	40	NA	NA	NA	NA	No well log available
Vicky Gillen-Nelson	36 West Leadville	17.75	NA	NA	NA	NA	No well log available
Paulette Carpenter	72 West Leadville	20.5	NA	NA	NA	NA	No well log available

2.6 Regional Hydrogeology

The Paleozoic limestone and quartzite bedrock are believed to be barren of water, as the fractures in these formations allow groundwater to descend to great depths. This is evidenced by several of the mines reaching elevations below 5,000 feet mean sea level without encountering water. In addition, strong evidence exists that indicates groundwater is compartmentalized from the numerous faults within the older formations which underlie the Site (Morris, 1968). Compartmentalization can occur when fault zones become re-cemented and mineralized, which eliminates porosity in the rock by creating a thick impermeable zone. These impervious fault zones intersect, forming hydrogeologically isolated "compartments". Further information on the groundwater compartmentalization phenomena in the East Tintic Mountain Range is available in Hamaker, 2005.

Numerous springs are found in areas immediately underlain by the Tertiary igneous rocks. Unweathered and unfractured igneous rocks act as an acquaclude for water percolating down through the weathered, upper strata and the overlying alluvium. Water accumulates or seeps along the surface of competent rock until it reaches a point where the rock outcrops, producing a spring or seep. A strong correlation exists between rainfall and production from springs and seeps in the area (Meinzer, 1911). Depth to groundwater in the Site varies from 35 feet to several hundred feet below ground surface (UDEQ, 2000). A map of the Tintic Mining District, which shows the relation of the water supply to the geologic material, is presented as Figure 2-2.

2.6.1 Site Specific Hydrogeology

Water level measurements and slug tests completed at the newly installed monitoring wells provide information on Site-specific hydrogeology. The depth to groundwater was measured using a water level meter in each of the monitoring wells and in private wells whose casings were open and accessible. The groundwater elevation data as used to infer groundwater contours, which indicate that groundwater generally flows from east to west, with a directional component towards the valley bottom in areas remote from Eureka Gulch.

Slug tests were performed at monitoring wells MW-1, MW-3, and MW-4 to estimate local hydraulic conductivity (K). A slug test was not performed at monitoring well MW-2 due to an insufficient amount of water entering the well. The calculated K values were consistent with the published ranges for both sandstone (10^{-8} to 10^{-4} cm/sec) and fractured igneous rock (10^{-6} to 10^{-2} cm/sec). The wells were surveyed using a Trimble Pro XRT GPS which, according to published information, provides approximately +/-1 foot accuracy. Given the size and topographic relief at the Site, it was determined that the GPS provided as appropriate level of accuracy.

2.7 Site Specific Hydrology

Surface water at the Site is primarily found in two ephemeral streams and a small permanent pond. Runoff from the Site is collected in Eureka Gulch, an ephemeral stream that extends through town adjacent to United States Highway 6 and empties into Tanner Creek. Tanner Creek is another ephemeral stream located approximately eight miles south-southwest of Eureka. Eureka Gulch flows only during heavy runoff events from rainfall or snow melt. Based on review of United States Geological Survey topographic mapping, Tanner Creek drains south until it terminates in sand dunes approximately 2.5 miles north of Lyndyll, Utah. Several small unnamed drainages are tributaries to Eureka Gulch. These, as well as Eureka Gulch, are visible on Figure 2-3. A small pond (Knight's Spring Pond) is the only permanent water body within the Site.

2.8 Site Features

Refer to Figure 2-4 for the location of surface water features discussed in this section.

2.8.1 Knight's Spring Pond

Knight's Spring is the only permanent water body located within the Site boundary. It is a small spring fed pond located adjacent to Knightsville Road near the Godiva tunnel. Field measurements taken in May 2007 identified the pond to be approximately 24 feet in diameter and 3.5 feet deep. According to the information collected from the State of Utah website (Utah, 2009) a water right (#68-1984) has been appropriated for this spring and is owned by Mr. Leo Bird of Eureka. The water right was approved by the State of Utah in 1977 and allows Mr. Bird to use up to 0.022 cubic feet per second (about 10 gallons per minute) from this source for irrigation during the period of April through October.

2.8.2 Dam Downgradient of Knight's Spring

A small dam, approximately three to four feet high, is present at the Site and is located adjacent to Knightsville Road north of Knight's Spring Pond. Based on information collected from Eureka residents, the dam was constructed by Grant Loader, who rents the property from Godiva Silver Mines, which is owned by Spenst Hansen. The surface water body is approximately 20 feet in diameter and up to two feet deep. Surface water impounded by the dam is likely used for watering livestock that graze on nearby land.

2.8.3 Constructed Sedimentation Ponds

Sedimentation ponds constructed as part of the Site remediation are located at the base of the Knightsville Drainage. Within the next two years additional drainage ponds are planned to be constructed within Gardner Canyon Drainage. The sedimentation ponds capture run-off during storm and spring melt periods to prevent recontamination of remediated areas at the Site. Anecdotal reports indicate that the ponds contain water for brief periods during spring snow melt. Existing and proposed ponds vary in size from approximately 0.1 to 0.6 acres and include rip-rap liners.

2.8.4 Eureka Gulch

Eureka Gulch is an ephemeral stream that passes through the central part of Eureka. Within the Site boundary, exposed areas of Eureka Gulch are lined with rip-rap and are located on the east end of town (Upper Eureka Gulch) and on the west end of town (Lower Eureka Gulch). West of the Site boundary, the gulch has not been altered and has a natural, cobbled bottom. In the town of Eureka, Eureka Gulch flows through a variety of unlined and lined open channels and culverts of various sizes. It reportedly contains water following precipitation events and spring snowmelt. Eureka Gulch joins with Tanner Creek, approximately 6.5 miles southwest of the Site. The extent that Eureka Gulch discharges to Tanner Creek is not known. Observations by Site personnel following storm events suggest that storm-water run-off usually infiltrates into the ground before the confluence with Tanner Creek.

2.8.5 Private Wells

A list of existing private wells within Eureka was complied from the State of Utah Division of Water Rights database, which was accessed via the Internet. Twenty four water points of diversion were identified through the internet search. The well owners were contacted to determine the physical location of the existing wells and their current use. Based on the owner inquiry 19 of the 24 points of diversion were identified as wells, eight of which were capped or abandoned, and eleven of which are active wells. In addition to these wells, three unregistered wells were identified as active during the course of the residential remediation. The locations of the active wells are identified on Figure 2-1. A summary of the information collected on the active wells is provided in Table 2-2.

Table 2-2
Active Private Wells, Eureka, Utah

Owner Name	Location	Available Well Log (Y/N)	Comments/Notes	Depth (Feet)	Diameter (inches)	Access Agreement (Y/N)
Registered Active Wells						
Eureka City	North of City Park (High School)	No	Active well used for H.S. and Elem school yards	100	NA	Yes

Table 2-2 (Con't)
Active Private Wells, Eureka, Utah

Owner Name	Location	Available Well Log (Y/N)	Comments/Notes	Depth (Feet)	Diameter (inches)	Access Agreement (Y/N)
Betty Robinson	40 N Spring	No	Active well used for lawn and garden purposes.	80	12	Yes
Elysabeth L. Franke	144 West Main	No	Active well used for lawn purposes.	20	2	Yes
Max Garbett	110 West Main	No	Active well used for lawn purposes.	83	12	Yes
Thomas E. and Cleo Judge	514 East Main	No	Well is located in shed behind V&J's gas station. Well served former laundry facility, is still functional, but not currently used.	165	NA	Yes
Edward Snell	151 E Godiva	Yes	Active well used for lawn purposes.	200	6	Yes
Max Berry	110 West Arlington	No	Active well used for lawn purposes. Well dug circa 1900.	40	16 X16	Yes
Bill B. Riley	197 N Butler Rd	Yes	Lawn / Garden	270	6	No
Bill B. Riley	330 E Main	Yes	Not currently in use	340	6	No
Ted Haynes	52 Iron & O'Connor	Yes	Lawn / Garden	200	6	No
Vicky Gillen-Nelson	36 West Leadville	No	Lawn/Garden	17.75	48	Yes
Unregistered Wells						
Paulette Carpenter	72 West Leadville	No	Not currently in use	20.5	40	Yes
John Miedell	63 East Arlington	No	Not currently in use	18.5	48	Yes
LDS Church	70 East Main	No	Not currently in use	290	Unknown	Yes

Notes:
1. NA indicates not applicable

2.8.6 Monitoring Wells

Four monitoring wells were installed at the Site to investigate the potential for elevated metal concentrations downgradient of the major mine waste piles and for development of an inferred groundwater flow direction.

- Monitoring well MW-1 was installed downgradient of the waste piles Chief Mine #1 and Eureka Hill.
- Monitoring well MW-2 was installed downgradient of Chief Mill Site #1.
- Monitoring well MW-3 was installed downgradient of Chief Mill Tailings.
- Monitoring well MW-4 was installed downgradient of Chief Mill Site #2; Godiva, and May Day.

Each of the wells was screened in the overlying alluvium and the weathered and fractured igneous rocks from which groundwater has been historically obtained. Further information regarding monitoring well construction is discussed in Section 4.3.

3.0 INVESTIGATION APPROACH

This section outlines the GW/SW RI approach for groundwater and surface water and details the criteria used in the decision-making process.

The Data Quality Objective (DQO) process was used to identify the decisions that needed to be made and the data types (quantity, type, and quality) that were needed. The DQO process, as outlined in "Guidance for the Data Quality Objectives Process" (EPA, 2000), is a strategic planning approach and is intended to ensure that task objectives are clearly defined, to determine what environmental data are necessary to meet these objectives, and to ascertain if the data collected are sufficient and of adequate quality for the intended usage. The DQO process is an iterative process designed to focus on the decisions that must be made and to ensure that data needed for the decisions is obtained.

To address potential releases to groundwater and surface water, the DQOs/project objectives included:

- Identification of potential contaminant release mechanisms and migration pathways.
- Identification of potential human receptors.
- Groundwater and surface water sampling and laboratory analysis to address potential contaminant release mechanisms.
- Comparison of detected analytical data concentrations to appropriate state and/or federal regulatory guidance or risk-based concentrations to identify chemicals of potential concern (COPCs).
- Evaluation of potential human health risks posed by detected COPCs.
- Recommendations for further action based on the results of the comparisons and evaluations listed above.

3.1 Site Conceptual Model and Data Gaps

The BHHRA did not address potential risks associated with exposure to surface or groundwater. Therefore, the Site Conceptual Site Model (CSM) for human exposure to mine-waste related contaminants developed for the BHHRA was revised to include exposure to surface and groundwater as potentially complete pathways. The CSM is presented as Figure 3-1. As indicated in the CSM, there are a number of potentially complete exposure pathways by which human receptors may come into contact with Site-related contaminants. Of these potential exposure pathways, those that involve contact/ingestion of solid media have or are being addressed through response actions required under existing Records of Decision (RODs).

The remaining exposure scenarios that cannot be excluded as a source of potential concern and should be evaluated further including:

- Ingestion of groundwater.
- Ingestion of vegetables irrigated with groundwater.
- Incidental ingestion of permanent and ephemeral surface water through recreation.

The sediment pathway was judged to be incomplete because of the lack of permanent surface water bodies at the Site. Refer to Section 2.7 of this report which describes site surface water features.

The following data collection activities were completed to support an assessment of the exposure scenarios of potential concern:

- Surface Water. Collection and analysis of surface water samples from Knight's Spring and Eureka Gulch (as Site conditions allowed), and surface water samples from current sedimentation ponds.
- Groundwater:
    - Collection and analysis of groundwater samples from accessible private water supply wells; and
    - Installation and development of monitoring wells in strategic locations, and collection and analysis of samples from the monitoring wells.

3.2 Site Geologic/Hydrogeologic Conceptual Model

As described in Section 2.5, the general geology of the Site is characterized as basement Paleozoic sedimentary rocks of quartzite or limestone overlain by Tertiary volcanic rocks and Quaternary alluvium. The sedimentary and igneous rock types exhibit different hydrogeology, which is described in Section 2.6. A conceptual geologic model is presented in Figure 3.2.

The focus of this RI is to investigate the shallow water table aquifer that resides within the alluvium and Tertiary volcanic formations. Based on the available data, private wells in Eureka are screened to capture the water table aquifer and were used for the investigation. Monitoring wells installed as part of this RI were placed to collect groundwater samples downgradient of the mine waste piles within the Eureka Mills Superfund Site. The monitoring wells were screened within the water table aquifer, as this aquifer is most susceptible to contamination as a result of water moving rapidly from the land surface to the groundwater, and thus carrying contaminants spilled on the surface or from runoff to the water table. The primary source of the shallow water table aquifer is infiltration of runoff through the weathered rock and overlying alluvium. It is believed that the unweathered igneous formations below the water table aquifer, act as an acquaclude preventing for water percolating into the older sand formations.

As discussed in Section 2.6, groundwater in the underlying igneous formations is believed to reside at depths more than a thousand feet below the ground surface. Evidence also indicates the deep groundwater is compartmentalized due to the architecture of the associated fault zones and fracture networks (Morris, 1986). There are no known wells within the Paleozoic limestones and quartzites and, based on information reviewed, groundwater from these formations has not historically been used for domestic or other purposes. For these reasons the scope of the groundwater RI did not include investigation of groundwater available in the underlying sedimentary rock formations.

3.3 Screening-Level Human Health Risk Evaluation

Groundwater and surface water data were compared with applicable regulatory criteria and standards in a screening-level human health risk evaluation to identify human health COPCs. The following sections describe the regulatory standards and criteria that were used:

3.3.1 Surface Water

The State of Utah Administrative Code provides standards for "waters of the state," which are defined as "all streams, lakes, ponds, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, public or private, which are contained within, flow through, or border upon this state or any portion of the state" (Utah, 2009). For surface waters, the State of Utah has developed State Designated Use codes which are applied to surface waters based on surface water characteristics and potential uses and provide numeric standards. The applicable Utah State Designated Use Codes and descriptions of the codes that are applicable to Tanner Creek and its tributaries under Rule R317-2 of the Utah Administrative Code (UAC) are provided in Table 3-1.

For Tanner Creek and tributaries, which includes Eureka Gulch, the use designations include 2B (secondary recreation), 3E (severely habitat-limited waters) and 4 (agricultural). Of these designations, the agricultural use code lists numeric criteria for metals and a secondary recreation standard for pH. Severely habitat-limited water standards are narrative standards designed to protect these waters for aquatic wildlife, and are therefore not applicable to human health.

Table 3-1
Numeric Criteria for Surface Water

Chemical	Concentration micrograms per liter (μg/L)	Applicable Use Designation
Arsenic	100	Agricultural (4)
Cadmium	10	Agricultural (4)
Chromium	100	Agricultural (4)
Copper	200	Agricultural (4)
Lead	100	Agricultural (4)
Selenium	50	Agricultural (4)
pH	6.5-9.0	Recreational (2B)

3.3.2 Groundwater

Groundwater data was compared to the following human health screening criteria:

- State of Utah Groundwater Quality Standards (GWQS), including the Water Quality Standards for Agricultural Use.
- National Primary Drinking Water Standards Maximum Contaminant Levels (MCLs) or National Primary Drinking Water Standards Action Levels (Action Levels) for groundwater (EPA, 2006).
- EPA Region 9 Preliminary Remediation Goals (PRGs). PRGs are for guidance only and are not legally enforceable.

The Utah GWQS for metals are equal to the MCL's/Action Levels, with the exception of arsenic which is less stringent. The Utah Water Quality Standards for Agricultural Use are all equal to or greater than the MCLs/Action Levels. For simplicity, the contaminants will be compared to MCL/Action Levels, which, in aggregate, are more stringent than the Utah GWQS and Water Quality Standards for Agricultural Use. Where no MCL/Action Level or Utah GWQS or Utah Water Quality Standards for Agricultural Use exists, the analytical results for each well will be compared with EPA Region 9 PRGs for tap water (EPA, 2004a). MCLs/Action Levels and Region 9 PRGs are shown in Table 3-2.

Table 3-2
Numeric Criteria for Groundwater

Metal	MCL (µg/L)	EPA Region 9 PRG (µg/L)
Aluminum (Al)	NA[1]	**3,600**[2]
Antimony (Sb)	**6**	15
Arsenic (As)	**10**	0.0045
Barium (Ba)	**2,000**	2,600
Beryllium (Be)	**4**	73
Cadmium (Cd)	**5**	18
Chromium (Cr)	**100**	NA
Chromium VI	NA	**110**
Cobalt (Co)	NA	**730**
Copper (Cu)	**1,300**[3]	1,500
Iron (Fe)	NA	**11,000**
Lead (Pb)	**15**[3]	NA
Manganese (Mn)	NA	**880**
Mercury (Hg)	**2**	11
Nickel (Ni)	NA	**730**
Selenium (Se)	**50**	180
Silver (Ag)	NA	**180**
Thallium (Tl)	**2**	2.4
Vanadium (V)	NA	**36**
Zinc (Zn)	NA	**11,000**

Notes:
1. NA indicates that no standard or guidance value has been established
2. **Bold** text indicates applicable standard or guidance values.
3. For this metal, the National Drinking Water Quality Standard is an Action Level

4.0 GW/SW REMEDIAL INVESTIGATION FIELD ACTIVITIES

4.1 Surface Water Investigation Activities

Surface water characterization and investigation activities were initiated in 2007 to support this GW/SW RI as well as the Baseline Ecological Risk Assessment for the Eureka Mills Superfund Site (SRC, 2009). Between May and September 2007, Site surface water features were monitored for the presence of water. Monitoring stations were selected within ephemeral surface water body locations that were most likely to retain water following a rainfall event. Monitoring locations identified as K1 through K3 and W1 through W10 are shown on Figure 2-4. A photograph log collected in 2009 for the surface water stations is contained in Appendix B.1. Each of these locations was monitored for the presence of water approximately 24 hours after a rainfall event. A sampling event occurred after a rainfall event when surface water was available for collection. Table 4-1 provides a record of rainfall during the monitoring period and a summary of sampling events, respectively. Rainfall data was collected from the website www.weatherbug.com, which was monitored by field personnel at the Site. Field data notes are included in Appendix B.2.

Table 4-1
Summary of Rainfall Data and Sampling

Date of Rain Event	Inches of Rain	Surface Water Sample Collection Date	Surface Water Stations Sampled
05/03/07	0.14		
05/04/07	0.04	05/04/07	K1, K2
05/06/07	0.03		
05/21/07	0.13		
05/23/07	0.05		
06/05/07	0.03		
06/06/07	0.74	06/07/07	K1, K2, K3, W5
07/25/07	0.29	07/25/07 & 07/26/07	K1, K2 & W5
08/01/07	0.28		
08/02/07	0.15		
08/03/07	0.02		
08/14/07	0.02		
08/15/07	0.01		
08/18/04	0.19		
08/19/07	0.02		
08/23/07	0.03	08/24/07	W5
08/26/07	0.05	08/28/07	W5
09/02/07	0.09		
09/03/07	0.01		
9/4/2007	0.03		
9/5/2007	0.22		
9/22/2007	0.40		
9/23/2007	0.05	09/23/07	W4

4.1.1 Knight's Spring Pond

Surface water samples from Knight's Spring Pond, which contains water year round, were collected for three consecutive months following rainfall events. Samples were collected from two locations in the pond: near the southeast corner and near the northwest corner. These locations were designated K1 and K2, respectively.

During the June 2007 sampling event, it was discovered that a small embankment had been constructed a few hundred feet downgradient of Knight's Spring Pond, apparently to provide an additional water source for sheep that graze in the area. A sample was collected from the pond that formed behind the embankment and designated as location "K3".

Samples were obtained by dipping the sample container below the water surface, two to three feet from the edge of the pond. At the sample locations the depth of water was less than one foot and the samples were collected from throughout the water column.

4.1.2 Knightsville Sedimentation Ponds

Two stations located in the sedimentation ponds designated W1 and W2 were monitored for the presence of standing surface water and the presence of sediment material over a four month period (May-September 2007). No surface water samples were collected from the sedimentation ponds during the 2007 field season due to insufficient water in either sedimentation pond during the monitoring period. It is noted; however, that since construction of the ponds in 2004, water has been observed in the sediments ponds following snowmelt in the Spring by the Site Remedial Action Project Staff.

4.1.3 Eureka Gulch

Eight stations in Eureka Gulch (W3 – W10) were monitored for the presence of surface water during a four month period (May – September 2007). Of these eight stations, two (W4 and W5) were found to contain surface water for a period of at least 24 hours after a rain event and were sampled during the field season. At station W4 (upper Eureka Gulch), surface water was observed in a small puddle, less than five feet in diameter and a few inches deep, after one rain event. A sample was collected on this occasion. At station W5 (lower Eureka Gulch), surface water was found on four occasions after rain events, also in a small puddle less than five feet in diameter and a few inches deep. Surface water samples were collected from this location after each of these occasions.

Sampling was completed by dipping the sample bottle into the puddle. As a result of the size and shallow nature of the puddles the surface water collected was often turbid.

4.2 Groundwater Investigation Activities

4.2.1 Review of Available information

Information on the number and use of private wells within the Site boundaries was collected from the State of Utah and private owners. The information collected is presented in Section 2.7.5 of this report as part of the Site Characterization.

Information on Eureka City public drinking supply wells was collected to provide additional information on local geology and to assess whether the Eureka City public drinking supply had a potential to be impacted by historic mining activities at the Site. The City of Eureka utilizes two sources for its drinking water; a high capacity well west of Eureka in the Tintic Valley, and a system of five wells (Doliner, Blue Rock, Eureka Hill, Vulcan, and Eagle Wells) located in east of Eureka, towards the now abandoned township of Homansville. The following paragraphs summarize the information collected on the Eureka drinking water sources.

4.2.1.1 Tintic Junction Well

The Tintic Junction Well is a 12" diameter, 450 feet deep well, located near Tintic Junction, approximately 2 miles from the western edge of Eureka. The well was constructed in 2002 and is pumped to Eureka through an 8" pipeline. The well and pipeline is capable of supplying 280 gallons per minute (gpm) of water to Eureka. This flow volume is greater than the required capacity of 251 gpm calculated in 2001 (Wall, 2001).

Tintic Junction is located in the Tintic Valley at an elevation about 500 feet lower than the western edge of Eureka. Topographically, the Tintic Valley and the East Tintic Mountain Range (the range in which Eureka is located) is located on the western edge of the Basin and Range Province, which covers much of the southwestern United States. The Basin and Range Province is typified by elongated north-south trending arid valleys bounded by mountain ranges. Geologically, basins are typically covered by rock debris and sediments from erosion of the range. According to Mabey, Morris, 1967, the Tintic Valley is filled with an irregular thickness of fanglomerate, volcanic debris, lacustrine sediments, and alluvium to a depth of up to 7000 feet. Review of boring logs from the Tintic Valley indicates thick layers of gravel, silty sand, and gravel and boulders to the depth of the borings (450 feet).
A pump test conducted on the new Mammoth Well, located in the Tintic Valley approximately ¼ of a mile from the City of Eureka Tintic Junction Well, was conducted after installation in 2003. The pump test reported a transmissivity of approximately 2,000 gallons per day-feet and a static groundwater level approximately 300 feet below ground surface (Anderson, 2004).

4.2.1.2 Homansville Wells

A system of five wells (Doliner, Blue Rock, Eureka Hill, Vulcan, and Eagle Wells) located in east of Eureka, towards the now abandoned township of Homansville. These wells are located east of the topographical divide that separates Juab County (to the west) and Utah County (to the east). This topographical divide is also the boundary between drainage basins regulated by the State of Utah, with the Sevier River Basin to the east and the Utah Lake Drainage Basin to the west. The wells are limited, based on water rights, to providing a maximum of approximately 79 (gpm) of water. The City of Eureka does not keep records on the amount of water it pumps from these wells. Project operations in the area indicate that only two of the five wells are currently operational. Table 4-2 provides well data for each of the five wells.

Table 4-2
Data for Eureka Wells East of Eureka

	Doliner	Blue Rock	Eureka Hill[1]	Vulcan	Eagle
Wellhead Elevation (feet)	6228	6180	6312	6300	6425
Total Depth of Well (feet)	250	35	120	100	200
Depth of Static Water Below Ground Surface (feet) [2]	14	12	12	24	12
Casing Diameter (inches)	8	48	8	8	8 & 12
Casing Type	Steel	RCP[3]	Steel	Steel	Steel

Source: Eureka City Wells, Drinking Water Source Protection Plan, May 1999 (Wall, 1999)
Notes
1. The Eureka Hill Well was originally a 4' X 8' X 120' deep timber lined shaft. It is connected by a horizontal shaft, 65 feet below the ground surface, to a second Eureka Hill Well, which is now abandoned.
2. April 26, 1999
3. RCP = Reinforced Concrete Pipe

Review of the boring logs and well drilling records available indicate that all of the wells are drilled into the same igneous, volcanic rock formation as the wells found within the Town of Eureka.

As part of the "Drinking Water Source Protection Plan" (Source Protection Plan) prepared for these wells (Wall, 1999), all of these wells were considered to be within the same aquifer and the aquifer characteristics were estimated. It was noted in the Source Protection Plan that pump tests were not practical because each well pumps directly into a distribution system and there was no means to isolate wells from the distribution system. The estimation considered water movement occurred through fractured rock and faults. Table 4-3 provides a summary of the estimated aquifer characteristics. These values indicate generally low aquifer transmissivity.

Table 4-3
Aquifer Characteristics, Well Field East of Eureka

Hydraulic Conductivity	1.5 ft/day
Transmissivity	50 ft^2/day
Hydraulic Gradient	0.0653 ft/ft
Porosity	5%
Saturated Aquifer Thickness	33 feet
Aquifer Confinement	Unconfined

4.2.1.3 Use of Private Wells in Eureka

According to City of Eureka officials, all residential properties have been provided taps for to the Eureka public drinking water distribution system. To date, EPA has remediated or prepared plans for remediation at approximately 85% of the private properties in Eureka. Because of the intrusive nature of the residential remediation, the location of the drinking water supply line to the house, water meter, and any wells are identified during the preparation of plans for remediation. To date, no resident has been found to be using a private well as a drinking water source. Functioning private wells are generally used for watering lawns or are not in use.

4.2.1.4 Data from Eureka Drinking Water Wells in Homansville

State of Utah regulations (R309-205-5(3) (a)) requires periodic testing of public drinking water supply sources for inorganic chemicals. Table 4.4 provides summary statistics of the metal in groundwater analytical data for Eureka's Homansville Wells, which was obtained from the State of Utah Division of Drinking Water. Note that the State of Utah does not keep reliable information on the location the samples are collected because it considers the entire data set representative of the drinking water source. Refer to Appendix E for tables containing the data obtained from the State of Utah.

The City of Eureka Water Supply Wells located in Homansville (about 1-2 miles northeast of Eureka) are drilled into the same igneous, volcanic rock formation as the wells found within the Town of Eureka. In addition, these wells are located in a separate hydraulic basin from Eureka and, based on soil analysis data collected in Homansville, are not within an area affected by the historic mining activities which occurred in the Tintic Mining District. Based on their location and the similar formation, these wells are ideal for background comparison for the wells in Eureka.

Table 4-4
Metal Concentrations in Groundwater, City of Eureka Homansville Wells

Element	# of Samples	# of Detections	Average Concentration[1] (ug/L)	High Concentration (ug/L)	Standard Deviation
Antimony	14	0	1.2	NA[2]	0.25
Arsenic	32	8	2.3	4	0.89
Barium	33	32	97	190	41
Beryllium	14	0	0.50	NA	0
Cadmium	32	6	0.69	2	0.45
Calcium	8	8	71	85	6.9
Chromium	32	0	2.2	NA	0.74
Chromium, Hex	13	0	2.2	NA	0.56
Copper	20	4	10	20	5.4
Iron	19	9	170	1,230	310
Lead	23	0	2.3	NA	1.5
Magnesium	19	19	16,400	37,000	6,100
Manganese	19	8	10	46	13
Mercury	32	2	0.044	0.7	0.14
Nickel	23	0	4.8	NA	0.94
Potassium	19	19	3.8	6	1.6
Selenium	32	4	1.3	5	1.4
Silver	18	0	0.86	NA	0.23
Thallium	14	0	0.50	NA	0
Zinc	39	51	19	195	15

Notes:
1. Where elements were not detected ½ the detection level was used to compute the average concentration.
2. NA – Not applicable

4.2.2 Monitoring Well Installation Activities

The monitoring wells (designated MW-1, MW-2, MW-3, and MW-4) were installed between September 29 and October 3, 2008. The locations of the monitoring wells are identified on Figure 2-1. Authorization for drilling activities from the State of Utah, Department of Natural Resources, and Division of Water Rights is provided in Appendix B.4. The well driller's report, well logs, and well development reports for each well are provided in Appendices B.5, B.6 and B.7, respectively. Construction details geologic formations encountered during drilling the well installation are summarized in Table 2-1.

Well locations were selected at locations downgradient of mine waste piles with the construction intent of collecting samples. The intent of each of the wells was to place the screen within the surficial groundwater aquifer. At MW-2, groundwater was not encountered during drilling. After increasing the depth of the well to approximately 85 feet, it was decided groundwater would likely enter the well after completion; however, this did not occur. During each of the following groundwater sampling events, the water level in MW-2 was less than 2 feet above the bottom of the well, insufficient to allow sampling. Following the March 2009 event, replacement of the well was considered; however, it was decided that sufficient monitoring points were available and sufficient data had been collected.

4.2.3 Groundwater Sampling Activities

Groundwater sampling activities were conducted during five events:

- Seven private wells, in which access agreements were obtained, were sampled on September 24 and 25, 2007.
- Ten private wells and three of the newly installed monitoring wells were sampled between November 10 and 13, 2008.
- Eight private wells and three monitoring wells were sampled between March 24 and April 30, 2009.
- Ten private wells and three monitoring wells were sampled between November 16 and 18, 2009.
- One private well was sampled on February 12, 2010.

Four additional private wells were identified and sampled during the November 2008; March/April 2009 and November 2009 events. The newly identified private wells are located at 36 West Leadville, 72 West Leadville, 63 East Arlington, and 70 East Main. A groundwater sample was not obtained from monitoring well MW-2 due to insufficient water.

Prior to sampling, each well was purged until the groundwater parameters pH, temperature, conductivity, oxidation reduction potential (ORP) and dissolved oxygen stabilized for three consecutive readings as measured using a Horriba U-22 water quality meter. Private wells with open casings and monitoring wells were purged and sampled using either a peristaltic GeoPump or stainless steel bladder pump with dedicated tubing. Existing well pumps were used to purge the other private wells and samples were obtained from a wellhead spigot.

Once the groundwater parameters stabilized, two unfiltered samples were collected from each of the private wells. Two filtered and two unfiltered samples were collected from the monitoring wells. The samples were placed into laboratory-supplied containers, preserved with nitric acid, and placed on ice. The groundwater monitoring/sampling forms completed during the field activities are provided in Appendix A.3.

4.2.3.1 Issues Encountered During Sampling Activities

Minor issues including inability to access previously sampled private wells, malfunctioning sampling equipment and sample preservation errors were encountered during the groundwater sampling events. The incidents are described in further detail below.

November 2008 Event

The following issues occurred during the November 2008 sampling event:

- Insufficient water in monitoring well MW-2 to collect sample.
- Private well located at 151 East Godiva was not sampled at the request of the owner.
- Turbidity sensor was not operating correctly, so turbidity was monitored visually.

March 2009 Event

The following issues occurred during the March/April 2009 sampling event:

- Insufficient water in monitoring well MW-2 to collect sample.
- Private well located at 151 East Godiva was not sampled at the request of the owner.
- Private well located at the Eureka City High School was not sampled due to repairs to a ruptured pipe.
- Private well located at 40 North Spring was not sampled because the owner could not be reached to obtain permission.
- Private wells sampled on March 25, 2009 were incorrectly preserved and were resampled during the April 2009 event. The private wells resampled were located at 110 West Arlington, 514 East Main Street, 72 West Leadville, 144 West Main Street and 36 West Leadville.

November 2009 Event

The following issues occurred during the November 2009 sampling event:

- Insufficient water in monitoring well MW-2 to collect sample.
- Private well located at 151 East Godiva was not sampled at the request of the owner.

4.2.3.2 Groundwater Elevation Data

The depth to groundwater was measured using a water level meter in each of the monitoring wells and in the private wells whose casings were open and accessible. The groundwater elevation data was used to infer groundwater contours, which are displayed on Figure 4-1. The contours indicate that groundwater generally flows from east to west, with a directional component towards the valley bottom in areas remote from Eureka Gulch. The location and elevation of each well was measured using a Trimble GEO XH GPS unit. Groundwater elevation date is summarized on Table 4-6.

Note that the contours shown on Figure 4-1 assume all of the wells are screened within the same aquifer. Boring logs are not available for the all of private wells used to generate the contours; however, based on the hydrogeologic conditions at the Site, it is likely that all wells are located in the same aquifer. Refer to Section 2.6 of this report for a description of the hydrogeolgic conditions at the Site.

Table 4-6
Groundwater Elevation Data

Groundwater Sample Location	November 2008		March 2009		November 2009	
	Static Water Level (ft bgs)	Static Water Level Elevation*	Static Water Level (ft bgs)	Static Water Level Elevation*	Static Water Level (ft bgs)	Static Water Level Elevation*
110 West Arlington	8.72	6,536.94	6.80	6,538.86	9.60	6,535.86
144 West Main Street	13.6	6,426.81	7.69	6,432.72	13.13	6,427.28
72 West Leadville	10.7	6,481.11	8.12	6,483.69	11.98	6,479.83
63 East Arlington	7.3	6,555.89	4.20	6,558.99	7.94	6,555.25
36 West Leadville	7.95	6,491.67	3.39	6,496.23	10.13	6,489.49
MW-1	34.36	6,360.47	31.25	6,363.58	34.02	6,360.81
MW-2	83.26	6,525.45	83.50	6,525.21	83.61	6,525.10
MW-3	25.55	6,496.60	24.42	6,497.73	34.90	6,322.98
MW-4	61.70	6,549.82	61.68	6,549.84	59.22	6,552.30

* Feet above mean sea level, North American Datum 1927

4.2.3.3 Slug Test Evaluations

Slug tests were performed at monitoring wells MW-1, MW-3, and MW-4 by adding a specified amount of water to the well and monitoring the change in hydraulic head through time to determine near well characteristics. A slug test was not performed at monitoring well MW-2 due to an insufficient amount of water entering the well. Hydraulic Conductivity (K) values were calculated for each monitoring well using the method of Bouwer-Rice (1976), as implemented in the AQTESOLV V.3.02 software package. The monitoring wells were installed in either sandstone (MW-1) or igneous rock (MW-3 and MW-4). The calculated K values were consistent with the published ranges for both sandstone (10^{-8} to 10^{-4} cm/sec) and fractured igneous rock (10^{-6} to 10^{-2} cm/sec). The inferred K values from the slug tests are summarized on Table 4-7. Assumptions, data, and references used to develop the estimates of hydraulic conductivity are provided in Appendix B.8.

Table 4-7
Estimated Hydraulic Conductivity

Monitoring Well Location	Hydraulic Conductivity (K) (cm/sec)	Hydraulic Conductivity (K) (ft/day)
Monitoring Well 1	2.0×10^{-4}	0.6
Monitoring Well 3	1.9×10^{-4}	0.5
Monitoring Well 4	1.7×10^{-4}	0.5

4.2.3.4 Estimated Groundwater Transit Time

Groundwater transit times were calculated between Chief Mine #1 and downgradient monitoring well MW-1, to provide an estimated time in which chemicals of potential concern in groundwater could be expected to migrate from mine waste piles, which are assumed to be pollution sources. Transit time is computed based on the distance of travel and the groundwater velocity. Groundwater flow equations based on Darcy's Law were used to assess groundwater velocity at the Site. Characteristics which effect groundwater velocity include aquifer hydraulic conductivity, groundwater horizontal gradient, and porosity of the aquifer formation. Of these three, estimates for hydraulic conductivity and groundwater horizontal gradient were available from site investigation activities. For porosity, a range of values based on the type of geologic material was used. Monitoring well MW-1 was installed in sandstone, which has a range of 0.05 to 0.3 based on literature values (Freeze and Cherry 1979). Two transit times were calculated based on the low and high range values for porosity. The groundwater transit time between Chief Mine #1 and monitoring well MW-1 was estimated to be within the range of 880 days (2.4 years) to 5,333 days (14.6 years).

This calculated transit time is based on groundwater flow through the aquifer formation and does not account for secondary porosity. Development of secondary porosity through generation of a fracture system often enhances the groundwater velocity.

Assumptions, data, and references used to develop the estimates of transit time are provided in Appendix B.9.

5.0 ANALYTICAL RESULTS

Analysis of all the collected groundwater samples was completed through the USEPA CLP. A summary of all the analytical data provided by the CLP laboratories is provided in Appendix C.

5.1 Surface Water

The surface water samples were packaged and shipped under chain of custody to Sentinel, Inc of Huntsville, Alabama. The laboratory analytical data is provided in Appendix C.1

During sampling events, adequate volume was collected for metals analysis using two methods: Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). In addition, samples were split and one aliquot was field filtered using a 0.45 micrometer filter and a peristaltic pump. On two occasions, only unfiltered samples were collected. This occurred at W5 on June 7, 2007, when insufficient surface water was available for collection of both filtered and unfiltered samples, and at K-3, where sample collection was opportunistic.

Surface water data was compared to numeric criteria for metals which apply to Tanner Creek and its tributaries under Rule R317-2 of the UAC. Use designations listed in UAC for Tanner Creek and tributaries include 2B (recreation), 3E (severely habitat-limited waters) and 4 (agricultural). Of these designations, only the agricultural use code lists numeric criteria for metals. Table 5-1 provides a comparison of the numeric criteria for agricultural use to the results obtained during the surface water sampling and analysis completed at the Site.

Table 5-1
Comparison of Surface Water Analytical Data to Regulatory Criteria

Location	Sample Date	Chemical	Dissolved Metal Concentration (µg/L)*	Utah State Criteria(µg/L)
K1	5/4/07	Arsenic	4.4	100
K1	5/4/07	Cadmium	2.3	10
K1	5/4/07	Chromium	1.9J	100
K1	5/4/07	Copper	1.3J	200
K1	5/4/07	Lead	6.4	100
K1	5/4/07	Selenium	0.67J	50
K2	5/4/07	Arsenic	4.4	100
K2	5/4/07	Cadmium	1.5	10
K2	5/4/07	Chromium	1.8J	100
K2	5/4/07	Copper	1.4J	200
K2	5/4/07	Lead	3.6	100
K2	5/4/07	Selenium	5U	50
K1	6/7/07	Arsenic	5.4	100
K1	6/7/07	Cadmium	1U	10
K1	6/7/07	Chromium	2.1	100
K1	6/7/07	Copper	1.9J	200
K1	6/7/07	Lead	6.5	100
K1	6/7/07	Selenium	5U	50
K2	6/7/07	Arsenic	5.8	100
K2	6/7/07	Cadmium	1	10
K2	6/7/07	Chromium	2.1	100
K2	6/7/07	Copper	1.6	200
K2	6/7/07	Lead	9	100
K2	6/7/07	Selenium	5	50
K1	7/25/07	Arsenic	2.9	100
K1	7/25/07	Cadmium	0.051J	10
K1	7/25/07	Chromium	0.14J	100
K1	7/25/07	Copper	0.74J	200
K1	7/25/07	Lead	1.4	100
K1	7/25/07	Selenium	5U	50
K2	7/25/07	Arsenic	2.7	100
K2	7/25/07	Cadmium	0.032J	10
K2	7/25/07	Chromium	0.29J	100
K2	7/25/07	Copper	0.91J	200
K2	7/25/07	Lead	1.3	100
K2	7/25/07	Selenium	5U	50
W5	7/26/07	Arsenic	13.1	100
W5	7/26/07	Cadmium	0.089J	10

Table 5-1
Comparison of Surface Water Analytical Data to Regulatory Criteria (Con't)

Location	Sample Date	Chemical	Dissolved Metal Concentration (µg/L)*	Utah State Criteria(µg/L)
W5	7/26/07	Chromium	1.3J	100
W5	7/26/07	Copper	4.6	200
W5	7/26/07	Lead	1.3	100
W5	7/26/07	Selenium	2.1J	50
W5	8/24/07	Arsenic	12.3	100
W5	8/24/07	Cadmium	0.058J	10
W5	8/24/07	Chromium	1.5J	100
W5	8/24/07	Copper	3.8	200
W5	8/24/07	Lead	1.7	100
W5	8/24/07	Selenium	1.4J	50
W5	8/28/07	Arsenic	11.8	100
W5	8/28/07	Cadmium	0.084J	10
W5	8/28/07	Chromium	1.5J	100
W5	8/28/07	Copper	4.7	200
W5	8/28/07	Lead	1.1	100
W5	8/28/07	Selenium	1.9J	50
W4	9/23/07	Arsenic	4.6	100
W4	9/23/07	Cadmium	1U	10
W4	9/23/07	Chromium	0.65J	100
W4	9/23/07	Copper	2.5	200
W4	9/23/07	Lead	0.47J	100
W4	9/23/07	Selenium	0.3J	50

Note:
1. * The UAC criteria apply to dissolved metals; therefore the analytical results from filtered samples are displayed.
2. J denotes estimated value

In addition to criteria for agricultural use, the State of Utah regulations for Tanner Creek includes criteria for recreational use. The criteria for recreational use is $6.5<pH<9.0$. Measurements of pH were not collected from samples collected in 2007. To investigate whether Site surface water meets State of Utah recreational criteria, four monitoring events from April 10 to May 1, 2009 were conducted. During each monitoring event, surface water monitoring stations were visually examined for the presence of surface water. Where surface water was present, five samples were collected from the monitoring station and field measurements of pH recorded for each sample. Field measurement of surface water pH was measured using a Horiba U-22.

The arthritic mean of the pH measurements (i.e., the five samples collected from each monitoring station) were calculated and are reported in Table 5-2.

Table 5-2
Comparison of Mean Surface Water pH to Recreational Criteria

Date	Sample Location							
	K1	K2	K3	W1	W2	W4	W5	W6
4/10/2009	6.04	6.49	7.03	7.55	-	-	-	-
4/20/2009	-	-	-	6.64	7.27	7.27	7.60	7.78
4/25/2009	6.53	6.76	6.92	-	-	-	-	-
5/1/2009	6.52	6.64	6.85	7.08	7.50	7.49	7.76	-

Note:
1."-" indicates insufficient water to collect a sample.

5.2 Groundwater

The laboratories utilized for each groundwater sampling event are as follows:

- Samples collected during the September 2007 event were shipped to DataChem Laboratories, Inc. of Salt Lake City, Utah (DataChem) on September 26, 2007.
- Samples collected during the November 2008 event were shipped to A4 Scientific, Inc., of The Woodlands, Texas between November 13 and 17, 2008.
- Samples collected during the March/April 2009 event were shipped to ChemTech Consulting Group, Inc. of Mountainside, New Jersey between March 26 and May 1, 2009.
- Samples collected during the November 2009 event were shipped to Bonner Analytical Testing Company of Hattiesburg, Mississippi on November 19, 2009.
- Samples collected during the February 2010 event were shipped to A4 Scientific, Inc., of The Woodlands, Texas on February 12, 2010.

All the groundwater samples were shipped under chain of custody. One sample from each well was designated for metal analysis using ICP-AES methods and the other for metals analysis using ICP-MS methods. The results displayed in the analytical tables are from the ICP-MS analyses except aluminum, calcium, iron, magnesium, mercury, potassium, and sodium, which are not quantified in the ICP-MS analysis and were analyzed using the ICP-AES method. Laboratory results for the September 2007, November 2008, March/April 2009, November 2009 and the February 2010 events are provided in Appendices C.2, C.3 C.4, C.5 and C.6, respectively. The analytical results for the groundwater sampling events were compared to the Federal MCLs/Action Levels or EPA Region 9 PRGs for tap water (EPA, 2004a) or health-based action levels where no MCL Action Level was available.

5.2.1 Private Wells

Analytical results for the private wells from the November 2009 sampling events and comparison of the September 2007, November 2008, March/April 2009, November 2009 and February 2010 are summarized in Table 5-3.

Table 5-3
Comparison of Analytical Results for Private Wells – 9/2007 to 2/2010

Metal	*Screening Criteria (µg/L)*	63 East Arlington			110 West Main St.				70 East Main		
		Nov-08	Mar-09	Nov-09	Sep-07	Nov-08	Mar-09	Nov-09	Nov-08	Mar-09	Nov-09
Aluminum (Al)	*3,600*	200U	32.1J	200 U	222U	200U	7.7J	200 U	200U	17J	200 U
Antimony (Sb)	***6***	2U	0.48J	0.37 J	0.12J	2U	2U	2.0 U	2U	0.59J	2.0 U
Arsenic (As)	***10***	3.3	2.8	1.6	0.76J	1.4	1U	0.28 J	1.7	1.2	0.83 J
Barium (Ba)	***2,000***	56.9	101	85.8	50.8	66.9	57.1	35.2	82.5	92.5	67.0
Beryllium (Be)	***4***	1U	1U	1.0 U	1U	1U	1U	1.0 U	1U	1U	1.0 U
Cadmium (Cd)	***5***	1U	0.09J	0.031 J	0.12J	1U	0.08J	0.022 J	1U	1U	0.035 J
Chromium (Cr)	***100***	2U	2U	0.16 J	0.46J	2U	5.1	0.11 J	1.2J	2U	0.23 J
Cobalt (Co)	*730*	1U	1U	0.21 J	0.51J	1U	1U	0.46 J	0.32J	0.34J	0.63 J
Copper (Cu)	***1,300***	1.1J	12.4	1.2 J	4.6	0.92J	15.5	0.55 J	3.8	19.3	4.6
Iron (Fe)	*11,000*	170	64.4J	100 U	7,560	1,750	3,540	1,230	15,200	20,700	21,100
Lead (Pb)	***15***	1.8	7.4	0.98 J	2.2	1U	0.87J	0.19 J	2	4.1	2.5
Manganese (Mn)	*880*	91	25.7	56.5	1,930	1,410	1,120	1,560	165	223	194
Mercury (Hg)	***2***	0.2U	0.2U	0.2 U	0.032J	0.2U	0.2U	0.2 U	0.2U	0.2U	0.2 U
Nickel (Ni)	*730*	0.51J	1.6	2.7	1.9	1U	2.4	2.8	0.53J	1.8	1.9
Selenium (Se)	***50***	5U	5U	5.0 U	0.32J	5U	5U	5.0 U	5U	2.3J	5.0 U
Silver (Ag)	*180*	1U	0.48J	1.0 U	1U	1U	1U	1.0 U	1U	0.11J	0.01 J
Thallium (Ti)	***2***	1U	1U	1.0 U	0.11J	1U	1U	0.048 J	1U	0.077J	1.0 U
Vanadium (V)	*36*	5U	5U	1.3 J	5U	5U	5U	5.0 U	5U	5U	5.0 U
Zinc (Zn)	*11,000*	47.2	65.1	31.8	1,420	80.6	226	102	47,900	33,400	46,700

Table 5-3
Comparison of Analytical Results for Private Wells – 9/2007 to 2/2010 (Con't)

Metal	*Screening Criteria (µg/L)*	110 West Arlington				514 East Main				72 West Leadville		
		Sep-07	Nov-08	Apr-09	Nov-09	Sep-07	Nov-08	Apr-09	Nov-09	Nov-08	Apr-09	Nov-09
Aluminum (Al)	*3,600*	96.8J	200U	36.5J	200 U	222U	200U	36.3J	200 U	200U	78J	200 U
Antimony (Sb)	***6***	0.32J	2U	0.93J	0.31 J	0.1J	2U	2 U	2.0 U	4U	0.63J	0.7 J
Arsenic (As)	***10***	4.3	5	6.9	5.2	0.53J	1.4	1 U	0.48 J	8.9	7.2	9.0
Barium (Ba)	***2,000***	75.3	79.3	71.3	65.3	54.3	49.4	47.3	61.8	214	221	194
Beryllium (Be)	***4***	0.037J	1U	1 U	1.0 U	1U	1U	1 U	1.0 U	2U	1 U	1.0 U
Cadmium (Cd)	***5***	0.16J	1U	1 U	0.14 J	1U	1U	1 U	1.0 U	2U	1 U	0.045 J
Chromium (Cr)	***100***	0.33J	2U	1.9J	0.22 J	0.43J	2U	1.5J	0.29 J	4U	1.8J	0.16 J
Cobalt (Co)	*730*	0.11J	1U	0.59J	0.12 J	0.57J	1U	0.11J	0.35 J	2U	0.13J	0.31 J
Copper (Cu)	***1,300***	1.1J	1.9J	3.4	2.0	31	1.1J	2.5	1.3 J	1.2J	3.0	1.7 J
Iron (Fe)	*11,000*	247	100U	35.6J	100 U	2,900	3,640	2,890	5,990	100U	56.8J	100 U
Lead (Pb)	***15***	0.75J	0.61J	0.46J	0.37 J	1.8	1U	0.31J	0.096 J	2U	0.77J	0.46 J
Manganese (Mn)	*880*	0.72J	117	9.4	2.8	307	253	169	275	10.8	2.2	0.88 J
Mercury (Hg)	***2***	0.048J	0.2U	0.2 U	0.2 U	0.052J	0.2U	0.2 U	0.2 U	0.2U	0.2 U	0.2 U
Nickel (Ni)	*730*	1.1	0.48J	1.4	4.0	1.7	1U	0.89J	1.3	2U	2.0	2.5
Selenium (Se)	***50***	0.56J	5U	5 U	0.61 J	0.41J	5U	5 U	5.0 U	10U	1.5J	1.2 J
Silver (Ag)	*180*	1U	1U	0.13J	1.0 U	1U	1U	0.047J	1.0 U	2U	0.1J	1.0 U
Thallium (Ti)	***2***	0.34J	1U	0.097J	0.068 J	0.046J	1U	1 U	1.0 U	2U	1 U	0.058 J
Vanadium (V)	*36*	6.3	4.2J	4.6J	7.7	5U	5U	5 U	5.0 U	4.5J	7.9	7.2
Zinc (Zn)	*11,000*	26.9	38.7	28.8	33.2	37.5	30.9	12.9	5.7	11.1	12.1	6.5

Table 5-3
Comparison of Analytical Results for Private Wells – 9/2007 to 2/2010 (Con't)

Metal	*Screening Criteria (µg/L)*	144 West Main St.					36 West Leadville			High School Well		
		Sep-07	**Nov-08**	**Apr-09**	**Nov-09**	**Feb-10**	**Nov-08**	**Apr-09**	**Nov-09**	**Sep-07**	**Nov-08**	**Nov-09**
Aluminum (Al)	*3,600*	143J	200U	46.1J	200 U	200U	200U	32.9J	200 U	43J	200U	200 U
Antimony (Sb)	***6***	1.4J	2U	1.2J	0.37J	0.64	4U	0.35J	0.29 J	0.21J	2U	0.22 J
Arsenic (As)	***10***	19.7	6.2	3.5	4.9	3.9	7.2	4.7	5.4	4.2	3.1	1.5
Barium (Ba)	***2,000***	202	268	280	237	196	225	213	207	54	40.9	34.5
Beryllium (Be)	***4***	0.025J	1U	1U	1U	1U	2U	1 U	1.0 U	2.4	1U	0.51 J
Cadmium (Cd)	***5***	1.6	1U	0.59J	0.17J	1U	2U	1 U	0.042 J	1U	1U	0.11 J
Chromium (Cr)	***100***	0.75J	2U	1.2J	0.21J	2U	4U	1.4J	0.17 J	0.66J	1.2J	0.44 J
Cobalt (Co)	*730*	1	1U	1U	0.3J	1U	2U	1 U	0.38 J	0.19J	0.34J	0.37 J
Copper (Cu)	***1,300***	14.8	1.7J	2.3	1.3J	1.5J	1.7J	2.8	1.9 J	10.2	1.1J	2.2
Iron (Fe)	*11,000*	6,200	118	36.8J	41.9 J	100U	100U	30.6J	100 U	9,040	8,660	3,640
Lead (Pb)	***15***	230	7.9	4.4	4.5	3.4	2U	0.49J	0.47 J	0.98J	1.3	5.4
Manganese (Mn)	*880*	174	1.3	1.7	0.82J	1U	1J	1.6	3.3	140	297	285
Mercury (Hg)	***2***	0.13J	0.2U	0.2U	0.2U	0.2U	0.2U	0.2 U	0.2 U	0.037J	0.2U	0.2 U
Nickel (Ni)	*730*	4.5	1U	1.8	2.2	0.41J	0.59J	2.0	2.8	4.8	0.81J	2.1
Selenium (Se)	***50***	1.2J	5U	2.2J	1.1J	1.3J	10U	1.5J	0.76 J	5U	5U	5.0 U
Silver (Ag)	*180*	0.65J	1U	0.087J	0.031J	1U	2U	0.057J	0.07 J	1U	1U	0.016 J
Thallium (Ti)	***2***	0.96J	1U	0.14J	0.86J	1U	2U	1 U	0.039 J	0.37J	1U	0.51 J
Vanadium (V)	*36*	14.1	4.4J	3.3J	6.4	4.8J	5J	2.5J	6.0	5U	5U	0.6 J
Zinc (Zn)	*11,000*	154	92.7	57.3	17.7	18.2	5.9	10.4	4.7	68.4	133	61.8

Table 5-3
Comparison of Analytical Results for Private Wells – 9/2007 to 2/2010 (Con't)

Metal	*Screening Criteria (µg/L)*	40 Spring St.			151 East Godiva
		Sep-07	Nov-08	Nov-09	Sep-07
Aluminum (Al)	*3,600*	222U	200U	200 U	222U
Antimony (Sb)	***6***	0.12J	2U	0.17 J	0.18J
Arsenic (As)	***10***	0.27J	1.7	0.8 J	1.6
Barium (Ba)	***2,000***	39	45.1	46.5	61.8
Beryllium (Be)	***4***	1U	1U	1.0 U	1U
Cadmium (Cd)	***5***	1U	1U	1.0 U	1U
Chromium (Cr)	***100***	0.26J	2U	0.12 J	0.22J
Cobalt (Co)	*730*	0.17J	1U	0.19 J	0.19J
Copper (Cu)	***1,300***	0.91J	0.9J	27.0	0.78J
Iron (Fe)	*11,000*	603	5,990	6,920	313
Lead (Pb)	***15***	0.17J	1U	5.7	0.58J
Manganese (Mn)	*880*	19.9	68.8	68.8	8.5
Mercury (Hg)	***2***	0.047J	0.2U	0.2 U	0.2U
Nickel (Ni)	*730*	1.8	1U	1.7	1.5
Selenium (Se)	***50***	0.26J	5U	5.0 U	0.77J
Silver (Ag)	*180*	1U	1U	1.0 U	1U
Thallium (Ti)	***2***	0.11J	1U	0.13 J	0.11J
Vanadium (V)	*36*	5U	5U	0.48 J	1.6J
Zinc (Zn)	*11,000*	61.8	33	36.3	169

Notes:
1. All results reported in µg/L
2. U denotes compound not detected at the detection level
3. J denotes estimated value
4. Shading denotes exceedance of applicable screening criteria.
5. "-"indicates that groundwater samples were not collected during that sampling event
6. **Bold** text indicates screening criteria is the National Primary Drinking Water Standards Maximum Contaminant Level or Action Level. Where the text is not bold, no Maximum Contaminant Level/Action Level exists and the EPA Region 9 Preliminary Remediation Goal is the screening criteria.

5.2.1 Monitoring Wells

Analytical results for the monitoring wells from the November 2008, March/April 2009, and November 2009 are summarized in Table 5-4.

Table 5-4
Comparison of Analytical Results for Monitoring Wells – 11/2008 to 11/2009

Metals	*Screening Criteria (µg/L)*	MW-01 Unfiltered			MW-01 Filtered			MW-04 Unfiltered			MW-04 Filtered		
		Nov-08	Mar-09	Nov-09	Nov-08	Mar-09	Nov-09	Nov-08	Mar-09	Nov-09	Nov-08	Mar-09	Nov-09
Aluminum (Al)	*3,600*	200U	21.3J	200 U	200U	15.6J	200U	134J	568	314	200U	8.1J	200 U
Antimony (Sb)	***6***	2U	0.49J	0.29 J	2U	0.47J	0.35 J	2U	0.65J	0.3 J	2U	0.60J	0.3 J
Arsenic (As)	***10***	2.2	0.66J	1.2	2.1	0.88J	1.1	3.4	1.9	1.4	3.2	0.88J	1.2
Barium (Ba)	***2,000***	263	208	183	269	202	185	84.2	65.5	44.0	85.4	48	36.5
Beryllium (Be)	***4***	1U	1U	1.0 U	1U	1U	1.0 U	1U	1U	1.0 U	1U	1U	1.0 U
Cadmium (Cd)	***5***	1U	0.12J	0.058 J	1U	0.11J	0.054 J	0.73J	0.72J	0.34 J	0.73J	0.52J	0.31 J
Chromium (Cr)	***100***	2U	0.19J	0.6 J	2U	0.27J	0.5 J	2U	0.12J	0.39 J	2U	2.8	0.16 J
Cobalt (Co)	*730*	1U	1U	0.3 J	1.8	0.27J	0.3 J	2.4	6.4	4.1	3.5	4.6	3.5
Copper (Cu)	***1,300***	1.3J	12.4	1.1 J	1.2J	13.3	1.1 J	1.7J	14	2.0 J	1.5J	11.3	1.8 J
Iron (Fe)	*11,000*	100U	34.1J	100 U	100U	31.5J	11.9 J	94.9J	734	238	100U	32.1J	21.5 J
Lead (Pb)	***15***	0.43J	0.68J	0.17 J	1U	0.61J	0.086 J	4.1	10.1	4.4	0.87J	2	2.4
Manganese (Mn)	*880*	165	46.7	5.4	172	47.7	3.6	429	1,400	738	391	1,190	678
Mercury (Hg)	***2***	0.2U	0.2U	0.2 U	0.2U	0.2U	0.2 U	0.2U	0.2U	0.063 J	0.2U	0.2U	0.2 U
Nickel (Ni)	*730*	2.7	3.2	2.6	2.6	3.4	2.6	3.9	10.1	9.0	4.7	10	8.7
Selenium (Se)	***50***	5U	1.3J	1.4 J	5U	1.9J	1.5 J	4.3J	7.2	4.9 J	4.7J	7.1	4.0 J
Silver (Ag)	*180*	1U	1U	0.0098 J	1U	1U	0.024 J	1U	0.07J	0.012 J	1U	0.097J	1.0 U
Thallium (Ti)	***2***	1U	1U	0.041 J	1U	1U	0.4 J	1U	0.09J	0.072 J	1U	0.07J	0.13 J
Vanadium (V)	*36*	1.8J	5U	2.3 J	1.7J	0.93J	2.3 J	5U	5U	1.5 J	5U	5U	1.0 J
Zinc (Zn)	*11,000*	5.3	18.7	2.8	4.2	19.7	2.4	33.4	1,020	46.7	30.5	77.4	42.8

Table 5-4
Comparison of Analytical Results for Monitoring Wells – 11/2008 to 11/2009 (Con't)

Metals	*Screening Criteria (µg/L)*	MW-03 Unfiltered				MW-03 Filtered			
		Nov-08	Mar-09	Apr-09	Nov-09	Nov-08	Mar-09	Apr-09	Nov-09
Aluminum (Al)	*3,600*	200U	24.8J	46.6J	200 U	200U	173J	35.6J	200 U
Antimony (Sb)	***6***	2U	0.41J	2 U	0.15 J	2U	0.37J	2 U	2.0 U
Arsenic (As)	***10***	2.1	1.2	1 U	0.57 J	1.9	0.5J	1 U	0.32 J
Barium (Ba)	***2,000***	110	86.2	69.2	64.2	110	85.6	68.6	65.1
Beryllium (Be)	***4***	1U	1U	1 U	1.0 U	1U	1U	1 U	1.0 U
Cadmium (Cd)	***5***	2.9	0.65J	0.23J	0.19 J	2.5	1U	0.11J	0.058 J
Chromium (Cr)	***100***	2U	2U	1.5J	0.21 J	2U	2U	1.6J	0.11 J
Cobalt (Co)	*730*	0.35J	0.43J	0.17J	0.28 J	2.2	0.48J	0.13J	0.28 J
Copper (Cu)	***1,300***	2.7	13.5	1.8J	0.72 J	1.1J	10.6	1.4J	0.37 J
Iron (Fe)	*11,000*	51.7J	51.7J	50.7J	50.8 J	100U	125	34.8J	42.9 J
Lead (Pb)	***15***	19.2	5.7	5.8	6.4	4.1	0.64J	1.6	0.096 J
Manganese (Mn)	*880*	126	212	121	144	133	199	124	113
Mercury (Hg)	***2***	0.2U	0.2U	0.2 U	0.2 U	0.2U	0.2U	0.2 U	0.2 U
Nickel (Ni)	*730*	7	3.9	1.7	2.6	6.5	4	1.9	2.2
Selenium (Se)	***50***	5U	5U	5 U	5.0 U	5U	5U	5 U	5.0 U
Silver (Ag)	*180*	1U	1U	0.087J	0.019 J	1U	1U	1 U	1.0 U
Thallium (Ti)	***2***	1U	1U	1 U	1.0 U	1U	1U	1 U	0.25 J
Vanadium (V)	*36*	5U	5U	5 U	0.53 J	5U	5U	5 U	5.0 U
Zinc (Zn)	*11,000*	160	53.5	18.1	8.3	136	50.8	12.2	2.5

Notes:
1. All results reported in µg/L
2. U denotes compound not detected at the detection level
3. J denotes estimated value
4. Shading denotes exceedance of applicable screening criteria.
5. "-"indicates that groundwater samples were not collected during that sampling event
6. **Bold** text indicates screening criteria is the National Primary Drinking Water Standards Maximum Contaminant Level or Action Level. Where the text is not bold, no Maximum Contaminant Level/Action Level exists and the EPA Region 9 Preliminary Remediation Goal is the screening criteria.

5.3 Data Review

Please note two inconsistencies with the data presentation that occurred during the November 2008 sampling event:

- Samples collected from 70 East Main (LDS Church) were incorrectly labeled in the field and subsequent data reports as being collected from 70 West Main.
- Samples collected from 514 East Main (VJ's Store) were incorrectly labeled in the field and subsequent data reports as being collected from the property owners address of 159 Church Street.

The data tables presented in this report indicate the true sample location.

5.3.1 Data Validation

The analytical data collected at Site were evaluated against the requirements established in the Quality Assurance Protection Plan (QAPP) (SRC, 2007). A data review was performed on the analytical data received in accordance with *EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 2004b). Appendix D provides data reviews performed by Diane Short and Associates. Note that data reviews include validation of all analytical data sets collected for the GW/SW RI and also to support the Site Baseline Ecological Risk Assessment, thus do not focus exclusively on surface and groundwater data. The reviews concluded that the data are considered fully useable for project purposes with consideration of data qualifiers.

6.0 SUMMARY OF FINDINGS

6.1 Discussion of Surface Water Findings

Based on field observations, it was concluded that surface water is typically only present during and following rainfall events within the Site, with the exception of Knight's Spring Pond and at W5. It was suspected that the daily release of several thousand gallons of decontamination water associated with Site remedial activities into Eureka Gulch was reaching monitoring station W5. As a result, twice daily observations of this monitoring station were made between September 11 and 13, 2007, a period when no rain occurred. Based on these observations it was concluded that the presence of surface water at station W5 is mostly due to the release of decontamination water. None of the surface water samples analyzed exceeded the applicable State of Utah surface water criteria for dissolved metals.

The arithmetic mean of the pH for samples analyzed from stations K1 and K2 on April 10, 2009 were outside of and below the State of Utah recreational criteria range of $6.5 < pH < 9.0$. Two additional monitoring events at these locations indicated the arithmetic mean from these two locations were within the criteria for recreational use.

6.2 Discussion of Groundwater Analytical Results

Groundwater samples were collected in 2007, 2008, 2009, and 2010 from existing wells and monitoring wells. Table 6-1 summarized the chemicals detected at concentrations exceeding screening levels.

Table 6-1
Chemicals Exceeding Screening Criteria – Groundwater

Metals	Minimum Detected Concentration Above Screening Criteria	Maximum Detected Concentration Above Screening Criteria	Samples Detected Above Screening Criteria	Screening Criteria
Arsenic	19.7 μg/L	19.7 μg/L	1 of 56	**10 μg/L**[1]
Lead	19.2 μg/L	230 μg/L	2 of 56	**15 μg/L**[2]
Manganese	1,120 μg/L	1,930 μg/L	6 of 56	**880 μg/L**[3]
Iron	15,200 μg/L	20,700 μg/L	3 of 56	**11,000 μg/L**[3]
Zinc	33,400 μg/L	47,900 μg/L	3 of 56	**11,000 μg/L**[3]

Notes:
1Screening criteria is the National Primary Drinking Water Standards MCL
2 Screening criteria is the National Primary Drinking Water Standards Action Level
3 Screening criteria is the EPA Region 9 Preliminary Remediation Goal

A summary of the occurrences of metals above the screening level in private wells is provided in Table 6-2 and in monitoring wells in Table 6-3. This analytical data is also presented on Figure 6-1. A discussion of the analytical results is provided below.

Table 6-2
Metal Concentrations Above Screening Level – Private Wells

Metal	***Screening Criteria (μg/L)***	**110 West Main St.**				**70 East Main**			**144 West Main St.**				
		Sep-07	**Nov-08**	**Mar-09**	**Nov--09**	**Nov-08**	**Mar-09**	**Nov-09**	**Sep-07**	**Nov-08**	**Apr-09**	**Nov-09**	**Feb-10**
Arsenic	***10***	0.76J	1.4	1U	0.28J	1.7	1.2	0.83J	19.7	6.2	3.5	4.9	3.9
Lead	***15***	2.2	1U	0.87J	0.19J	2	4.1	2.5	230	7.9	4.4	4.5	3.4
Iron	11,000	7,560	1,750	3,540	1,230	15,200	20,700	21,100	6,200	118	36.8J	41.9J	100U
Manganese	880	1,930	1,410	1,120	1,560	165	223	194	174	1.3	1.7	0.82J	1U
Zinc	11,000	1,420	80.6	226	102	47,900	33,400	46,700	154	92.7	57.3	17.7	18.2

Notes:
1. **Bold** text indicates screening criteria is the National Primary Drinking Water Standards Maximum Contaminant Level or Action Level. Where the text is not bold, no Maximum Contaminant Level/Action Level exists and the EPA Region 9 Preliminary Remediation Goal is the screening criteria.
2. Shading indicates metal concentration above screening criteria.
3. U denotes compound not detected at the detection level
4. J denotes estimated value

Table 6-3
Metals Concentrations Above Screening Level – Monitoring Wells

Metal	***Screening Criteria (μg/L)***	**MW-03 Unfiltered**				**MW-04 Unfiltered**			**MW-04 Filtered**		
		Nov-08	**Mar -09**	**Apr-09**	**Nov-09**	**Nov-08**	**Mar-09**	**Apr-09**	**Nov-08**	**Mar-09**	**Apr-09**
Lead	*15*	19.2	5.7	5.8	6.4	4.1	10.1	4.4	0.87J	2	2.4
Manganese	*880*	126	212	121	144	429	1,400	738	391	1,190	678

Notes:
1. **Bold** text indicates screening criteria is the National Primary Drinking Water Standards Maximum Contaminant Level or Action Level. Where the text is not bold, no Maximum Contaminant Level/Action Level exists and the EPA Region 9 Preliminary Remediation Goal is the screening criteria.
2. Shading indicates metal concentration above screening level.
3. J denotes estimated value

<u>Lead</u>

- Lead was detected at a concentration above the Action Level in the private well located at 144 West Main during the September 2007 event. During the November 2008 and March/April, November 2009, and February 2010 sampling events, lead was detected in the samples collected, but at concentrations below the Action Level.
- Lead was also detected in the unfiltered sample collected from MW-3 above the Action Level. The filtered sample from this well had a lead concentration of 4 μg/l,

which is below the Action Level. Lead was detected in the samples collected from MW-3 during the March/April 2009 and November 2009 events, but at concentrations below screening guidelines.

- The two wells with lead detections above the Action Level, 144 West Main and MW-3, are located approximately 1,600 feet apart. One private well, 110 West Main, is located between the two wells did not exhibited lead above the Action Level, providing evidence that the two positive reading are not part of a plume of high lead concentration and may be unrelated.
- Review of the spatial distributions of lead concentrations for the sampling events did not reveal a discernable pattern of lead concentration in the groundwater.

Arsenic

- Arsenic was detected above the MCL level in the private well located at 144 West Main during the September 2007 event. This was the only detection of arsenic above the MCL.

Manganese

- Manganese was detected at a concentration above the PRG in the private well located at 110 West Main Street during the September 2007, November 2008 March/April 2009 and November 2009 events, as well as in the filtered and unfiltered sample collected from MW-4 in March 2009. Manganese was not detected at a concentration above the PRG in monitoring well MW-4 during the November 2009 event.
- According to the EPA's Drinking Water Health Advisory for Manganese (EPA, 2004c), manganese is a naturally-occurring element that can be found ubiquitously in the air, soil, and water, and is an essential nutrient for humans and animals.
- Iron was also found at relatively high concentrations (though not exceeding screening levels) in each of these samples. Manganese and iron are chemically similar and manganese is typically found in water with high iron content. Oxides of these metals commonly accumulate in water pipes, especially when the water is slightly acidic, as is the case in the groundwater at Eureka.
- The source of iron and manganese in groundwater is typically the geologic formation within the aquifer, but corroded iron pipes can also be a source. Another problem that frequently results from iron and manganese in water is iron and manganese bacteria. These non health threatening bacteria feed on iron and manganese and form red-brown (iron) and black-brown (manganese) slime that often cause staining (Wilkes University, 2008). It was noted that the well pipe at 110 West Main Street was rusty and purge water during sampling of this well was noted to be cloudy.

Based on these observations, the source of the manganese may be the presence of manganese bacteria or from pipe corrosion.

Iron and Zinc

- Iron and zinc was detected at a concentration above the PRG in private well located at 70 East Main during the November 2008, March/April 2009 and November 2009 events.
- Iron is an essential mineral for human health and is one of the Earth's most abundant elements. Ingesting iron from drinking water is not directly associated with adverse health effects (EPA, 2009).
- Zinc is also essential to human health and an abundant mineral, although ingestion of high concentrations of zinc can cause be detrimental to human health (ATSDR, 2005). Concentration of zinc from unfiltered samples collected from wells other than the 70 East Main well averaged approximately 138 µg/l, which is two orders of magnitude lower than the zinc concentration found at the 70 East Main well. High zinc levels in drinking water appear to be isolated to this well.
- A common cause for high zinc concentration in drinking water is corrosion or leaching from piping and fittings. Although there is not direct evidence that this is the source of high zinc at the 70 East Main well, given that this well is the only one that exhibited a high concentration of zinc, it is a plausible explanation.

6.3 Summary and Conclusions

6.3.1 Surface Water

- Knight's Spring Pond is the only permanent surface water body within the Site.
- Analysis of the surface water samples met the Utah State Criteria for agricultural use.
- One of three sampling events conducted at Knight's Spring Pond for pH monitoring indicated a pH level below 6.5, and thus below the State of Utah regulations for recreational use. The pond is relatively small (about 24 feet in diameter and 3-4 feet deep), located remote from residential areas, and shows no signs of recreational use. Although the pond may contain water below Utah recreational regulations, because the pond appears to have no recreational value, it is not likely a threat to human health.
- No additional surface water sampling is recommended.

6.3.2 Groundwater

- Arsenic was found in one of 56 groundwater samples above the MCL in a private well during one event. Subsequent samples from this well had detections of arsenic, but at concentrations below the MCL.
- Lead was found in two of 56 samples above the Action Level; one from a monitoring well and one from a private well. Subsequent samples from these wells had detections of lead, but at concentrations below the Action Level.
- Based on the noted condition of the pipe and purge water, and the ubiquity of manganese, it is suspected that the manganese concentrations that have been found in samples collected from the well at 110 West Main Street are not Site related.
- High iron and zinc content isolated at the 70 East Main well is likely the result of corrosion from the well spigot from which the water sample was collected or leaching from piping and fittings and is not site related.
- Based on results of the groundwater analytical data and the spatial distribution of the chemicals detected above the screening criteria, it does not appear that a defined plume of contaminants exists at the Site.
- The Eureka City wells in Homansville are suitable for use as background wells. Based on review of the data from these wells, the instances where concentrations observed in Eureka domestic or monitoring wells exceeded screening criteria cannot be attributed to background concentrations.
- There is no evidence that private wells in Eureka are being used for drinking water purposes. Well are used for watering lawns or are not in service. While there are no controls in place to prevent citizens from using water from domestic wells for consumption, based on low aquifer transmissivity, it is unlikely that the wells could be used to consistently provide sufficient volume of water for domestic purposes.
- Based on the research completed on the Eureka public water supply system, there is a low potential that Eureka City Drinking Water sources have been or are in jeopardy of being impacted from historic mining activities at the Eureka Mills Superfund Site.
- Monitoring well MW-1 is the most downgradient monitoring well installed by the EPA at the Site. Based on interpreted groundwater flow paths, dissolved phase contaminants from historical mining waste piles south and west of Eureka should flow toward MW-1. The estimated groundwater transit time between the Chief Mine #1 waste pile and Monitoring Well MW-1 (2.4 to 14.6 years), coupled with the estimated age of this waste pile (over 100 years) and the lack of elevated metals

found in MW-1, is an indication that heavy metals are not leaching from waste piles into the groundwater.

- No additional data collection is recommended for this GW/SW RI.

7.0 REFERENCES

ATSDR, 2005. ToxFAQs™ for Zinc**.** Agency for Toxic Substances and Disease Registry, August 2005.

EPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final. Environmental Protection Agency. EPA/540/G-89/004OSWER Directive 9355.3-01. October 1988

EPA, 2000. Guidance for the Data Quality Objectives Process (QA/G-4). Final. U.S. Environmental Protection Agency, Quality Assurance Management Staff. EPA/600/R-96/055.

EPA, 2004a. Preliminary Remediation Goals (PRGs): EPA Region 9 PRGs Table. U.S. EPA. Dated 12/28/04. On-Line Address: http://www.epa.gov/region09/waste/sfund/prg/index.html.

EPA, 2004b. *EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review,* EPA 540-R-04-004, Office of Superfund Remediation and Technology Innovation, U.S. EPA, 2004 Environmental Protection Agency, Washington, DC 20460, October 2004

EPA, 2004c. *Drinking Water Health Advisory for Manganese*, EPA 822-R-04-003, Office of Water, U.S. EPA, January 2004

EPA, 2006. USEPA Region 8 Superfund Webpage for the Eureka Mills Superfund Site. http://www.epa.gov/region8/superfund/ut/eureka/index.html. Accessed October 2006.

EPA, 2009. Corrosion, Scaling, and Metal Mobility Research Website, Downloaded from the Internet at: http://www.epa.gov/nrmrl/wswrd/cr/corr_res_iron.html

Hamaker, 2005. Relationship Between Fault Zone Architecture and Groundwater Compartmentalization in the East Tintic Mining District, Utah. Sandra M. Hamaker, December 2005.

Meinzer, 1911. United States Geological Survey Water Supply Paper 277, Groundwater in Juab, Millard, and Iron Counties Utah, Oscar Meinzer, 1911.

Morris, 1964. Geological Survey Bulletin 1142-K, Geology of the Eureka Quadrangle, Utah and Juab Counties, Utah. H.T. Morris, 1964.

Morris, Lovering, 1979. Geological Survey Professional Paper 1024, General Geology and Mines of the East Tintic Mining District, Utah and Juab Counties, Utah, H.T. Morris and Thomas Seward Lovering, 1979.

Morris, 1968, Ore Deposits of the United States 1933-1967, Chapter 8: The American Institute of Mining, Metallurgical, and Petroleum Engineers, H.T. Morris, 1968.

SRC, 2007. Quality Assurance Project Plan and Sampling and Analysis Plan to Support the Ecological Risk Assessment. Syracuse Research Corporation. April 2007.

SRC, 2009. Baseline Ecological Risk Assessment for the Eureka Mills Site, Draft Final. Syracuse Research Corporation. April 2009.

UDEQ, 2000. Site Inspection Analytical Results Report, Eureka Mills, Juab County, Utah, UT0002240158. Utah Department of Environmental Quality. December 2000

Utah, 2009. Utah Division of Water Rights Website, downloaded from: http://nrwrt1.nr.state.ut.us/cblapps/wrprint.exe?wrnum=68-1984

WGI, 2002. Remedial Investigation Report for Operable Units 1-4 at the Eureka Mills Site. Eureka, Utah. Washington Group International. July 23, 2002.

WRCC, 2001a. *Period of Record Monthly Climate Summary; Period of Record: 7/1/48 to 7/31/84*. Western Regional Climate Center web page: http://www.wrcc.dri.edu/

WRCC, 2001b. Email communication from Jim Ashby, Western Regional Climate Center, jawrcc@dri.edu; July 16, 2001.