Form No. 630 R05/2014

PETITION FOR CONTROLLED GROUNDWATER AREA

This form can be filed by a state or local public health agency for identified public health risks; a municipality, county, conservation district, or local water quality district formed under Title 7, chapter 13, part 45; or by at least one third of the water right holders in an area proposed for designation of a controlled groundwater area. An incomplete or non-qualifying petition will be returned.

A fee of $1500 must accompany this petition. Petitioners must also pay reasonable costs of giving notice pursuant to MCA § 85-2-506 and A.R.M. 36.12.103

Make checks payable to "DNRC"

Filing Fee: $1500.00

RECEIVED
AUG 25 2014
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FOR DEPARTMENT USE ONLY

Application # 30070516 Basin 41I
Date 8/25/14
Time 2:40 AM / PM (PM circled)
Rec'd By KW
Fee Rec'd $ 1500.00 Check # 002744
Deposit Receipt # HES1504069
Payor MT Environmental Trust Gro...
Refund $ ______ Date ______

Contact Person: X Contact is Petitioner ☐ Contact is Consultant ☐ Contact is Attorney ☐ Contact is Other

Contact Name: Kathy Moore, Lewis & Clark City-County Health Department 340680

Mailing Address: 316 North Park Avenue

City: Helena State: MT Zip: 59623

Phone Numbers: Home ______ Work ______ Cell (406) 457-8926 - Work

Email Address: kmoore@lccountymt.gov

General Location of Proposed Controlled Groundwater Area: Eastern portion of Helena Valley, Lewis & Clark County

TYPE OF DESIGNATION OR PROVISIONS REQUESTED: Is the petition for a permanent or temporary designation?

X **Permanent**. If permanent, proceed to Section 1.

X **Temporary**. If temporary, proceed to Section 2.

Section 1. PERMANENT DESIGNATION PROPOSED *Please provide the following:*

A. MCA § 85-2-506 requires that this petition must contain analysis prepared by a hydrogeologist, a qualified scientist, or a qualified licensed professional engineer concluding that one or more of the following criteria:

☐ Current or projected reductions of recharge to the aquifer or aquifers in the proposed controlled ground water area will cause ground water levels to decline to the extent that water right holders cannot reasonably exercise their water rights;

☐ Current or projected ground water withdrawals from the aquifer or aquifers in the proposed controlled ground water area have reduced or will reduce ground water levels or surface water availability necessary for water right holders to reasonably exercise their water rights;

☒ Current or projected ground water withdrawals from the aquifer or aquifers in the proposed controlled ground water area have induced or altered or will induce or alter contaminant migration exceeding relevant water quality standards;

☐ Current or projected ground water withdrawals from the aquifer or aquifers in the proposed controlled ground water area have impaired or will impair ground water quality necessary for water right holders to reasonably exercise their water rights based on relevant water quality standards;

☒ Ground water within the proposed controlled ground water area is not suited for beneficial use; or public health, safety, or welfare is or will become at risk.

B. Please attach all supporting information, including the name, address and qualifications of the person who prepared the analysis. See Attached Supplemental Information.

C. Explain why the condition occurring or likely to occur cannot be appropriately mitigated. See Attached Information.

D. Describe the kind of corrective controls or provisions you are requesting. A controlled ground water area may include but is not limited to the following control provisions:

☒ A provision closing the controlled ground water area to further appropriation of ground water;

☒ A provision restricting the development of future ground water appropriations in the controlled ground water area by flow, volume, purpose, aquifer, depth, water temperature, water quality, density, or other criteria that the department determines necessary;

☐ A provision requiring measurement of future ground water or surface water appropriations;

☐ A provision requiring the filing of notice on land records within the boundary of a permanent controlled ground water area to inform prospective holders of an interest in the property of the existence of a permanent controlled ground water area.

☐ A provision for well spacing requirements, well construction constraints, and prior department approval before well drilling, unless the well is regulated pursuant to Title 82, chapter 11;

☐ A provision for mitigation of ground water withdrawals;

☒ A provision for water quality testing;

☐ A provision for data reporting to the department

Proceed to Section 3.

Section 2. <u>TEMPORARY DESIGNATION PROPOSED</u> *Please provide the following:*

A. A study plan that may include measurement, water quality testing, and reporting requirements for new and/or replacement wells during the period of the temporary closure. See Attached Information.

B. Include information on funding for any proposed investigations including any plans for pursuing funding under the renewable resource grant and loan program, and any planned investigation under the ground water investigation program. See Attached Information.

C. Describe how any necessary investigations can be completed in a timely fashion not to exceed 6 years. See Attached Information.

Proceed to Section 3.

Section 3. PERMANENT OR TEMPORARY DESIGNATION PROPOSED *Please provide the following:*

A. **Map:** A U.S. Geological Survey quadrangle map, or one of similar size, scale and detail level **must** accompany the petition. In addition to the information provided on the USGS map, the map **must** also show the following:
   a. north direction;
   b. township and range numbers;
   c. section corners and numbers; See Attached Information.
   d. accurate outline of the proposed controlled area;
      i. location of any known groundwater recording equipment;
      ii. points of diversion of all groundwater users, including wells and developed springs.

B. **Land Ownership:** Attach a list to this petition of all the landowners within the proposed boundaries of the controlled groundwater area. Land ownership may be found at the county assessors office or at http://svc.mt.gov/msl/mtcadastral/ The list must include the name and complete mailing address of the property owner. See Attached Information.

WATER RESOURCES OFFICES

BILLINGS: AIRPORT INDUSTRIAL PARK, 1371 RIMTOP DR., BILLINGS MT 59105-1978
PHONE: 406-247-4415 FAX: 406-247-4416
SERVING: Big Horn, Carbon, Carter, Custer, Fallon, Powder River, Prairie, Rosebud, Stillwater, Sweet Grass, Treasure, and Yellowstone Counties

BOZEMAN: 2273 BOOT HILL COURT, SUITE 110, BOZEMAN MT 59715
PHONE: 406-586-3136 FAX: 406-587-9726
SERVING: Gallatin, Madison, and Park Counties

GLASGOW: 222 6TH STREET SOUTH, PO BOX 1269, GLASGOW MT 59230-1269
PHONE: 406-228-2561 FAX: 406-228-8706
SERVING: Daniels, Dawson, Garfield, McCone, Phillips, Richland, Roosevelt, Sheridan, Valley, and Wibaux Counties

HAVRE: 210 6TH AVENUE, PO BOX 1828, HAVRE MT 59501-1828
PHONE: 406-265-5516 FAX: 406-265-2225
SERVING: Blaine, Chouteau, Glacier, Hill, Liberty, Pondera, Teton, and Toole Counties

HELENA: 1424 9TH AVE., PO BOX 201601, HELENA MT 59620-1601
PHONE: 406-444-6999 FAX: 406-444-9317
SERVING: Beaverhead, Broadwater, Deer Lodge, Jefferson, Lewis and Clark, Powell, and Silver Bow Counties

KALISPELL: 655 TIMBERWOLF PARKWAY, SUITE 4, KALISPELL MT 59901-1215
PHONE: 406-752-2288 FAX: 406-752-2843
SERVING: Flathead, Lake, Lincoln, and Sanders Counties

LEWISTOWN: 613 NORTHEAST MAIN ST., SUITE E, LEWISTOWN MT 59457-2020
PHONE: 406-538-7459 FAX: 406-538-7089
SERVING: Cascade, Fergus, Golden Valley, Judith Basin, Meagher, Musselshell, Petroleum, and Wheatland Counties

MISSOULA: 2705 SPURGIN RD. BLDG. C, PO BOX 5004, MISSOULA MT 59806-5004
PHONE: 406-721-4284 FAX: 406-542-5899
SERVING: Granite, Mineral, Missoula, and Ravalli Counties

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
Water Resources Division - Water Rights Bureau
1424 9th Avenue, PO Box 201601, Helena, MT 59620-1601
***Phone: 406-444-6610 Website:* http://dnrc.mt.gov/wrd/**

Montana DNRC Form No. 630 R05/2014 Supplemental Information

Petition for East Valley Controlled Groundwater Area – August 11, 2014

SECTION 1: PERMANENT DESIGNATION PROPOSED

A. MCA § 85-2-506 requires that this petition must contain analysis prepared by a hydrogeologist, a qualified scientist, or a qualified licensed professional engineer concluding that one or more of the following criteria:

Attach all supporting information including analysis prepared by a Hydrogeologist, a qualified scientist, or a qualified licensed professional engineer.

The criteria that exist or are likely to occur include:

- ***Current or projected groundwater withdrawals from the aquifer or aquifers in the proposed controlled groundwater area (CGWA) have induced or altered or will induce or alter contaminant migration exceeding relevant water quality standards;***
- ***Groundwater within the proposed CGWA is not suited for beneficial use; or public health, safety, or welfare is or will become at risk.***

A detailed demonstration of these facts is provided in the attached report, "SUPPORTING INFORMATION FOR THE EAST VALLEY CONTROLLED GROUNDWATER AREA PETITION - LEWIS AND CLARK COUNTY, MONTANA". Section 3.0 of the report summarizes how groundwater within the proposed East Valley CGWA meets the criteria for implementation of a CGWA.

B. Please attach all supporting information, including the name, address and qualifications of the person who prepared the analysis.

All supporting information is included in the attached report, "SUPPORTING INFORMATION FOR THE EAST VALLEY CONTROLLED GROUNDWATER AREA PETITION - LEWIS AND CLARK COUNTY, MONTANA".

C. Explain why the condition occurring or likely to occur cannot be appropriately mitigated.

As noted in the attached supporting document, the elevated groundwater contaminant concentrations necessitating implementation of the East Valley CGWA are the result of more than a century of industrial activities at the Former East Helena Lead Smelter.

Therefore, mitigation of the criteria leading to this petition will be extremely complex and will require considerable time (i.e., years) to implement. As noted in Section 6 of the attached "SUPPORTING INFORMATION FOR THE EAST VALLEY CONTROLLED GROUNDWATER AREA PETITION - LEWIS AND CLARK COUNTY, MONTANA", the Montana Environmental Custodial Trust is currently developing and implementing an extensive remediation program at the former smelter under the federal Resource Conservation and Recovery Act (RCRA) Corrective Measures program to address offsite groundwater contamination in the proposed CGWA. It should be noted, however, that the time required to implement all corrective measures and for the full benefits of the corrective measures on groundwater quality to be realized cannot be quantified at this time, although the time requirement for the full benefits to groundwater to take effect is on the order of years. In addition, the extent of benefits to groundwater (i.e., improvement in groundwoter quality) achievable through the remediation program cannot be quantified at this time.

D. Describe the kind of corrective controls or provisions you are requesting.

The proposed groundwater usage restrictions for the East Valley CGWA are described in detail in Section 5.0 of the attached "SUPPORTING INFORMATION FOR THE EAST VALLEY CONTROLLED GROUNDWATER AREA PETITION - LEWIS AND CLARK COUNTY, MONTANA" report. The permanent portion of the East Valley CGWA would consist of two subareas or zones with the following restrictions:

- *Groundwater usage restrictions within Subarea 1 include a complete moratorium on all new water supply wells. Monitoring, test, and remediation wells would be allowed in Subarea 1, provided that they would not cause unacceptable contaminant exposure or migration. Continued use of existing wells within Subarea 1 would also be allowed, subject to water quality monitoring requirements outlined in the attached report. Replacement wells would also be allowed if the replacement well location, depth, completion details, pumping rates and water usage are the same as the originol well, and completion of the well is in accordance with all local, state, and other regulations, laws, ordinances and permitting requirements.*
- *Groundwater usage restrictions within Subarea 2 would require obtaining a permit prior to constructing any new water supply well. Permits would be administered by a Technical Advisory Group to include project stakeholders such as appointees from the Lewis and Clark County Board of Health and Water Quality Protection District, the USEPA, and the State of Montana (MDEQ, DNRC). Both exempt and nonexempt wells would be allowed pending approval from the Technical Advisory*

Group and compliance with all other applicable local, state, and other regulations, laws, ordinances and permitting requirements. Monitoring, test, and remediation wells would be allowed in Subarea 2 and would not be subject to the permitting process, provided that they would not cause unacceptable contaminant exposure or migration.

The East Valley CGWA also includes a Temporary CGWA intended to facilitate study and determination of potential sources of arsenic in area groundwater besides those sources currently documented. There are no groundwater usage restrictions proposed within the Temporary CGWA.

SECTION 2: TEMPORARY DESIGATION PROPOSED

A. A study plan that may include measurement, water quality testing, and reporting requirements for new and/or replacement wells during the period of the temporary closure.

A general study plan for evaluating sources of arsenic in groundwater within the proposed temporary CGWA is outlined in Section 6 of the attached "SUPPORTING INFORMATION FOR THE EAST VALLEY CONTROLLED GROUNDWATER AREA PETITION - LEWIS AND CLARK COUNTY, MONTANA" report. The study plan includes: compilation and review of previous studies and the considerable volume of data previously collected in the proposed temporary area; identification of potential data gaps or additional data needs to identify all arsenic sources; preparation and implementation of a work plan to complete the temporary CGWA evaluation; and reporting requirements for new and/or replocement wells.

B. Include information on funding for any proposed investigations.

Initial components of the temporary CGWA evaluation will be funded under the ongoing former smelter cleanup program. This funding will cover compilation and review of existing information and data, identification of data gaps and additional data needs, and development of a temporary CGWA site investigation work plan, if necessary. The Lewis and Clark County Water Quality Protection District Board and/or City/County Board of Health will apply for a grant under the Renewable Resource Grant and Loan Program to fund any additional site investigations deemed necessary. The grant application will be submitted by May 15, 2016, the next RRGP cycle, with the grant being available after July 1, 2017 if approved.

C. Describe how any necessary investigations can be completed in a timely fashion not to exceed 6 years.

Section 6 of the attached "SUPPORTING INFORMATION FOR THE EAST VALLEY CONTROLLED GROUNDWATER AREA PETITION - LEWIS AND CLARK COUNTY, MONTANA" report includes a timeline for completion of any temporary CGWA investigations. Assuming designation of the CGWA by mid-2015, the initial phase, compilation and review of previous studies and available data, and preparation of a work plan for additional site investigation(s), if needed, would be completed by March 2016 to support an application for the RRGP grant. Based on award of a RRGP grant in July 2017, all additional site investigations will be completed by the end of 2018, with recommendations for converting the temporary area to a permanent controlled groundwater area, extending the temporary area for up to a total duration of 6 years, or discontinuing the temporary CGWA entirely made by March 2019. The petition requests an initial duration of 4 years for the temporary CGWA to accommodate this schedule.

SECTION 3: PERMANENT OR TEMPORARY DESIGNATION PROPOSED

A. <u>Map: A U.S. Geological Survey quadrangle map, or one of similar size, scale, and detail level must accompany the petition.</u>

Multiple maps showing the proposed East Valley CGWA in detail and the required information are included with the attached report. The primary figure showing the East Valley CGWA is Figure 4-1, which includes both a topographic and aerial photo base. The proposed CGWA is also shown on Figure 1-1 and Figure 5-1 (including known existing wells within the CGWA) and on Exhibit 4.

B. <u>Land Ownership: Attach a list to this petition of all the landowners within the proposed boundaries of the controlled groundwater area.</u>

Property ownership within the proposed East Valley CGWA is shown on Exhibit 4 of the attached report and a list of landownership identified by geocode is in Appendix E of the attached report. A full list of landownership with landowner names and mailing addresses has been provided separately to DNRC to protect landowner privacy.

LEWIS AND CLARK
CITY-COUNTY BOARD OF HEALTH
1930 Ninth Avenue, Helena, MT 59601

LEWIS AND CLARK COUNTY
WATER QUALITY PROTECTION DISTRICT
316 North Park, Room 230, Helena, MT 59601

August 14, 2014

Bryan Gartland, Deputy Regional Manager
Helena Water Resource Regional Office
Department of Natural Resources and Conservation
1424 Ninth Avenue
PO Box 201601
Helena, MT 59620-1601

Dear Mr. Gartland:

Attached please find a copy of Form 630 R05/2014 Petition for Controlled Groundwater Area for the East Valley Controlled Groundwater Area near East Helena, Montana.

This petition is being jointly submitted by the Lewis and Clark City-County Board of Health and the Lewis and Clark County Water Quality Protection District Boards. The Boards have carefully reviewed the materials and found that arsenic and selenium are present in concentrations that exceed Montana's groundwater Human Health Standards and the U.S. Environmental Protection Agency human health based Maximum Contaminant Levels.

After reviewing the documentation presented by the Montana Environmental Custodial Trust, we determined that it is necessary to restrict future groundwater withdrawals within the specified area to prevent human and environmental exposure risks, and to prevent possible pumping-induced spread of groundwater contamination.

If you have any questions or require more information, please contact Kathy Moore, Environmental Services Division Administrator at 406-457-8926 or kmoore@lccountymt.gov.

Sincerely,

Anne Weber, Chair
City-County Board of Health

Stan Frasier, Chair
Water Quality Protection District

Cc Melanie Reynolds, Health Officer
Kathy Moore, Environmental Division Administrator
Lewis and Clark Board of County Commissioners
James Schell, Mayor, City of East Helena
Jim Smith, Mayor, City of Helena

SUPPORTING INFORMATION FOR THE EAST VALLEY CONTROLLED GROUNDWATER AREA PETITION LEWIS AND CLARK COUNTY, MONTANA

Prepared for:

Montana Environmental Trust Group, LLC
Trustee of the Montana Environmental Custodial Trust
P.O. Box 1230
East Helena, MT 59635

and

Lewis and Clark County
316 North Park Avenue
Helena, MT 59623

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

August 2014

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LIST OF ABBREVIATIONS AND TERMS

AOC – Area of Contamination

BGS – Below Ground Surface

CAMU – Corrective Action Management Unit

CD – Consent Decree

CERCLA – Comprehensive Environmental Response, Compensation and Liability Act

CGWA – Controlled Groundwater Area

CMS – Corrective Measures Study

Custodial Trust – Montana Environmental Trust Group, LLC, Trustee of the Montana Environmental Custodial Trust

CWA – Clean Water Act

DNRC – Montana Department of Natural Resources and Conservation

ET – Evapotranspiration

Facility – All former ASARCO-owned East Helena properties now owned by the Custodial Trust including the Former Smelter site

Former Smelter - The former ASARCO East Helena Lead Smelter Plant Site

HHS – Human Health Standard

IC – Institutional Controls

ICS – Interim Cover System

IM – Interim Measures

MCA – Montana Code Annotated

MCL – Maximum Contaminant Level

MDEQ – Montana Department of Environmental Quality

PPC – Prickly Pear Creek

RCRA – Resource Conservation and Recovery Act

RFI – RCRA Facility Investigation

SPHC – South Plant Hydraulic Control

TAG – Technical Advisory Group

TPA – Tito Park Area

UOSA – Upper Ore Storage Area

USEPA – United States Environmental Protection Agency

EXECUTIVE SUMMARY

This petition is being submitted to the Montana Department of Natural Resources and Conservation (DNRC) to request the designation of a Controlled Ground Water Area (CGWA) encompassing approximately 3,290 acres in the eastern portion of the Helena Valley near the City of East Helena, in Lewis and Clark County, Montana. The overall objective of the CGWA is to restrict future groundwater withdrawals and use in order to prevent exposure to certain contaminants (arsenic and selenium) that could result in unacceptable risk to human health or the environment, and to prevent possible pumping-induced spreading of groundwater contaminants. The East Valley CGWA is being requested in accordance with applicable laws and regulations included in Montana Code Annotated 85-2-500, and related groundwater rules and regulations.

Groundwater quality in the area of the proposed CGWA has been impacted by contaminants migrating from the former East Helena lead smelter (former smelter) as well as other sources, possibly including naturally occurring or "background" contaminant sources. Groundwater contaminants of concern include arsenic and selenium that have been identified in separate contaminant plumes that extend from the former smelter northward (up to three miles in the case of the selenium plume) within the Helena Valley alluvial aquifer. Concentrations of arsenic and/or selenium exceed applicable groundwater quality standards including State of Montana groundwater Human Health Standards (MDEQ, 2012) and the United States Environmental Protection Agency (EPA) maximum contaminant levels (MCLs) established for protection of human health. The CGWA is requested because: arsenic and selenium concentrations in the area are above drinking water standards and therefore ingestion of such water could pose a public health risk; the groundwater is unsuitable for certain designated beneficial uses, including public and private drinking water supplies, and culinary and food processing purposes; and additional pumping of groundwater could cause spreading of the contaminant plumes.

The proposed East Valley CGWA includes 3,290 acres (5.1 square miles) within Lewis and Clark County in the southeastern portion of the Helena Valley. The CGWA boundaries (Figure 1-1) include the former smelter plant site; portions of the City of East Helena including the main downtown area and Manlove Addition; Seaver Park; and surrounding agricultural, industrial, residential and open lands. The CGWA includes all of Sections 23, 25, 26, 35, 36 and a portion of Section 24 in Township 10 North, Range 3 West. 1,120 of the total 3,290 acres included in the proposed CGWA are owned by the Montana Environmental Trust Group, Trustee of the Montana Environmental Custodial Trust (the Custodial Trust), where groundwater usage restrictions can readily be applied as appropriate. An additional 1,270 acres are situated within East Helena where a moratorium on new wells currently exists. The remaining 900 acres of the CGWA include various agricultural, industrial and residential properties.

The CGWA includes two subareas or zones with differing groundwater usage provisions, plus an adjacent Temporary CGWA. Subarea 1 includes those portions of the aquifer where concentrations of arsenic and/or selenium exceed human health standards and a small buffer zone around the edge of the plumes to account for uncertainty in the precise exceedance boundary and potential future shifts in the plume boundary. The CGWA proposes a total ban on drilling new wells and groundwater appropriations within the 1,190 acres (or 1.9 square miles) of Subarea 1. Existing wells would not be affected. Subarea 2 includes those portions of the aquifer outside of Subarea 1 where, based on currently available data, arsenic and/or selenium concentrations do not currently exceed applicable human health standards, but exceedances of human health standards may occur due to future groundwater withdrawals or other changes in the hydrologic system. The CGWA proposes to require issuance of a permit by a designated East Valley CGWA technical advisory group for any new wells and groundwater appropriations within the 734 acres (1.2 square miles) of Subarea 2. The proposed East Valley CGWA also includes a Temporary CGWA (1366 acres/2.0 square miles) to the south and west of the "permanent" CGWA where "background" sources of arsenic unrelated to the former smelter are believed to affect groundwater quality. Designation of a temporary CGWA will allow the occurrence and source(s) of arsenic in this area to be further evaluated, and the area converted to a permanent CGWA in the future, if warranted.

Data collected through CERCLA and RCRA cleanup activities performed under the oversight of the US Environmental Protection Agency (EPA), initially focusing on ASARCO's operations, have shown that the former smelter is the primary source of arsenic and selenium contamination to groundwater within the proposed CGWA. The Custodial Trust assumed responsibility for the former smelter cleanup as a result of the ASARCO bankruptcy settlement, with EPA as the designated lead regulatory agency. Cleanup of the former smelter is proceeding under the RCRA Corrective Action Program with the remediation and protection of groundwater being a primary objective. Remedy identification and evaluations are currently underway as part of a RCRA Corrective Measures Study, and cleanup actions are being performed as Interim Measures (IMs) to address contaminant loading to groundwater while final remedy evaluations are completed. Remedial activities scheduled to be implemented as IMs over the next few years include lowering of groundwater levels on the former plant site to reduce contaminant leaching from soils, removal of certain contaminated soils, and placement of a soil cap over the former smelter plant site. Groundwater monitoring will be conducted to monitor the effectiveness of implemented cleanup activities and the potential need for additional remedial actions in the future. The monitoring program will also serve to track groundwater quality within the CGWA so that adjustments to the CGWA boundaries and/or groundwater usage provisions can be made, as appropriate. Cleanup activities are designed to reduce downgradient groundwater contamination from the former smelter that will enable reductions in the CGWA boundaries and/or provisions, although the process may take several years.

SUPPORTING INFORMATION FOR THE EAST VALLEY CONTROLLED GROUNDWATER AREA PETITION LEWIS AND CLARK COUNTY, MONTANA

1.0 INTRODUCTION

This document provides information in support of a petition to establish and maintain a controlled groundwater area (CGWA) near the City of East Helena in Lewis and Clark County, Montana. Groundwater quality in the area is impacted by multiple sources, including the former East Helena lead smelter (former smelter), apparent natural or background sources, and other possible sources. Concentrations of certain constituents in groundwater, primarily arsenic, selenium, and some trace metals, exceed applicable water quality standards (State of Montana Human Health Standards (MDEQ, 2012) and U.S. Environmental Protection Agency Maximum Contaminant Levels[1]), rendering portions of the aquifer unsuitable for certain designated beneficial uses. Designation of the East Valley CGWA is being requested to prevent exposure to specific contaminants in groundwater where Human Health Standards (HHS) are exceeded, and to prevent groundwater withdrawals that may alter or induce contaminant migration. Specific objectives of this petition include:

- Establishing a CGWA encompassing portions of the Helena Valley alluvial aquifer and adjacent foothills where observed contaminant concentrations exceed State of Montana HHSs for protection of human health. For purposes of the CGWA, primary contaminants of concern (COCs) include arsenic and selenium since these are the primary COCs in groundwater originating from the former lead smelter; and
- Establishing appropriate groundwater usage restrictions to prevent unacceptable human exposure to groundwater contaminants or pumping-induced spreading of contaminants.

This CGWA petition is being submitted to the Montana Department of Natural Resources and Conservation (DNRC) by the Lewis and Clark City-County Board of Health and Water

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[1] Applicable groundwater quality standards for protection of human health include State of Montana Human Health Standards (HHS) and U.S. EPA Maximum Contaminant Levels (MCLs). For the contaminants of concern (arsenic and selenium), the HHS and MCLs are identical. To avoid redundancy, the HHS standards are used in this document when referring to applicable groundwater quality standards.

Quality Protection District Board and has been prepared in accordance with applicable laws and regulations included in Montana Code Annotated (MCA) 85-2-500, and related groundwater rules and regulations as referenced below.

1.1 CGWA DESCRIPTION AND BACKGROUND

For the purposes of this petition, the project area (or proposed CGWA) includes those portions of the Helena Valley alluvial aquifer and adjacent southern foothills with elevated concentrations of arsenic, selenium, and/or trace metal concentrations attributable to the former smelter as well as other sources of contaminants of concern in the area. As described in Section 4, the proposed CGWA boundaries are based on the current areal extent of contaminants exceeding applicable state Human Health Standards (10 micrograms per liter (µg/L) for arsenic and 50 µg/L for selenium), plus buffer zones around the contaminant plumes where water quality exceedances could occur due to future changes in contaminant migration or pumping-induced changes to the plume boundaries. The areal extent of exceedances has been defined based on groundwater quality data collected by the Custodial Trust as part of the RCRA Corrective Action work being performed at the former East Helena Facility[2]. Figure 1-1 shows the general project area with key physical and geographical features identified.

The proposed CGWA encompasses approximately 3,290 acres (5.1 square miles) including all or portions of Sections 23, 24, 25, 26, 35 and 36 in Township 10 North, Range 3 West (Figure 1-1). Key features in the area, in terms of relevance to the CGWA, include the former smelter site, the Tertiary sediment foothills or uplands around the former smelter site, the City of East Helena (East Helena), Prickly Pear Creek, Lamping Field, and Seaver Park (Figure 1-1). Following is a description of aspects of these key site features relevant to the CGWA petition.

1.1.1 Former Smelter Site

ASARCO began smelting operations at the former smelter in 1888, producing lead bullion from a variety of foreign and domestic concentrates, ores, fluxes, and other non-ferrous metal bearing materials. In addition to lead bullion, the smelter produced copper by-products and food-grade sulfuric acid. Smelter operations were terminated in 2001, and in 2005 ASARCO filed for Chapter 11 bankruptcy. In December 2009, as part of the ASARCO bankruptcy settlement agreement, ownership of and cleanup responsibility for the former smelter site and associated ASARCO-owned properties (collectively referred to as the Facility) were transferred from ASARCO to the Custodial Trust.

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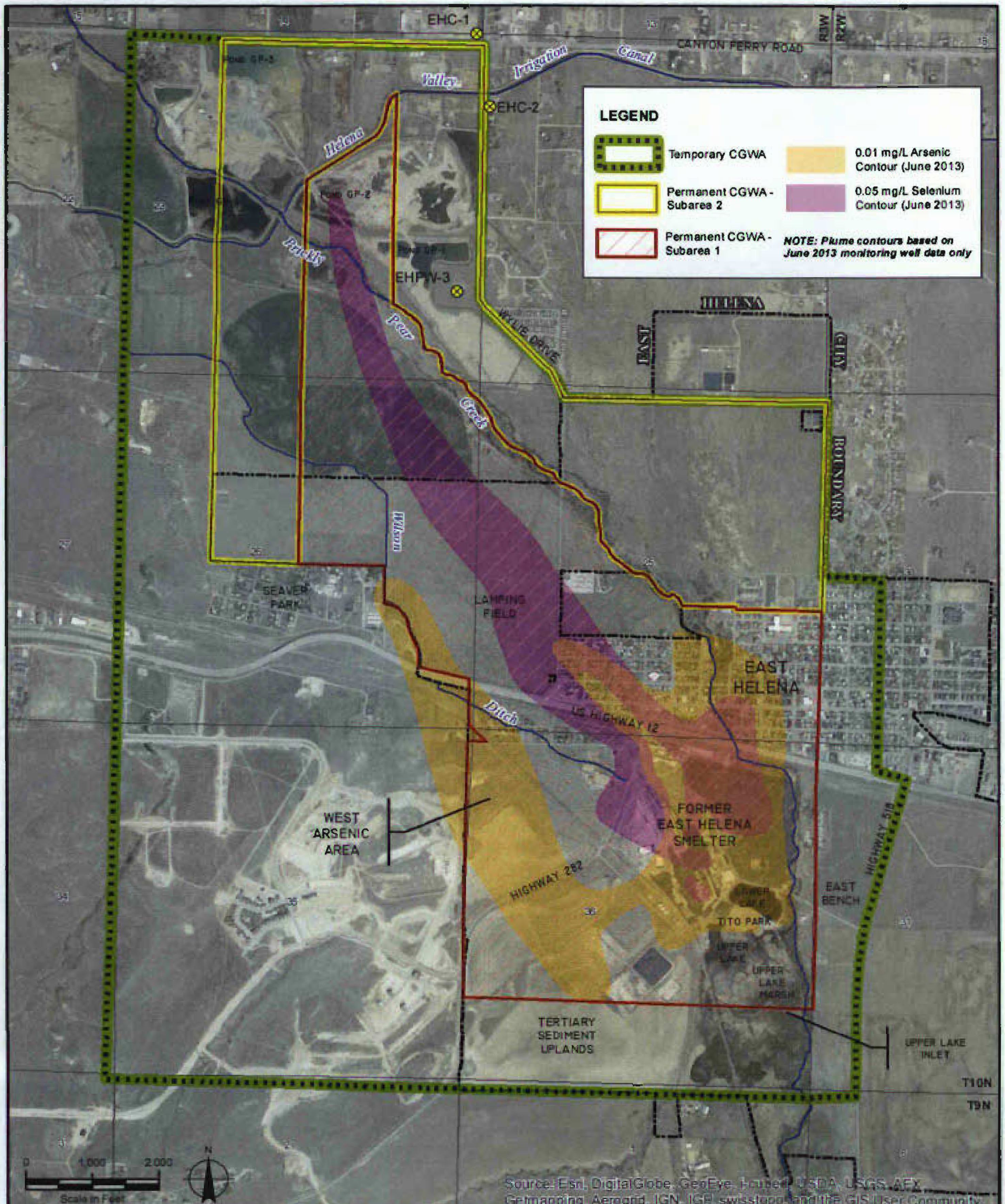
[2] The terms smelter or former smelter refer to the former smelter plant site while Facility refers to all properties formerly owned by ASARCO and transferred to the Custodial Trust, including the former smelter site.



Hydrometrics, Inc. Consulting Scientists and Engineers Date Saved: 6/2/2014 9:51:11 AM V:\10022\GIS\CGWA\Figures\Figure 1-1.mxd	PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	SITE FEATURES NEAR THE PROPOSED EAST VALLEY CONTROLLED GROUNDWATER AREA	FIGURE 1-1

The former smelter plant site, where actual smelting operations occurred, occupies approximately 142 acres in the northeast quarter of Section 36, Township 10N, Range 3 West (Figure 1-1). The former smelter site is bounded to the south by a lake/marsh complex (Upper Lake and Marsh) and to the east and northeast by Prickly Pear Creek. Uplands or foothills comprised of tertiary-age sediments border the smelter on the west and southwest, and U.S. Highway 12 and the American Chemet plant (a manufacturer and marketer of metals-based chemicals) border the smelter to the north. The City of East Helena business district and major residential areas are located north of Highway 12 and the former smelter (Figure 1-1). Based on data collected over a period of twenty-five years, the smelter and surrounding soils and groundwater contain elevated concentrations of certain metals, including cadmium, copper, lead and zinc, as well as arsenic and selenium. Groundwater monitoring on and downgradient of the smelter has also identified a groundwater arsenic plume and a groundwater selenium plume originating from the former smelter site and extending to the north/northwest into the Helena Valley (Figure 1-1). This environmental data has confirmed that the former smelter site is a primary source of contaminant loading to groundwater in the proposed CGWA.

The extreme southern portion of the former smelter site is occupied by a lake/marsh complex referred to as Upper Lake and Upper Lake Marsh. The marsh is associated with the Prickly Pear Creek riparian area, while Upper Lake is primarily a manmade feature constructed by ASARCO to provide water for smelting operations. Historically, leakage from Upper Lake was a significant source of recharge to the local groundwater system. Starting in November of 2011, the Custodial Trust began draining Upper Lake to assess the effect on groundwater elevations and flow rates on the former smelter site, and ultimately the effect on contaminant leaching and migration from plant site soils (see Upper Lake Drawdown Test Technical Memorandum, Appendix A). Other surface water features on or near the former smelter site include Lower Lake, another manmade process water storage pond, Prickly Pear Creek which flows from south to north along the eastern smelter boundary, and Wilson Ditch, an irrigation ditch historically fed by Upper Lake and extending from the western smelter boundary northward into the Helena Valley (Figure 1-1). Wilson Ditch has not been used to deliver irrigation and/or stock water to the Prickly Pear Simmental (Burnham) Ranch since the end of the 2011 irrigation season. Since then, use of the ditch to deliver Prickly Pear Creek water has been discontinued and the Prickly Pear Simmental Ranch has permanently relinquished all interest in Wilson Ditch. Future use of some or all of Wilson Ditch, if any, will be consistent with the East Valley CGWA requirements and restrictions.

Cleanup of the former smelter and the surrounding areas was initiated under EPA's CERCLA program and, since 1998, has been managed under EPA's RCRA Corrective Action Program (USEPA, 1994) pursuant to a 1998 Consent Decree entered into by EPA and ASARCO. The Consent Decree was modified by EPA and the Custodial Trust and the First

Modification to the Consent Decree (the First Modification), (US District Court, 2012) was entered in Federal District Court in 2012. The First Modification specifies requirements for cleanup of the Facility under the RCRA Corrective Action program, with EPA as the lead regulatory agency. Pursuant to the First Modification, the Custodial Trust is preparing a Corrective Measures Study (CMS) to identify and evaluate remedies that are protective of human health and the environment. The cleanup and control of contaminated groundwater migrating from the former smelter site is a primary objective of the CMS. Remedies being evaluated include addressing source areas as well as both engineering controls and institutional controls. The CGWA is a critical institutional control and interim measure to prevent exposure to groundwater with contaminant concentrations exceeding State of Montana HHSs. The Custodial Trust is also implementing additional Interim Measures (IMs) intended to reduce contaminant mass loading to groundwater and migration of contaminated groundwater from the former smelter site while final remedy evaluations are being completed. Implementation of the IMs (described in more detail in Section 6 of this document) is also consistent with provisions within the First Modification specifying the use of IMs to address the spread of and potential exposure to contaminants associated with the Facility.

1.1.2 City of East Helena

East Helena is located north of the smelter with much of the main business and residential areas overlying the groundwater plumes (Figure 1-1). The majority of residences within city limits are served by the municipal water system. In 2003, the city adopted an ordinance (City Code 8-3-7) prohibiting drilling of private water wells, and reactivation of existing inactive private water wells within the city water service area. Under East Helena Code 8-3-6, the East Helena water service area is defined as including all areas within the city boundaries as well as some areas outside the city boundaries that are served by the municipal water system. In November of 2009, prior to the creation of the Custodial Trust, all ASARCO-owned property in the vicinity of East Helena was annexed into the city. Therefore, the Custodial Trust property is subject to all East Helena municipal Codes, including city codes 8-3-7 and 8-3-6. A significant portion of the proposed CGWA north of the former smelter site is subject to the East Helena well moratorium, thus restricting future groundwater usage in these areas. A limited number of "grandfathered" private wells do still exist within the East Helena well ban area. Although most of these private wells are used for lawn irrigation, a few are still used for potable water. The Custodial Trust regularly samples many of these private wells (where owner permission has been granted) and provides sampling results to the well owners. The Custodial Trust's residential well sampling program and results, and their relevance to the CGWA petition, are discussed in various sections of this document.

The three municipal wells serving the East Helena municipal water system are shown on Figure 1-1. All three wells are located outside of the arsenic and selenium plumes. Regular sampling by city personnel and the Custodial Trust confirm that these public water supply wells are not impacted by the former smelter site groundwater plumes. One of the municipal wells (EHPW-3) is located inside the proposed CGWA boundaries to protect against potential future plume encroachment towards the well due to future groundwater development in the area.

1.1.3 Surface Water Features

Primary surface water features within the proposed CGWA include Prickly Pear Creek, the Helena Valley Irrigation Canal, and a number of gravel pit ponds northwest of the Facility (Figure 1-1). A number of active and inactive irrigation ditches are also located in the proposed CGWA. Prickly Pear Creek flows northwestward from the smelter through East Helena and towards the Helena Valley. The creek is a losing stream through most of this reach, meaning it leaks water to the underlying groundwater system. Leakage from the creek results in groundwater mounding beneath the creek, which in turn influences groundwater flow patterns and contaminant plume migration north of the former smelter site. The Helena Valley Irrigation Canal (HVIC) flows from east to west across the northern portion of the project area (Figure 1-1). Previous studies have documented average HVIC leakage rates of approximately 280 gallons per minute (gpm) per mile along the entire canal length (Briar and Madison, 1992). The effects of leakage from the creek and canal on local groundwater flow and plume migration patterns are discussed further in Section 2.2.2.

A number of gravel pit ponds are present near the intersection of the HVIC and Prickly Pear Creek. The ponds are fed primarily by groundwater with the pond water levels dictated in part by past gravel mining operations. Water levels within the gravel pit ponds are believed to have a direct influence on the horizontal and vertical migration of the selenium plume in this area, and are further addressed in Section 2.2.3.

Wilson Ditch, an irrigation ditch extending from Upper Lake into the Helena Valley, borders the west side of Lamping Field. Historically, leakage from the ditch resulted in groundwater mounding along its course, affecting groundwater flow and contaminant plume migration patterns. As noted above, Wilson Ditch has not been used to convey water since late 2011. This change in the local groundwater flow regime has been factored into development of the CGWA boundaries as described in this petition.

1.1.4 Other Relevant Features

In addition to the primary features described above, other relevant features in the area include the Tertiary sediment foothills or uplands in the southwestern portion of the CGWA, Lamping Field, and Seaver Park. As described in Section 2, the Tertiary sediment uplands west and southwest of the former smelter influence both the regional groundwater flow and chemistry. The Tertiary sediments are believed to contribute to elevated groundwater arsenic levels in the area, and therefore are relevant to the CGWA petition.

Lamping Field is a large area of vacant land northwest of the former smelter. The Lamping Field property is owned by the Custodial Trust and has been annexed into the City of East Helena. Although the East Helena municipal water and sewer system does not currently service this area, future property development will require hook ups to the municipal water system. Besides serving as a locational reference throughout this document, Lamping Field is relevant to the East Valley CGWA petition since the groundwater contaminant plumes pass directly beneath the property and it therefore represents a significant portion of the proposed CGWA.

Seaver Park is a residential subdivision located north of Highway 12 and west of Lamping Field (Figure 1-1). Seaver Park has been included in the proposed CGWA because past sampling has shown a number of wells in the subdivision exceed the State of Montana HHS for arsenic. There are approximately 50 residences in Seaver Park with all residences serviced by individual private water supply wells. ASARCO and/or the Custodial Trust sampled the majority of Seaver Park wells in 2009 and/or 2010 as part of the Facility groundwater monitoring program. Sampling results showed 19 of the wells exhibited arsenic concentrations at or above the 10 µg/L human health standard[3]. Based on evaluations to date, as described further in Section 2 and Appendix B, the elevated arsenic concentrations in the Seaver Park wells are believed to be attributable, at least in part, to source(s) other than the former smelter. Nevertheless, because of the number of private wells and the presence of elevated arsenic in groundwater, and its proximity to the former smelter, this petition includes the Seaver Park subdivision as a Temporary CGWA to allow for additional evaluation of the occurrence and source(s) of arsenic in this area. Pending the evaluation results, the area would be converted to a permanent CGWA in the future, if warranted, or deleted entirely from the East Valley CGWA.

The preceding sections provide a brief overview of the former smelter site and surrounding area. Detailed discussions of the former smelter operations, environmental conditions and past remediation activities are provided in a number of documents including Hydrometrics, 1990 and 1999, ASARCO Consulting, Inc. (ACI), 2005, as well as documents and reports prepared by the Custodial Trust and submitted to EPA including interim measures work plans (CH2MHill, 2013a, 2013b), Phase II RFI Work Plan (Hydrometrics, 2010), Phase II RFI Report (METG, 2011), annual water resources monitoring plans (Hydrometrics, 2013), and groundwater modeling activities (Newfields, 2014). Additional detail on the history and physical characteristics of the smelter and surrounding area, as relevant to the CGWA

[3] Although elevated arsenic is known to occur in portions of Seaver Park, the June 2013 arsenic plume on Figure 1-1 does not encompass Seaver Park since there is no groundwater data available for Seaver Park private wells for that time period.

petition, are presented in Section 2 and Appendix B of this document. Key components of the proposed East Valley CGWA and information required for or relevant to the petitioning process are described in subsequent sections.

2.0 HYDROGEOLOGIC SETTING

The hydrogeology or groundwater characteristics of the area are relevant to the East Valley CGWA petition since these factors control the current extent of the contaminant plumes, and ultimately the appropriate horizontal and vertical boundaries of the CGWA. The hydrogeology of the former smelter site and the Helena Valley has been described in numerous reports. Groundwater flow and chemistry on and around the former smelter site have been investigated as part of, and prior to, the RCRA Corrective Action program currently being conducted by the Custodial Trust. The results of these studies are best described in the Current Conditions/Release Assessment (CC/RA) Report (Hydrometrics, 1999), the Phase I RCRA Facility Investigation (RFI) report (ASARCO Consulting, Inc., 2005), the Phase II RFI Work Plan (Hydrometrics, 2010), and the Phase II RFI report (METG, 2011). The East Helena Facility cleanup program includes extensive groundwater and surface water monitoring on a seasonal basis. For instance, the 2013 monitoring program including groundwater level and/or groundwater quality sampling at 200 monitoring wells and piezometers (Hydrometrics, 2013). The East Helena Facility monitoring well network is shown in Exhibit 1.

The hydrogeology of the general Helena Valley area has been described in a number of previous reports including Briar and Madison (1992), Thamke (2000), and Swierc (2013). Previous studies have differentiated between the Helena Valley "valley-fill" aquifer, comprised of unconsolidated sands, gravels, silts and other granular material, and the underlying bedrock aquifer. The East Valley CGWA petition is applicable to the valley-fill aquifer only, where the presence of arsenic and selenium plumes have been documented. Following is a general description of the hydrogeology and groundwater quality of the Helena valley-fill aquifer (also referred to as the Helena Valley alluvial aquifer) and a more detailed discussion of the hydrogeology of the area proposed for inclusion in the CGWA.

2.1 REGIONAL HYDROGEOLOGY

The Helena valley-fill aquifer covers an area of approximately eight square miles within the Helena Valley basin. The valley-fill aquifer is comprised of Tertiary and Quaternary-age unconsolidated granular material ranging in size from cobble and boulder down to silt and clay. The unconsolidated valley-fill overlies bedrock at depth, with the valley-fill aquifer reaching 6,000 feet or more in thickness in the northeast portion of the Valley (Briar and Madison, 1992). The majority of valley fill is comprised of Tertiary age sediments with the upper 100 feet or more comprised of younger alluvium (Briar and Madison, 1992). The valley-fill aquifer serves as a drinking water source for the majority of Helena Valley residents through individual domestic wells, community wells, and public water supply wells.

Recharge to the valley-fill aquifer occurs from streamflow infiltration, leakage from irrigation ditches and canals, infiltration of excess irrigation water, inflow from the surrounding and underlying bedrock aquifer, and, to a lesser extent, direct precipitation. Inflow from the surrounding bedrock aquifer is the greatest source of recharge to the valley-fill aquifer basin-wide, with bedrock recharge accounting for about 46% of annual recharge (Briar and Madison, 1992). Recharge from irrigated fields accounts for about 31% of annual recharge, with stream leakage and irrigation canal/ditch leakage accounting for 15% and 8%, respectively.

Groundwater flow directions in the valley-fill aquifer are generally from the north, west and south valley margins, towards Lake Helena, the regional groundwater drain in the northeast portion of the valley. As a result, the valley-fill potentiometric surface, or contour map of groundwater potential head, forms a more or less concentric pattern with the low point centered on Lake Helena. A generalized potentiometric map of the valley-fill aquifer, with the former smelter and approximate East Valley CGWA shown for reference, is included in Figure 2-1.

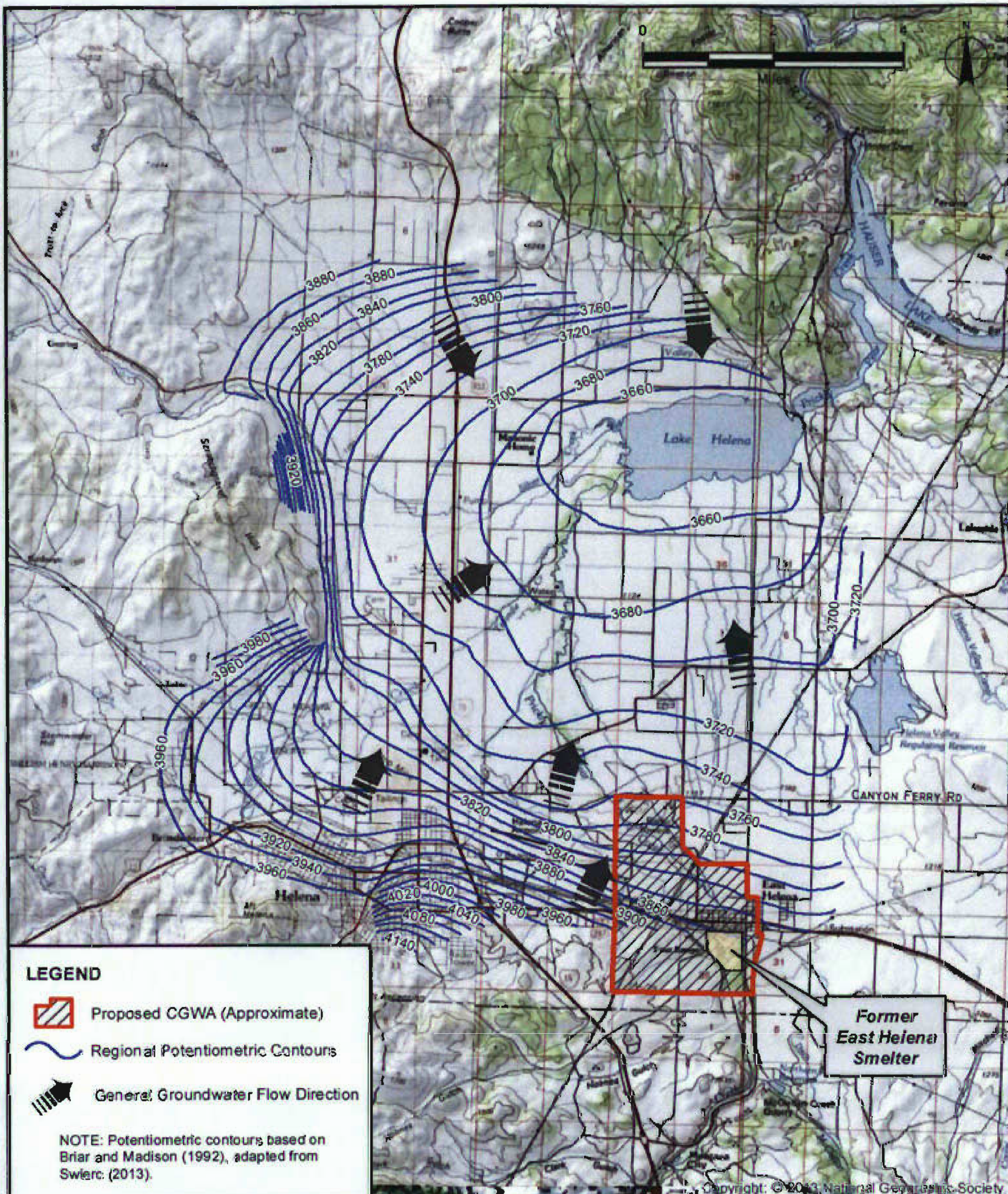
The valley-fill material generally consists of relatively permeable sands, gravel, and cobbles, with interlayered zones of less permeable silt and clay. The silt/clay layers are relatively thin (a few feet to 10 feet in thickness) and are laterally discontinuous. As such, the silt/clay layers inhibit but do not prevent vertical flow between the more extensive and more permeable coarser-grained water-bearing zones. This general stratigraphic pattern, which has been documented near and north of the former smelter site through the Facility investigations, directly influences contaminant plume migration and the proposed CGWA boundaries.

2.2 LOCAL HYDROGEOLOGY

Within the proposed CGWA, groundwater conditions are generally similar to the regional conditions described above. On and north of the former smelter (the primary contaminant source within the proposed CGWA), the valley-fill stratigraphy and hydrogeology have been documented through logging of more than 200 monitoring wells, piezometers, and soil borings as well as by reviewing available well completion logs from private and public water supply wells. The area of interest and key features for the local hydrogeology discussion (and the CGWA petition) are shown in Figure 1-1.

2.2.1 Geology and Hydrostratigraphy

The local geology, both surficial and subsurface, has a strong influence on groundwater flow and contaminant plume migration. Important features of the local geology include: exposed metasedimentary Spokane formation bedrock (Ys) in the southwest portion of the CGWA; a large area of alluvium (Qa) extending along Prickly Pear Creek from the former smelter site



Hydrometrics, Inc. Consulting Scientists and Engineers Date Saved: 4/10/2014 1:49:25 PM	PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	REGIONAL POTENTIOMETRIC MAP	FIGURE **2-1**

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northward into the Helena Valley; the uplands or foothills comprised of fine-grained Tertiary sediments south, east (OgS) and west (OgtS) of East Helena; and commingled alluvium and colluvium (Qac) intermediate to the Tertiary uplands and alluvium along the Prickly Pear Creek corridor. The surficial geology of the immediate area is shown in Figure 2-2. Following is a summary of the CGWA geology and hydrostratigraphy. Additional detail is provided in Appendix B.

<u>Younger (Quaternary) Alluvium and Mixed Alluvium/Colluvium:</u> Much of the CGWA including the former smelter site is situated on recent unconsolidated alluvial/colluvial sediments that extend northward from the southern basin margin into the valley. The alluvium (Qa in Figure 2-2) represents relatively recent sediment deposition from Prickly Pear Creek and forms in part the primary groundwater-bearing unit within the CGWA. The thickness of the alluvium, where present, ranges from about 20 feet in the south portion of the CGWA, to 100 feet or more in the northern portion.

Distal from Prickly Pear Creek the alluvium grades to a heterogeneous mixture of alluvium and colluvium (Qac). The alluvium/colluvium contains a higher percentage of fine-grained silt and fine sand than the alluvium. Fine sediment content increases with distance from the creek, resulting in a lower permeability. This difference in permeability influences groundwater flow and plume migration in the CGWA.

<u>Older Quaternary/Tertiary Alluvium:</u> Older alluvium of early Quaternary and late Tertiary age underlies the more recent alluvium. Based on data obtained through drilling within the proposed CGWA, these sediments are weakly consolidated sand, silty sand and gravel with discontinuous silt layers. The thickness of this unit ranges up to about 30 feet on the former smelter site, and increases to 100 feet or more at the north end of the CGWA near Canyon Ferry Road (Figure 1-1). Overall, the older alluvium contains more fine-grained sediment and is more highly cemented with secondary mineral precipitates than the younger alluvium, but still serves as a primary water-bearing unit in the valley-fill aquifer.

<u>Tertiary Sediments:</u> Tertiary-age sediments (OgS) consisting primarily of fine-grained sediments (silt/fine sand) form the foothills south of East Helena and in the southwest portion of the CGWA (Figure 2-2). In the southwest area, the Tertiary sediments contain significant volcanic ash and tuff beds (OgtS) partially or completely altered to clay. A laterally extensive weathered ash/clay unit within the Tertiary sediments underlies a substantial portion of the former smelter and surrounding area. As discussed below (and in Appendix B), the ash/clay unit plays an important role in groundwater flow while the volcaniclastic sediments affect the regional groundwater chemistry and distribution of arsenic in the proposed CGWA.

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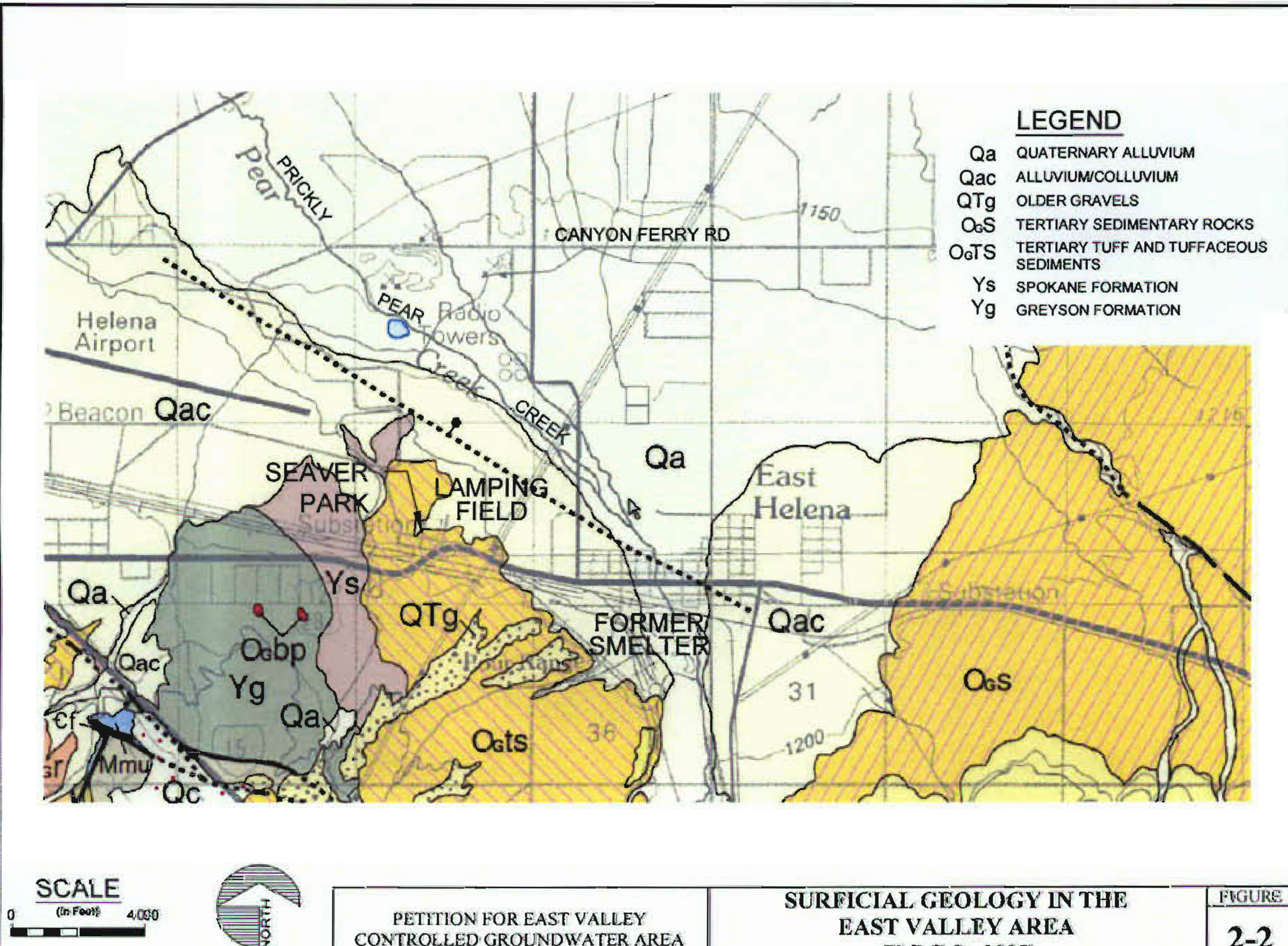


Hydrometrics, Inc.
Consulting Scientists and Engineers

PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA

SURFICIAL GEOLOGY IN THE EAST VALLEY AREA (U.S.G.S., 2005)

FIGURE 2-2

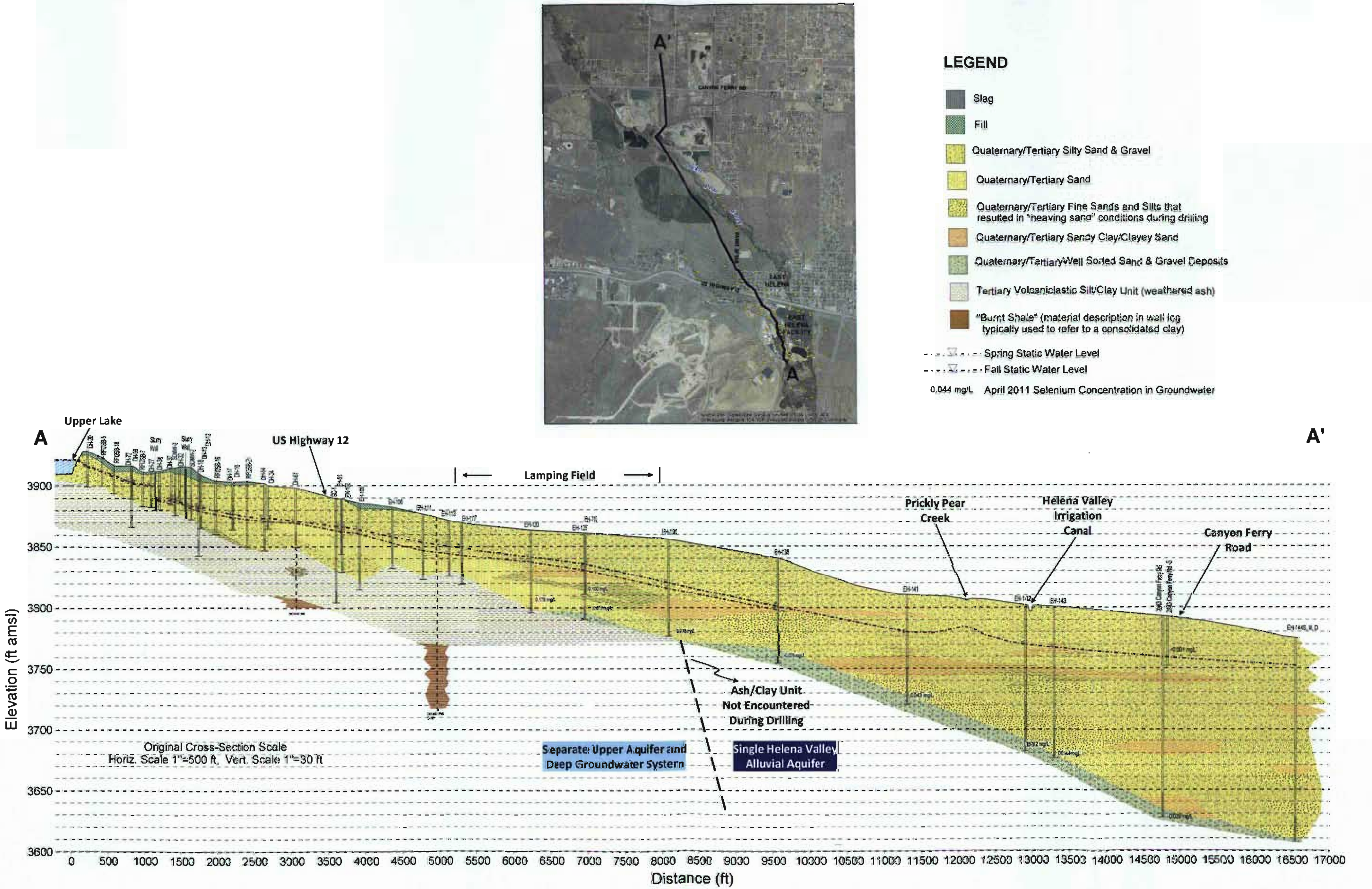
A hydrostratigraphic unit is one or more stratigraphic units with similar hydrologic characteristics allowing for grouping into a single unit for purposes of describing groundwater occurrence and flow. Based on the local geology and stratigraphy, the following hydrostratigraphic units have been identified within the proposed CGWA.

Upper Aquifer: The Upper Aquifer is comprised of unconsolidated granular fill and alluvial/colluvial sediments extending from ground surface down to the top of the weathered Tertiary ash/clay layer. The Upper Aquifer hydrostratigraphic unit extends from Upper Lake on the south end of the former smelter site, northward through the East Helena area and into the Helena Valley.

Tertiary Ash/Clay Confining Unit: Underlying the Upper Aquifer in the southern portion of the CGWA is a clay-rich low permeability unit inhibiting vertical groundwater flow. This confining unit, or aquitard, is comprised of the weathered Tertiary volcaniclastic sediments described above. Based on extrapolation of well log data throughout the CGWA, the low permeability clay unit appears to be continuous from south of the former smelter site northward through Lamping Field, with depths ranging from about 20 feet below ground surface at the south end of the smelter, to 50 feet bgs at the north end, and 80 feet bgs north of Lamping Field. The ash/clay unit has not been identified in monitoring wells completed to depths of 175 feet in the vicinity of Canyon Ferry Road. Figure 2-3 shows the cross sectional relationship between the Upper Aquifer and the ash/clay aquitard from the smelter on the south, extending northward approximately three miles into the Helena Valley.

Deeper Groundwater System: Besides the Upper Aquifer, groundwater in the southern portion of the CGWA, including the former smelter site, occurs at depths below the ash/clay confining layer. Unlike the Upper Aquifer, which occurs as one continuous saturated unit, the deeper groundwater occurs as multiple coarser-grained layers interspersed within and beneath the ash/clay unit. Because the deeper water bearing zones may have limited interconnectivity, they are referred to as the deep groundwater system as opposed to a single aquifer. These deeper water-bearing zones are present within different materials at various depths.

In the northern portion of the CGWA (north of Lamping Feld), the hydrostratigraphy changes due to the apparent absence of the ash/clay aquitard. As shown in Figure 2-3, the ash/clay layer has not been detected during monitoring well drilling or through review of private well completion logs in the northern portion of the CGWA (north of Section 26, Figure 1-1). Therefore, groundwater within the Upper Aquifer and deeper groundwater systems present in the southern portion of the CGWA apparently merges into a single, vertically continuous aquifer (the Helena Valley alluvial or valley fill aquifer) north of Lamping Field.



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PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	GEOLOGIC CROSS SECTION	FIGURE 2-3

2.2.2 Groundwater Recharge/Discharge

The primary documented sources of groundwater recharge within the CGWA include leakage of surface water to groundwater and possibly inflow from the surrounding Tertiary sediment and bedrock uplands (Briar and Madison, 1992). Until recently, leakage from Upper Lake was a significant source of recharge to the Upper Aquifer at the former smelter site, with the Upper Lake seepage water flowing north-northwest through the smelter towards the Helena Valley. Historic releases of contaminants from former smelter operations, and ongoing leaching of contaminants to groundwater from the plant site soils, are primary mechanisms for contaminant transport and plume migration leading to this petition. As part of implementation of IMs, in the fall of 2011 the Custodial Trust began dewatering Upper Lake to determine if reducing recharge from the surface water bodies would lower groundwater elevations (Appendix A). Extensive monitoring of groundwater levels following dewatering of Upper Lake, and installation of a temporary bypass for Prickly Pear Creek in October 2013, shows that groundwater elevations have declined in response to these activities. Therefore, Upper Lake is to remain dewatered indefinitely to lower groundwater elevations and reduce groundwater flow through the contaminated former smelter site on a permanent basis.

Of the primary sources of groundwater recharge, leakage from area surface waters to the valley fill aquifer has the greatest influence on groundwater flow and contaminant migration patterns within the proposed CGWA. June 2013 streamflow monitoring on Prickly Pear Creek by Hydrometrics (Table 2-1, Figure 2-4) shows a decrease in creek flow from 90 to 55 cfs between the Highway 12 bridge in East Helena (site PPC-7) to Canyon Ferry Road (site SG-16), a distance of roughly 3 miles. This represents a loss of about 35 cfs or 15,700 gpm, the majority of which likely recharges the underlying groundwater system. In September 2013, the measured streamflow loss was approximately 11 cfs across the same reach, or about 5,000 gpm (Table 2-1). Similar results have been obtained by Lewis and Clark County through streamflow monitoring within this reach of Prickly Pear Creek (Appendix B).

As discussed below, leakage and associated groundwater mounding beneath the creek imparts a strong influence on groundwater flow and contaminant plume migration patterns in the CGWA. As such, future changes in Prickly Pear Creek streamflow and leakage rates could affect future groundwater flow and plume migration patterns. Potential changes in creek flow and leakage rates could result from changes to in-stream leasing agreements currently in effect on Prickly Pear Creek, modifications to the creek channel as part of the Custodial Trust's proposed South Plant Hydraulic Control IM, and/or future drought or other climatic conditions. All of these potential influences, some acting to increase and some decrease future streamflow, have the potential to influence future groundwater flow and plume migration patterns, and have been considered in development of the proposed CGWA boundaries (Section 4).

Hydrometrics, Inc. Consulting Scientists and Engineers Date Saved: 4/10/2014 1:57:41 PM	PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	SYNOPTIC STREAMFLOW MONITORING LOCATIONS	FIGURE 2-4

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TABLE 2-1. PRICKLY PEAR CREEK SYNOPTIC STREAMFLOW MEASUREMENTS

Site ID	Location	Flow - cfs	
		6/11/13	9/16/13
PPC-3A	Upstream near Kleffner Ranch	86.5	17
PPC-22	Near Upper Lake Diversion	89.1	17.3
PPC-5	Below Smelter Dam	92.7	15.2
PPC-23	East of Slag Pile	82.9	15.8
PPC-7	Upstream of Highway 12 Bridge	89.9	16.3
PPC-36A	Upstream of Wylie Drive	70	16.1
PPC-10	Near Wylie Drive Gravel Pit	61.7	10.3
SG-16	At Canyon Ferry Road	54.9	5.2
Total Leakage PPC-7 to SG-16		**35.0 cfs**	**11.1 cfs**

Notes: Locations shown on Figure 2-4.

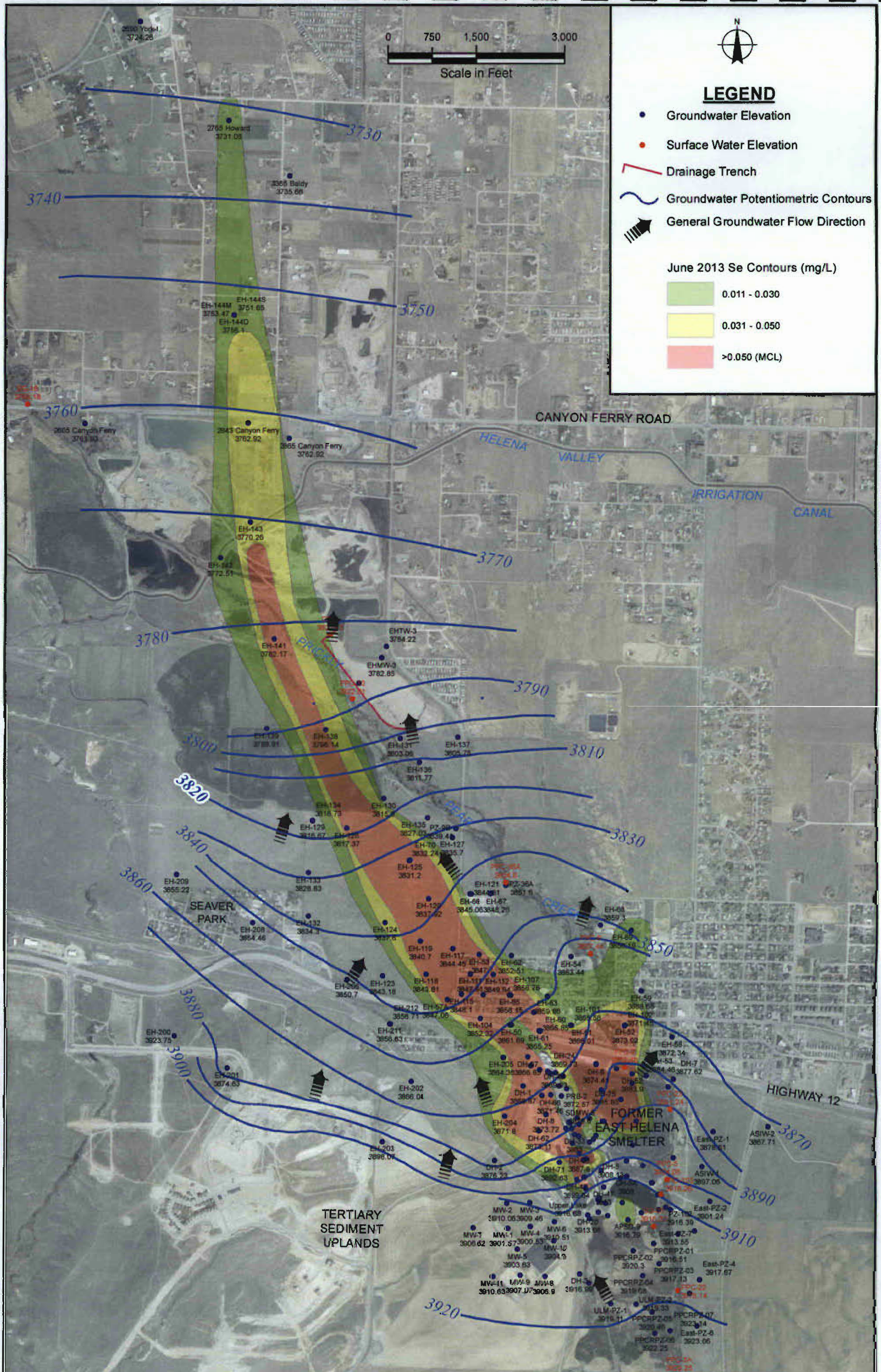
Wilson Ditch is an unlined irrigation ditch which previously conveyed irrigation water from Upper Lake northwestward to the Burnham Ranch in the Helena Valley (Figure 2-4). Historically, leakage from Wilson Ditch recharged groundwater west of the former smelter and along the west side of Lamping Field. In conjunction with the Upper Lake dewatering program (Appendix A), Wilson Ditch has not been operational since the end of the 2011 irrigation season, and use of the ditch to deliver Prickly Pear Creek water has been discontinued. Similar to Prickly Pear Creek, leakage from Wilson Ditch (Appendix A) resulted in seasonal groundwater mounding along the west side of the smelter and Lamping Field, limiting the westward migration of the groundwater plumes in this area. The effects of the discontinued use of Wilson Ditch on future groundwater flow and plume migration patterns has been evaluated through various hydrologic analyses and groundwater flow modeling, and has been accounted for in establishing the proposed CGWA boundaries (Section 4).

As shown in Figure 2-4, the Helena Valley Irrigation Canal is located about two miles north of the former smelter and within the area of the groundwater plumes. Briar and Madison (1992) estimated an average leakage rate of 0.63 cfs (280 gpm) per mile for the Helena Valley Irrigation Canal based on synoptic streamflow measurements collected along the entire canal length. Hydrometrics collected synoptic streamflow measurements on the segment of canal crossing the groundwater plumes (Figure 2-4) to better define canal leakage, and possible effects on groundwater flow and contaminant migration in the downgradient plume area. Differences in the upstream and downstream flow measurements were largely within the flow measurement margin of error (+/-10%), meaning the canal leakage rate (and associated groundwater recharge) in the vicinity of the plumes could not be quantified. However, the section of canal crossing the plume area is partially lined with asphaltic membrane, which likely reduces the actual leakage rate in this area to less than the 0.63 cfs/mile estimated for the entire 53-mile length of the canal.

2.2.3 Groundwater Flow Patterns

Figure 2-5 shows a map of the valley-fill aquifer potentiometric surface within the proposed CGWA. The map was produced from groundwater level measurements collected from the more than 200 monitoring wells and piezometers included in the East Helena Facility groundwater monitoring program, as wells as from surveyed stage elevations along Prickly Pear Creek. Consistent with the regional potentiometric surface and groundwater flow patterns (Figure 2-1), the local groundwater flow direction is generally from the valley margin on the south, northward towards the Helena Valley and ultimately towards Lake Helena, which receives regional groundwater drainage. Primary points of interest in the local potentiometric map (Figure 2-5) include the following:

- The effect of leakage from Prickly Pear Creek on the potentiometric surface is evident from the map. The northward bulge in the potentiometric surface extending from the smelter northward through Lamping Field (to about the 3820 potentiometric contour) represents groundwater mounding due to leakage from the creek. This northwestward-oriented groundwater mound or ridge influences groundwater flow directions along the west side of the creek, and is responsible in part for the northwestward groundwater plume trajectory.
- North of the 3820 potentiometric contour, groundwater mounding is greatly reduced. The reduced mounding is believed to primarily result from groundwater drainage associated with a nearby gravel pit. As shown on Figure 2-5, a perimeter drain is located along the gravel pit floor, presumably to lower the adjacent water table to support prior mining operations (the pit is no longer active). Based on field measurements, the perimeter drain flow rate varied from 2 to 3 cfs (900 to 1350 gpm) in 2012 and 2013. Groundwater drainage through the perimeter trench is believed to be responsible, at least in part, for dissipation of the groundwater mound in this area, which in turn imparts controls on the selenium plume orientation. Dissipation of the groundwater mound causes the groundwater flow direction (and the selenium plume) to veer northward at this location crossing beneath the creek. As a consequence, future changes in the gravel pit groundwater drain system may have implications for future plume migration patterns, and has been considered in development of the proposed CGWA boundaries (Section 4).



PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA

LOCAL GROUNDWATER POTENTIOMETRIC MAP FOR JUNE 2013

FIGURE 2-5

Hydrometrics, Inc.

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- As shown on both the local potentiometric map (Figure 2-5) and the regional Helena Valley potentiometric map (Figure 2-1), groundwater west and southwest of the former smelter site flows in a northeasterly direction. This influx of groundwater from the southwest acts to buttress groundwater flow on and north of the former smelter (i.e., in Lamping Field), limiting westward groundwater flow and plume migration, even in the absence of Wilson Ditch leakage. The groundwater flow from the southwest is also believed to contribute to the elevated arsenic concentrations in the vicinity of the proposed CGWA as discussed below and in Appendix B.

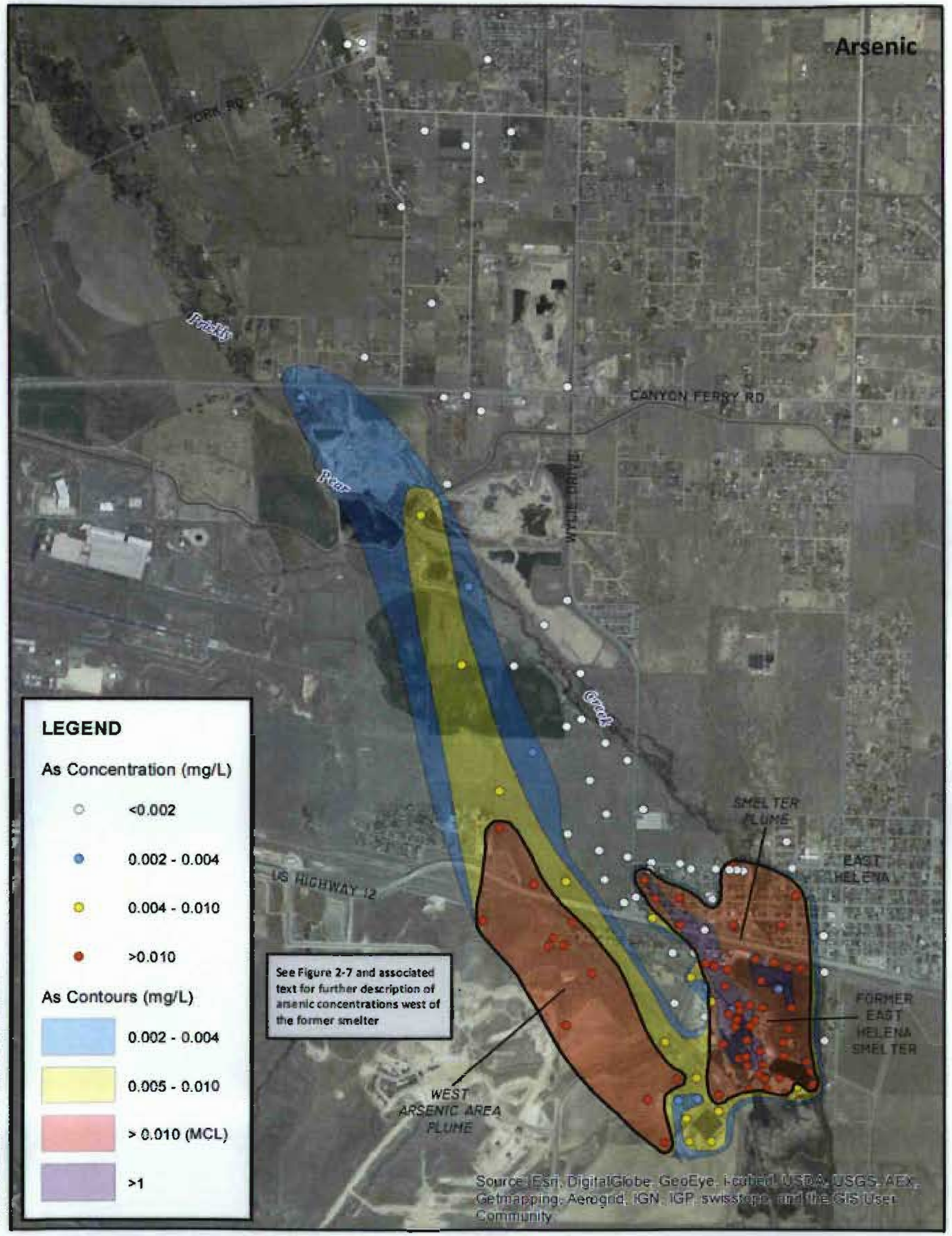
The area hydrogeology as described above, coupled with the groundwater chemistry and plume information presented below, forms the framework for the East Valley CGWA boundaries and provisions outlined in the following sections.

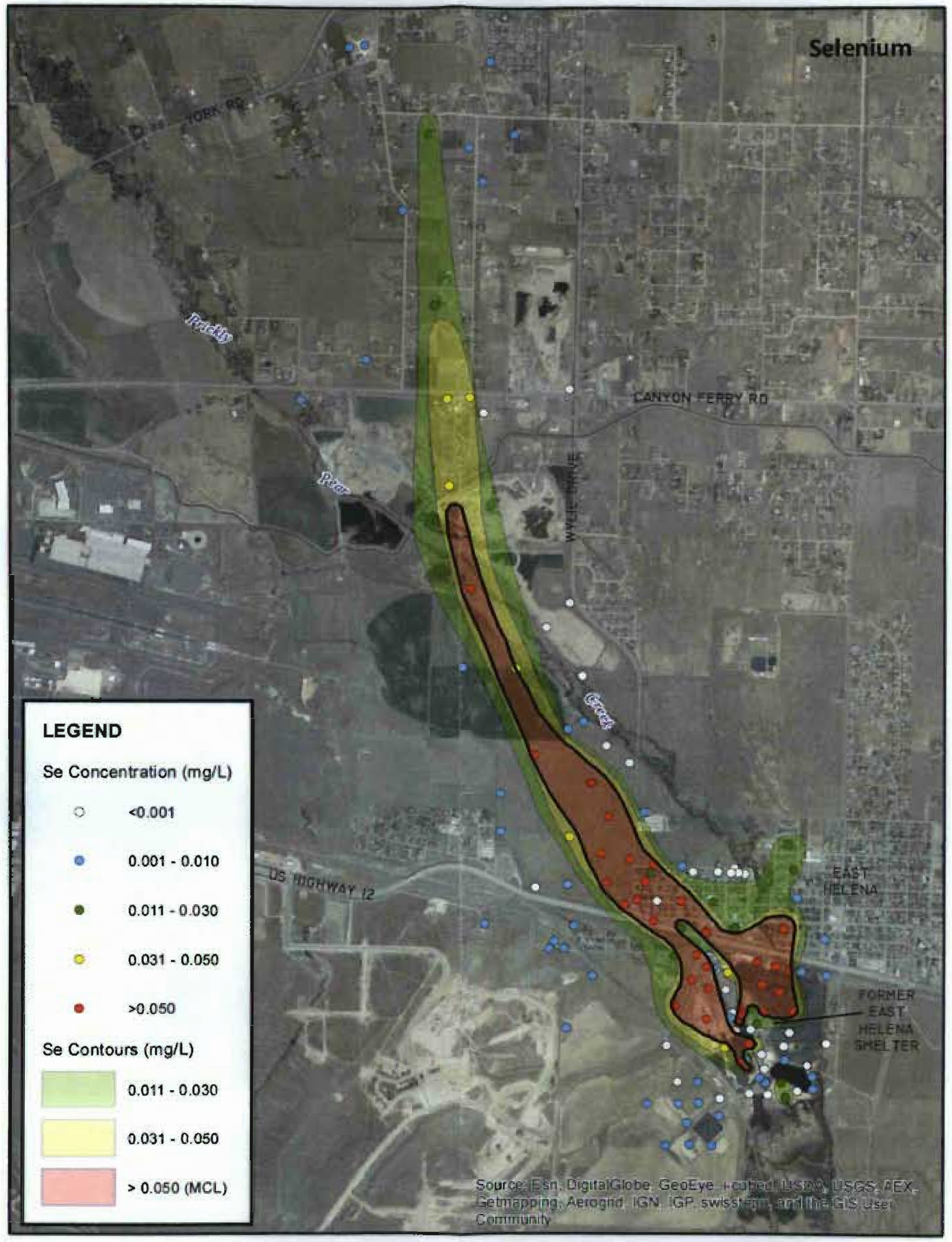
2.3 FORMER SMELTER SITE GROUNDWATER PLUMES

Two groundwater contaminant plumes, one containing elevated concentrations of arsenic and the other selenium, originate from the former smelter site and extend north-northwest towards the Helena Valley (Figure 2-6). As previously mentioned, historic smelter operations released contaminants to the environment over many decades. Although smelter operations ceased in 2001, the leaching of contaminants (i.e., arsenic and selenium) from soils, slag, and/or smelter debris is ongoing. Once partitioned from soil to groundwater, the contaminants migrate with groundwater following the general direction of groundwater flow.

The rate and spatial extent of contaminant migration (i.e., spatial extent of plumes), is based on source mass, source status (historic or current), groundwater flow rates, patterns and mixing with other groundwater sources (dilution/dispersion), and the chemical behavior of the contaminants (attenuation). Generally, arsenic is considered to be a "non-conservative" contaminant, meaning it readily adsorbs to soil or precipitates out of solution as a secondary mineral, whereas selenium is more conservative and tends not to adsorb or precipitate from solution. These distinctive geochemical characteristics explain the relatively limited extent of the smelter arsenic plume, extending approximately 1,500 feet north of Highway 12, as compared to the selenium plume which extends more than three miles northwest of Highway 12 (Figure 2-6).

The groundwater plume patterns, particularly the larger selenium plume, closely mimic the general groundwater flow patterns. As shown in Figure 2-6, the selenium plume is relatively long and narrow, extending about 15,000 feet north of Highway 12 and only 1,500 feet wide at its maximum. The plume extends to the north-northwest through Lamping Field, paralleling Prickly Pear Creek for most of its length, before turning due north and crossing under the creek. The plume migration pattern through and north of Lamping Field is largely





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PETITION FOR EAST VALLEY
CONTROLLED GROUNDWATER AREA

JUNE 2013 ARSENIC AND SELENIUM GROUNDWATER CONCENTRATIONS
FORMER EAST HELENA SMELTER

FIGURE
2-6

controlled by leakage from and associated groundwater mounding beneath Prickly Pear Creek. Near the Wylie Drive gravel pits, the groundwater mound beneath the creek dissipates, due at least in part to groundwater drainage associated with the gravel pits (Figure 2-5). Dissipation of the groundwater mound in this area allows the groundwater to flow in a more northerly direction (towards the Lake Helena regional groundwater drain) resulting in the northward turn in the selenium plume.

Also shown on Figure 2-6 is an additional area of elevated arsenic west of the former smelter referred to as the west arsenic area or plume. As discussed in Section 2.4 and Appendix B, the "west arsenic plume" is believed to be attributable, at least in part, to source(s) other than the former smelter. Based on currently available information, the most likely source appears to be naturally occurring "background" arsenic originating from the Tertiary volcano-clastic sediments, with possible contributions, either current or historic, from the former smelter site and related facilities. The west arsenic area is proposed as a temporary CGWA acknowledging the need for additional evaluation of the occurrence and source(s) of arsenic in this area.

2.3.1 Plume Status

Of primary interest to the East Valley CGWA petition, as well as the East Helena Facility RCRA Corrective Action program, is the current status of the plumes in terms of their stability (i.e., are the plumes advancing, receding or in equilibrium). The groundwater arsenic plume originating from the former smelter site was identified in site investigations dating back to the early 1980s. Since then, groundwater sampling has been conducted under various CERCLA, RCRA and State programs, typically at a minimum frequency of semiannually, with additional monitoring wells installed to track and monitor changes in the arsenic plume. As a result, an extensive database for groundwater arsenic concentrations has been established and the arsenic plume is well-defined. While the plume has expanded into East Helena over time and concentrations in some East Helena area monitoring wells have increased, the current extent as defined by the 10 µg/L HHS contour on Figure 2-6 has remained relatively stable for the past eight to ten years. The primary (highest concentration) arsenic plume extending into the northwest corner of East Helena (Figure 2-6) is characterized by substantial decreases in groundwater arsenic concentration over very short distance. Near the leading edge of the plume, arsenic concentrations currently decrease from nearly 5 mg/L to less than 0.002 mg/L over a distance of approximately 500 feet. This behavior is likely due to strong attenuation of arsenic through adsorption and/or co-precipitation reactions with aquifer material, which has been identified as a key control on arsenic fate and transport at the site through adsorption and leach testing, as well as through examination of arsenic trends and spatial distribution in groundwater. Although some expansion of the groundwater arsenic plume may occur in the future, and trends within the plume likely will vary, existing data and historical trends suggest that the overall extent of the plume should be constrained as a result of geochemical attenuation.

The groundwater selenium plume originating at the former smelter site was identified more recently than the arsenic plume, with extensive testing for selenium in groundwater starting in 2006. As a result, much of the recent site investigation activities have been focused on characterizing the nature and extent of selenium concentrations in groundwater. In contrast with arsenic, selenium is relatively mobile in groundwater, with limited attenuation except under reducing conditions. The long, narrow selenium plume extending more than 1.5 miles from the former smelter site to the northwest (Figure 2-6) demonstrates the mobility of selenium in groundwater. Data collected over the last five to seven years has helped define the spatial extent of the groundwater selenium plume and confirm that the area where concentrations exceed the 50 µg/L HHS has remained relatively stable during that timeframe. However, because data on groundwater selenium concentrations near the leading edge of the plume is limited to the past three years, there is greater uncertainty regarding the selenium plume status. In addition, data from monitoring wells installed in various locations within the selenium plume (both closer to the former smelter site and further downgradient) have shown significant seasonal variability in selenium concentrations, likely due to slight shifts in plume direction related to seasonal water level fluctuations. Given the overall mobility demonstrated by selenium in the groundwater system, additional plume expansion is possible. As previously mentioned and further outlined in Section 6, addressing these two groundwater plumes is a primary focus of the remedy evaluations (both interim and final corrective measures) being conducted as part of the Custodial Trust's CMS.

2.4 CONTAMINANT SOURCES

As noted in Section 1, the primary contaminants of concern for the East Valley CGWA are arsenic and selenium with the contaminated soils at the former smelter being the primary contaminant source. As noted above, an additional source of arsenic loading to groundwater has been identified west of the smelter site and is believed to be related, at least in part, to naturally occurring arsenic in the Tertiary sediment uplands. Conversely, the former smelter as the only identified source of selenium within the East Valley CGWA, although the presence of other unidentified sources is possible. Following is a summary of smelter and non-smelter related contaminant sources affecting water quality within the CGWA.

2.4.1 Former Smelter-Related Contaminant Sources

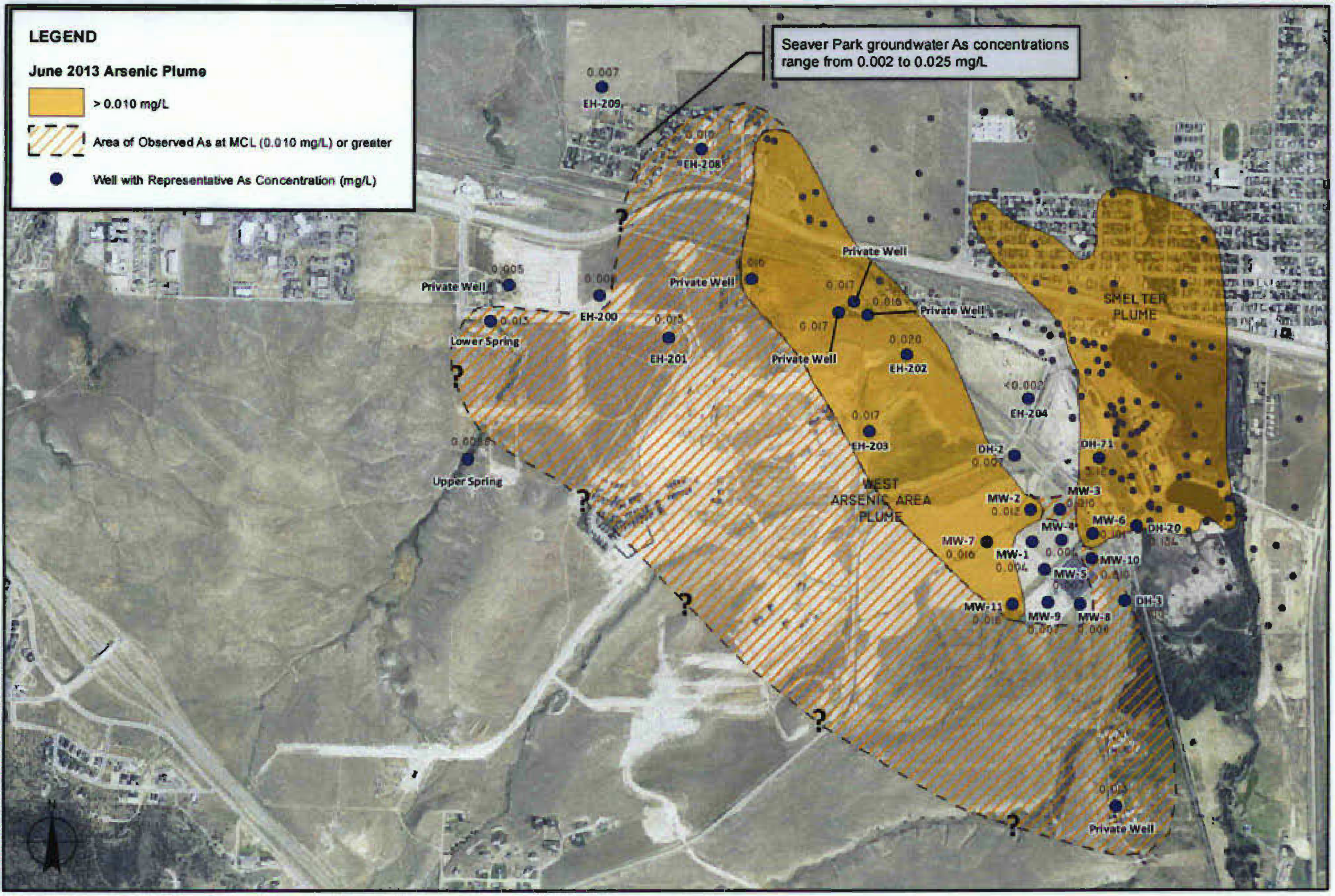
The relationship between the downgradient groundwater plumes and source areas on the former smelter site is well documented, and is the focus of the current East Helena Facility CMS remedy evaluations and current and planned interim measures. The groundwater plume maps (Figure 2-6), along with the groundwater potentiometric map and flow patterns (Figure 2-5) clearly demonstrate the relationship between the main groundwater plumes and the former smelter plant site. Groundwater originating on and south of the site flows north/northwestward through the contaminated plant site soils, releasing contaminants from soils to groundwater. Contaminant source areas on the smelter have been characterized through a number of studies including the Comprehensive RI/FS (Hydrometrics, 1990), the Phase I RFI (ACI, 2005), and the Phase II RFI (METG, 2011). Documented groundwater contaminant source areas on the former smelter property, either current or historic, include: acid plant area soils; speiss/dross area soils; and the south plant area including Tito Park and the Acid Plant sediment drying area (METG, 2011). Other potential contaminant source areas include the west plant site where the highest selenium groundwater concentrations (up to 7 mg/L) have been observed within the CGWA, and the slag pile, although the magnitude of and/or mechanisms for contaminant loading from these source areas is not well defined. Once released to groundwater, the contaminants travel with groundwater to the north/northwest, resulting in the current arsenic and selenium smelter plume configurations shown in Figure 2-6.

2.4.2 Additional Contaminant Sources

An area of elevated groundwater arsenic concentrations west of the former smelter site (west arsenic plume or area, Figure 2-6) was identified as part of the groundwater evaluations being conducted under the RCRA Corrective Action program. Despite its proximity to the former smelter site, evaluations to date indicate that the elevated arsenic concentrations west of the smelter are believed to be related, at least in part, to other sources. Figure 2-7 focuses on the west arsenic plume area as delineated by the June 2013 groundwater sampling data, as well as a number of additional data points collected at different times from the area. As shown in the figure, elevated arsenic concentrations near or above the 10 μg/L HHS have been documented hydrologically upgradient of the former smelter, including to the south and southwest. Examples include:

- Arsenic concentrations in samples from a private water well located on Smelter Road south of the smelter range from 9 to 16 μg/L from 2011 through 2013. Groundwater elevations at this well are 3920 to 3925 feet AMSL, or 5 to 10 feet higher than the smelter property groundwater levels.
- The R&D spring located southwest of the smelter site was sampled once in 2010 with an arsenic concentration of 9 μg/L. The elevation of the spring is about 4010 feet AMSL, or about 100 feet higher in elevation than the smelter site groundwater. A second sampling site further downstream on the spring drainage, approximate elevation 3945 AMSL, or 25 to 30 feet higher than the south plant site groundwater, had an arsenic concentration of 13 μg/L.

Although the presence of elevated arsenic concentrations in groundwater hydrologically upgradient of the former smelter indicates a separate source, it does not rule out the



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PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	WEST ARSENIC PLUME AREA CONCENTRATIONS	FIGURE 2-7

possibility that groundwater from the former smelter site may contribute to portions of the west arsenic area plume. In order to evaluate the potential for smelter groundwater to contribute to the west arsenic plume, an evaluation of the potential hydrologic connection between the two areas was conducted by the Custodial Trust. The evaluation included a review of groundwater flow patterns and water level trends, a review of groundwater chemistry, and a groundwater flow particle tracking analysis using the East Helena Facility numerical groundwater flow model. Results of these evaluations are presented in Appendix B. In summary, these studies and analyses suggest the following:

- Groundwater levels in most monitoring wells west of the former smelter site exhibit little or no correlation in water level trends with smelter site monitoring wells, suggesting a lack of or limited groundwater interaction between these areas. Elevated arsenic concentrations in these wells, generally between 10 and 20 µg/L, suggest an arsenic source other than the smelter.
- The general groundwater chemistry in the west area monitoring wells is variable, with some wells showing an alluvial groundwater signature, some a Tertiary sediment signature, and others a bedrock (Spokane Formation) signature (see Appendix B and Exhibit 3). Groundwater throughout most of the former smelter property exhibits unique chemical signatures associated with elevated sodium, chloride, and/or sulfate. The presence of elevated arsenic concentrations in the west area wells with varying chèmical signatures suggest a source of arsenic (and groundwater) that is different than the smelter.
- The East Helena Facility groundwater model was used to simulate groundwater flow southwest of the smelter site including the west arsenic area. Based on reverse particle tracking simulations, groundwater flow west of the smelter, including all west area wells with elevated arsenic concentrations, originates from the southwest and not from the smelter. The modeling results are included in Appendix C.

In summary, elevated arsenic concentrations hydrologically upgradient of the former smelter site indicate a distinct source of arsenic other than the former smelter, most likely derived from the Tertiary volcano-clastic sediments to the southwest. Based on a review of available groundwater level and chemistry data, and particle tracking using the numerical groundwater flow model (Appendix C), current contributions from the smelter site to the west arsenic area plume appear to be limited, although commingling of "background" contaminants and smelter-derived contaminants, either from current or historic smelter sources, cannot be ruled out. As outlined in the following sections, this petition for the East Valley CGWA addresses all arsenic and selenium groundwater contamination in the vicinity of the former smelter, regardless of source.

3.0 CRITERIA FOR CGWA PETITION

Montana code 85-2-506 MCA defines specific criteria that must be satisfied for implementation of a CGWA. According to the statute, a CGWA may be designated by rule if one or more conditions or specific criteria are met. The criteria include various water quality and/or quantity issues that do, or may, jeopardize the designated beneficial uses of water or the ability to exercise permitted water right withdrawals. In the case of the East Valley CGWA petition, applicable criteria include:

- *85-2-506 (5)(c): current or projected ground water withdrawals from the aquifer or aquifers in the proposed controlled ground water area have induced or altered or will induce or alter contaminant migration exceeding relevant water quality standards.*
- *85-2-506 (5)(e): ground water within the proposed controlled ground water area is not suited for beneficial use.*
- *85-2-506 (5)(f): Public health, safety, or welfare is or will become at risk.*

Water quality standards for groundwaters in Montana are specified in the Administrative Rules of Montana (ARMs). ARM 17.30.1006 lists various groundwater classifications and associated intended beneficial uses. Groundwaters are classified by their natural specific conductance, with Class I groundwater having a natural specific conductance (SC) equal to or less than 1,000 microsiemens/centimeter (μs/cm) at 25° C, Class II groundwater having an SC between 1,000 and 2,500 μs/cm, Class III between 2,500 and 15,000 μs/cm, and Class IV groundwater greater than 15,000 μs/cm. With few exceptions, groundwater in the East Helena area, including the former smelter, is less than 1,000 μs/cm. Those portions of the smelter where the groundwater exceeds 1,000 μs/cm are impacted by historic smelter activities and likely had a natural SC of less than 1,000. Therefore, groundwater in the East Helena area is designated Class I groundwater.

ARM 17.30.1006 defines beneficial uses of Class I groundwater, with minimal or no treatment, as:

1. Public and private water supplies;
2. Culinary and food processing purposes;
3. Irrigation; Livestock and wildlife consumption; and
4. Commercial and industrial purposes.

A water body's ability to meet a designated beneficial use is based in part on the quality of that water body. In the case of potable use of groundwater (beneficial uses 1 and 2), the State of Montana human health water quality standards from Circular DEQ-7 (MDEQ, 2012), typically the same as federally promulgated MCLs, are used to assess the suitability of a source. As established in Circular DEQ-7, the human health standards for arsenic and selenium are 10 and 50 µg/L, respectively.

Based on extensive groundwater sampling and testing over the past several years, arsenic and selenium concentrations in groundwater near and downgradient (north) of the former Smelter site consistently exceed the applicable human health standards. Table 3-1 includes a statistical summary of arsenic and selenium concentrations at select wells within and peripheral to the contaminant plumes. The statistical summary is based on recent water quality data (2010 through June 2013), reflecting current water quality conditions. The summary includes the number of samples, minimum, maximum and mean concentrations for each well, and the number and percentage of HHS exceedances. Monitoring wells included in the statistical summary are shown on Figure 3-1. As shown in Table 3-1, HHS exceedances for arsenic at representative wells are consistent (exceedance rates of 86% to 100%) within the currently defined 10 µg/L arsenic contour, while concentrations outside the contour are consistently below the arsenic HHS (exceedance rates of 0%). For selenium, HHS exceedance rates are also consistent for wells on the former Smelter site, near source areas and near the centroid of the downgradient plume (exceedance rates of 91% to 100% in Table 3-1). Lower exceedance rates for some wells near the 50 µg/L selenium plume margins (19% to 38%, see Figure 3-1 and Table 3-1) illustrate that selenium concentrations fluctuate seasonally, and may exceed the HHS only during certain times of the year or under certain groundwater flow conditions. Overall, this information confirms that groundwater quality within and downgradient of the former smelter site does not meet applicable groundwater quality standards, may present a health risk if exposures are not properly controlled, and therefore is not suitable for all intended beneficial uses.

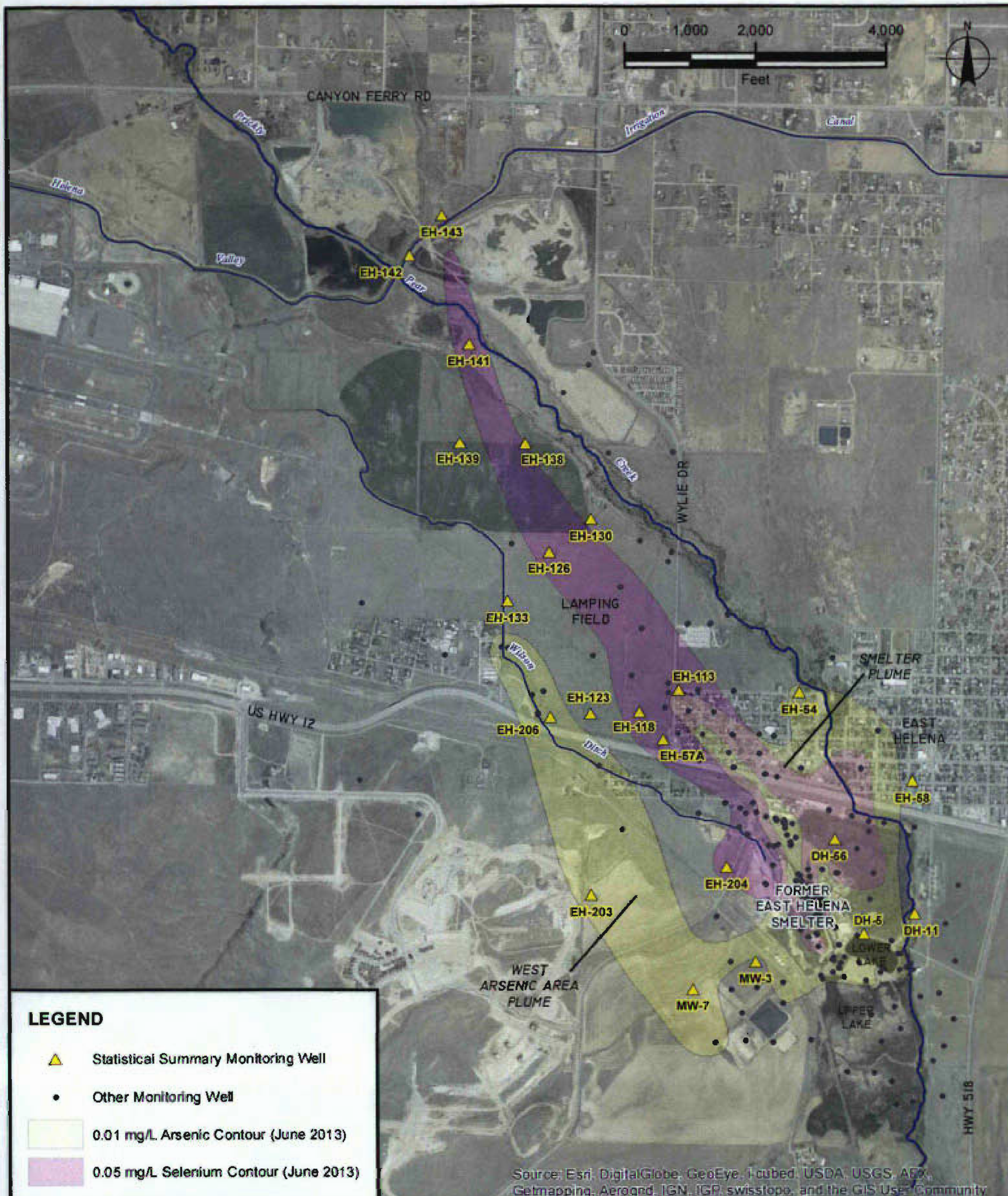
Furthermore, development of new pumping wells peripheral to the groundwater plumes has the potential to lower groundwater levels, alter groundwater flow patterns, and thus cause the groundwater plumes and associated contaminants to migrate into currently unaffected areas. This potential indicates that the criteria presented in 85-2-506 (5)(c) MCA should also be considered in the designation process.

Based on the above information, groundwater quality on and north of the former smelter is not suitable for all intended beneficial uses and exceeds Montana groundwater HHSs, meeting the CGWA petitioning criteria listed in MCA 85-2-506 (5)(c), (5)(e), and 5(f). The full East Helena Facility monitoring well water quality database is included on CD in Appendix D. All well locations are shown on Exhibit 1.

TABLE 3-1. STATISTICAL SUMMARY OF ARSENIC AND SELENIUM CONCENTRATIONS AT SELECT MONITORING WELLS NEAR THE EAST VALLEY GROUNDWATER PLUMES

Well ID	Arsenic Concentrations mg/L					Selenium Concentrations mg/L				
	N	Min	Max	Mean	Number (%) Exceedances	N	Min	Max	Mean	Number (%) Exceedances
MW-7	12	0.013	0.018	0.015	12 (100%)	12	0.001	0.001	0.001	0 (0%)
MW-3	13	0.008	0.01	0.01	0 (0%)	13	0.002	0.009	0.007	0 (0%)
DH-5	7	0.077	0.413	0.23	7 (100%)	7	0.001	0.002	0.001	0 (0%)
DH-11	7	0.002	0.002	0.002	0 (0%)	7	0.001	0.003	0.001	0 (0%)
EH-203	7	0.005	0.017	0.014	6 (86%)	7	0.002	0.002	0.002	0 (0%)
EH-204	10	0.002	0.002	0.002	0 (0%)	10	0.07	0.115	0.096	10 (100%)
DH-56	17	0.778	4.13	1.91	17 (100%)	17	0.514	2.02	0.8	17 (100%)
EH-58	7	0.002	0.002	0.002	0 (0%)	7	0.001	0.004	0.002	0 (0%)
EH-206	9	0.02	0.031	0.025	9 (100%)	8	0.001	0.012	0.003	0 (0%)
EH-123	10	0.007	0.008	0.007	0 (0%)	9	0.002	0.003	0.002	0 (0%)
EH-57A	8	0.002	0.002	0.002	0 (0%)	8	0.003	1.06	0.273	3 (38%)
EH-54	10	0.009	0.029	0.021	9 (90%)	10	0.001	0.001	0.001	0 (0%)
EH-118	8	0.002	0.002	0.002	0 (0%)	8	0.005	0.74	0.165	2 (25%)
EH-113	2	0.002	0.003	0.003	0 (0%)	2	0.10	0.12	0.11	2 (100%)
EH-133	8	0.007	0.008	0.008	0 (0%)	8	0.001	0.002	0.001	0 (0%)
EH-126	16	0.002	0.005	0.004	0 (0%)	16	0.005	0.089	0.027	3 (19%)
EH-130	16	0.002	0.005	0.002	0 (0%)	16	0.003	0.033	0.013	0 (0%)
EH-138	10	0.002	0.002	0.002	0 (0%)	11	0.049	0.082	0.063	10 (91%)
EH-139	9	0.002	0.006	0.005	0 (0%)	9	0.001	0.002	0.002	0 (0%)
EH-141	10	0.002	0.005	0.003	0 (0%)	10	0.023	0.07	0.046	3 (30%)
EH-142	10	0.004	0.005	0.005	0 (0%)	10	0.009	0.018	0.013	0 (0%)
EH-143	10	0.002	0.002	0.002	0 (0%)	10	0.024	0.044	0.037	0 (0%)

N-Number of Results
Number of exceedances includes results greater than 0.010 mg/L arsenic or 0.050 mg/L selenium.
Well Locations shown on Figure 3-1.



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4.0 CONTROLLED GROUNDWATER AREA BOUNDARIES AND PROPERTY OWNERSHIP

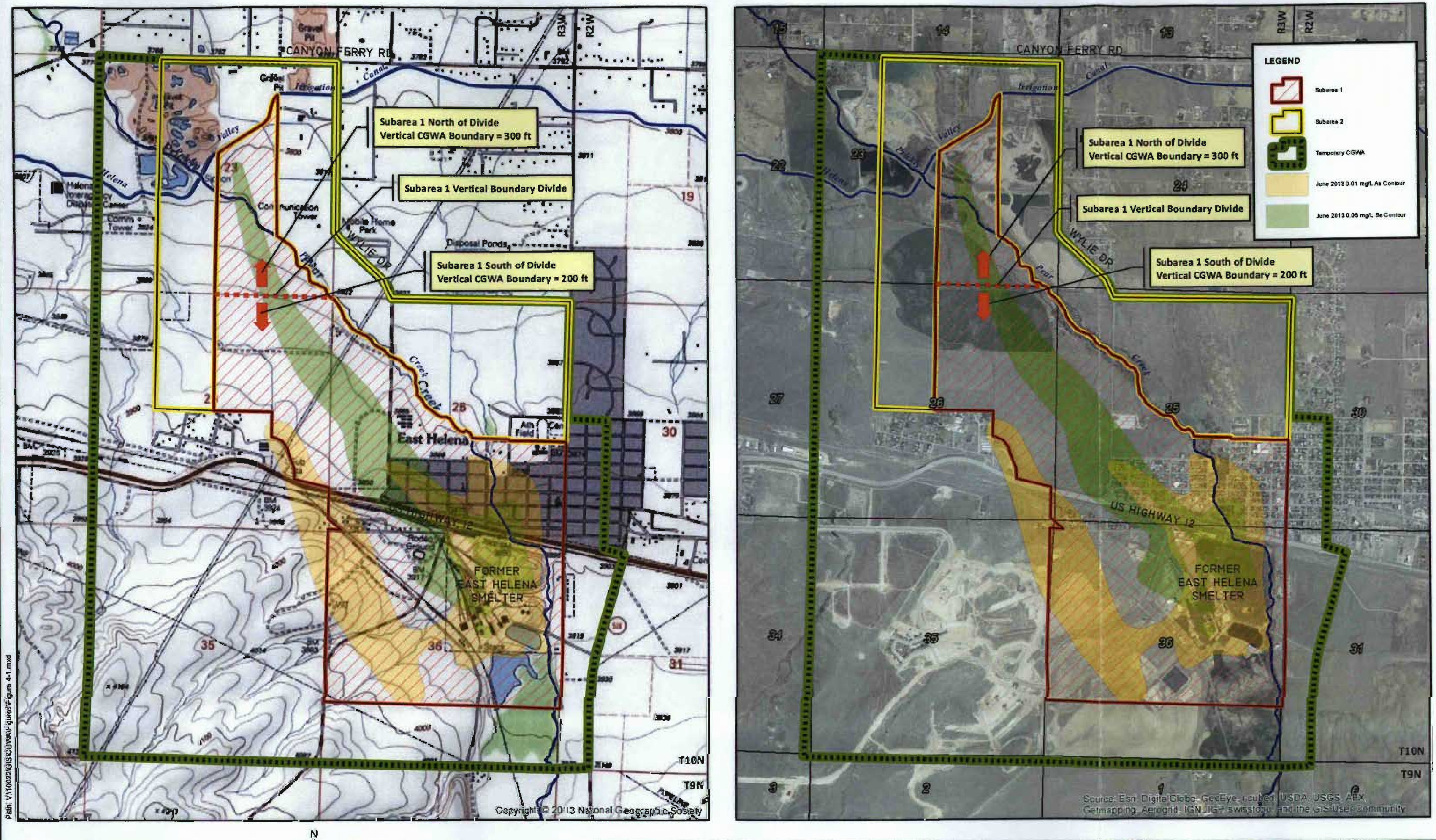
The East Valley CGWA boundaries are based on the distribution of contaminants in the groundwater plumes, and potential future changes in groundwater flow and plume migration patterns. Where possible, the boundaries are located to coincide with physical features, such as roads, or legal boundaries such as parcel boundaries or section lines to facilitate physical interpretation of boundary locations. The boundaries are consistent with the CGWA objectives of preventing unacceptable exposure to groundwater-borne contaminants (i.e., arsenic and selenium) or spreading of the groundwater plumes due to groundwater pumping, while minimizing the impacts of groundwater usage restrictions on property owners to the extent practicable.

The proposed East Valley CGWA lies entirely within Lewis and Clark County in the southeastern portion of the Helena Valley. The CGWA includes both a temporary and permanent[4] CGWA component, with the overall boundaries encompassing the former smelter site, portions of the City of East Helena (including the main downtown area and Manlove Addition), Seaver Park, and surrounding agricultural, industrial, residential and open lands. The CGWA includes all of Sections 23, 25, 26, 35, 36 and a portion of Section 24 in Township 10 North, Range 3 West (Figure 4-1). The CGWA covers a total of 3,290 acres or about 5.1 square miles. A total of 1,120 acres within the CGWA is owned by the Custodial Trust where groundwater usage controls are already in place and 1,360 acres lies within the East Helena city boundaries where a moratorium on new wells currently exists (Table 4-1).

TABLE 4-1. EAST VALLEY CONTROLLED GROUNDWATER AREA

	Area (Acres/Square Miles)	Custodial Trust Owned Property	Area within City of East Helena
Subarea 1	1,190/1.9	693 acres	910 acres
Subarea 2	734/1.2	257 acres	280 acres
Temporary CGWA	1,366/2.0	170 acres	170 acres
Total	**3,290/5.1**	**1,120 acres**	**1,360 acres**

[4] The statutes refer to two types of CGWAs; permanent and temporary. The designations refer primarily to groundwater usage controls and not the duration of the CGWA. Use of the term "permanent" does not imply that the CGWA will be in effect for perpetuity.



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PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA

EAST VALLEY CGWA BOUNDARIES

FIGURE 4-1

4.1 CGWA BOUNDARIES

As noted above, the proposed East Valley CGWA includes a primary or permanent CGWA component and a temporary CGWA component. The primary difference between the two components is that groundwater usage restriction can be applied within a permanent CGWA while usage restrictions cannot be applied in a temporary CGWA. Each of the components is described below.

4.1.1 Permanent Controlled Groundwater Area

The proposed permanent CGWA encompasses approximately 1,924 acres (3.1 square miles) in area. As allowed by statute (85-2-506 MCA), the permanent CGWA is divided into two subareas based on proximity to the HHS-defined plume boundaries. Subarea 1 is the smaller of the two and conforms more closely to the plume boundaries, while the Subarea 2 boundaries lie outside of, or in some places are coincident with, the Subarea 1 boundaries. The two subareas are included to allow for application of different groundwater usage restrictions based on proximity to the plumes. The two subareas are shown on Figure 4-1 and are described below.

Subarea 1 includes those areas with arsenic and/or selenium concentrations that exceed groundwater HHSs due to conditions at the former smelter and includes: the former smelter site and Custodial Trust owned properties immediately to the west; the majority of the City of East Helena main residential/business districts and the Manlove Addition residential area; the majority of Lamping Field; and privately owned properties to the north. In addition to the areas of observed groundwater HHS exceedances, the Subarea 1 boundaries include a buffer zone to account for uncertainty in the precise HHS boundary locations, and possible near-term changes in groundwater flow directions and plume migration patterns. As noted above, the boundaries also coincide with physical or legal boundaries, where possible, to facilitate on-the-ground interpretation of CGWA boundaries. Subarea 1 is approximately 1,190 acres (1.9 square miles) in area (Table 4-1).

Subarea 2 includes those areas in the vicinity of the groundwater plumes where elevated arsenic and selenium concentrations persist but, based on currently available data, at concentrations below the HHSs. Subarea 2 is intended to address areas where there may be insufficient data to conclusively identify the extent of groundwater contamination related to the former smelter, where excessive groundwater pumping could cause plumes to migrate into currently unimpacted areas, or where other changes in the hydrologic system (such as reduced leakage from Prickly Pear Creek due to changes in local water management practices or climatic conditions) could cause changes in the groundwater plume migration patterns in the future. Groundwater usage restrictions are less stringent in Subarea 2 (Section 5). Subarea 2 is approximately 734 acres (1.2 square miles) in area, excluding Subarea 1 (Table 4-1).

4.1.2 Temporary Controlled Groundwater Area

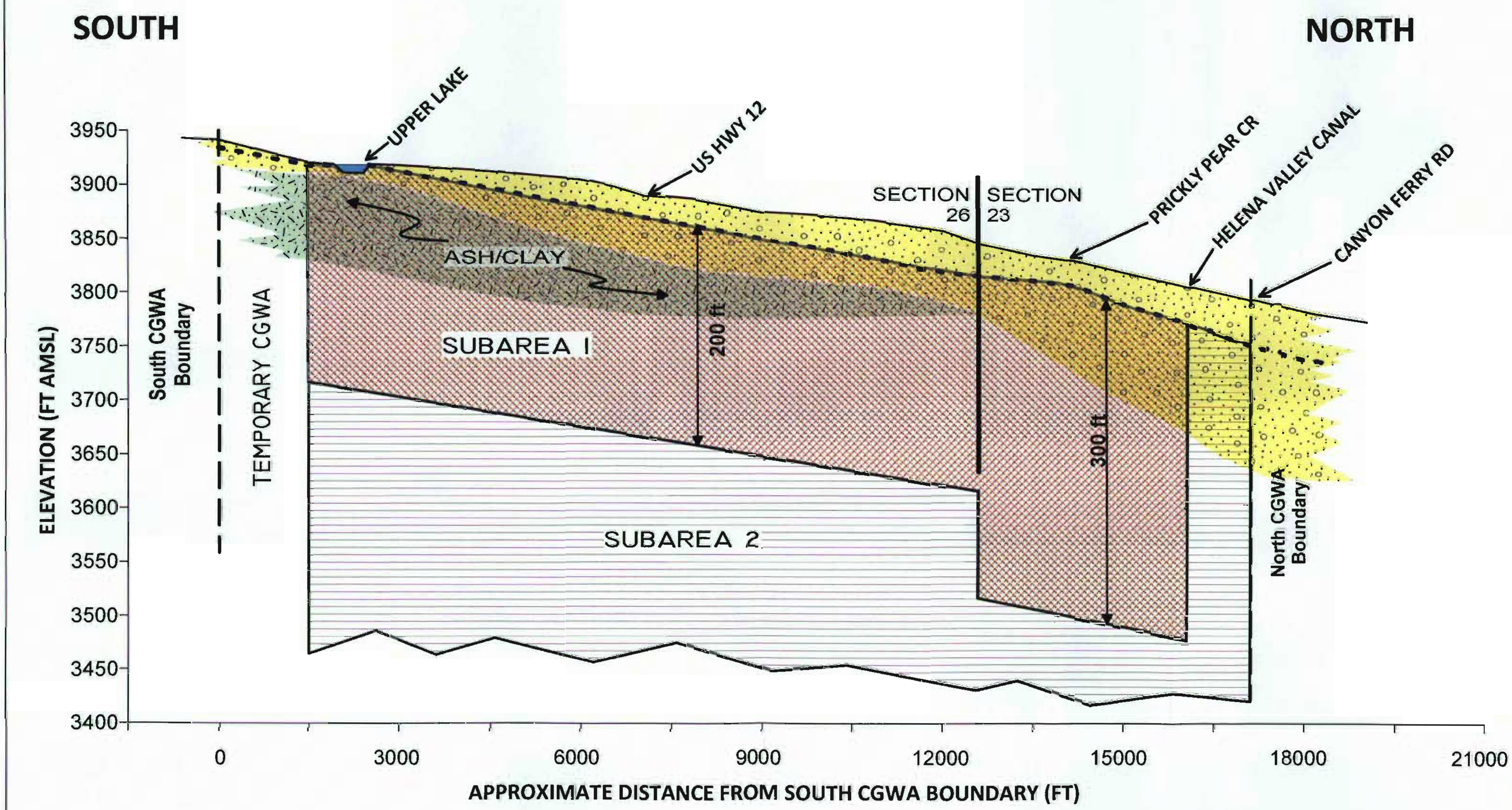
As provided for in statute (MCA 85-2-506(6)): "If the department finds that sufficient facts are not available to designate a permanent controlled ground water area, it may designate by rule a temporary controlled ground water area to allow studies to obtain the facts needed to determine whether or not it is appropriate to designate a permanent controlled ground water area." For the East Valley CGWA, a temporary CGWA is proposed for the areas south and west of the permanent CGWA where exceedances of the 10 µg/L arsenic HHS are known to occur, but the distribution, concentrations and source(s) of arsenic in groundwater are less well defined. Designation of a temporary CGWA is intended to allow for study of the area and cannot include any groundwater usage restrictions, other than measurement, water quality testing, and reporting requirements. The purpose of the East Valley temporary CGWA would be to allow for additional evaluation of water quality conditions and contaminant sources in the area (Section 6), in order to determine if the area warrants designation as a permanent CGWA.

As proposed, the temporary CGWA encompasses 1,366 acres (2.0 square miles), including areas south and west of the former smelter site and the Seaver Park subdivision. A four year duration is proposed for the temporary CGWA, after which time a determination would be made to either convert the area to a permanent CGWA, remove the area from the CGWA, or extend the duration of the temporary CGWA. According to statute, a temporary CGWA can be extended by the department up to a total duration of six years.

4.2 VERTICAL BOUNDARIES

In addition to the lateral boundaries shown in Figure 4-1, vertical boundaries must also be defined for the permanent CGWA to meet the CGWA objectives (Figure 4-2). The upper boundary is proposed to coincide with the top of the saturated zone, or groundwater table, throughout the entire CGWA. The depth to the saturated zone varies from ten feet or less in the south part of the former smelter and along Prickly Pear Creek to the north, to approximately 50 to 60 feet in the northwestern portion of Lamping Field. Groundwater depths then decrease to between 20 and 30 feet further north near Canyon Ferry Road. Information on groundwater depths in the southwest portion (south half of Section 35) is limited, but based on water level data in the north half of Section 35, groundwater depths in this area likely reach 100 feet or more.

The proposed lower CGWA boundary varies by subarea and location. For Subarea 1, where contaminant concentrations approach or exceed the HHSs and the stratigraphy and hydrogeology is relatively well defined, the proposed lower boundary ranges from 200 to 300 feet. For the majority of Subarea 1 (within Section 25, 26 and 36), the boundary is proposed



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PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	EAST VALLEY CGWA VERTICAL BOUNDARIES	FIGURE 4-2

to be set at 200 feet below ground surface. The 200-foot limit recognizes the presence of the low permeability silt/clay layer at depth in this area to establish a base for the Upper Aquifer and the groundwater plumes (Figure 2-4, Appendix B). The 200-foot depth also recognizes that some monitoring wells located on and around the smelter site and completed beneath the top of the silt/clay layer (to depths of 75 feet), have shown exceedances of arsenic and/or selenium HHSs. Thus, the 200-foot depth boundary is intended to prevent usage of potentially contaminated groundwater, and avoid vertical spreading of the contaminant plumes due to pumping at depth.

North of Section 26, the proposed Subarea 1 lower CGWA boundary steps down to 300 feet. The lower boundary is deeper to the north due to the absence of the low permeability silt/clay layer and the increasing depth of the selenium plume in this area. Based on groundwater quality sampling in this area, and particle tracking analyses completed with the groundwater flow model (see groundwater modeling tech memo, Appendix C), the highest selenium concentrations in this area occur at depths of 150 to 200 feet. Establishing the lower boundary at 300 feet accounts for uncertainty in selenium concentrations with depth, and possible future downward migration of the plume due to either natural conditions or excessive groundwater withdrawals at depth. The depth of the lower boundary may be modified in the future if warranted based on additional information on the vertical distribution of the groundwater plumes.

Because the groundwater usage controls are less restrictive for Subarea 2 (see Section 5), no lower vertical boundary is specified. All new wells in Subarea 2 would require a permit before drilling to assure the proposed well completion details, pumping rates and water usage are protective of human health and consistent with the CGWA objectives. The Subarea 2 provisions (permit requirements) would also apply at depths below the Subarea 1 vertical boundary within the Subarea 1 lateral boundaries. Vertical boundaries do not apply to the temporary CGWA.

4.3 BASIS FOR CGWA BOUNDARIES

As noted above, the CGWA boundaries have been proposed with consideration to the designation criteria, based primarily on the distribution and concentrations of the contaminants of concern (arsenic and selenium), and the potential for withdrawals to induce spreading of contaminants. The boundaries are also defined on the basis of other factors, including: current knowledge of groundwater flow and contaminant transport processes responsible for the current plume patterns; potential stresses or changes in the hydrologic system that could affect these mechanisms, and existing property boundaries. Each of these factors is described below.

1. As noted in Appendix A, dewatering of Upper Lake and Wilson Ditch since late 2011 has lowered groundwater levels on the west side of the former smelter and the west side of Lamping Field. This has resulted in a westward shift in groundwater flow and plume migration patterns on and north of the smelter. The 3-D numerical groundwater flow model was used to predict the extent of westward migration of the plumes in the future using forward particle tracking. Based on the predictive modeling results, the groundwater plumes originating from the former smelter site are expected to migrate to the west as much as 1500 feet in the future. The CGWA boundaries proposed in this petition are intended to account for this potential westward shift in the plumes.
2. The CGWA Subarea 1 and Subarea 2 boundaries also address the potential for groundwater pumping to cause the plumes to migrate into currently unaffected areas. Using the numerical groundwater flow model (Appendix C), the capture zone radius, or lateral distance from which a pumping well will draw in surrounding groundwater was estimated for various pumping scenarios. To simulate the effects of a private residential water supply well, the groundwater capture zone was calculated based on one year of continuous pumping at 6.2 gpm. Private residential wells (i.e., exempt wells) are limited to a maximum pumping rate of 35 gpm or a total volume of 10 acre-feet/year (an average annual rate of 6.2 gpm). Additional capture zone simulations were run with pumping rates up to 350 gpm to simulate effects of large scale irrigation or other production wells. The simulation results show that new residential wells should not be completed within 250 feet and higher capacity (350 gpm) productions wells within 700 feet of the HHS-exceeding portions of the plumes. Subarea 2 is intended, in part, to place controls on future development of wells outside of Subarea 1 that have the potential to cause problematic spreading of the groundwater plumes.
3. Other factors accounted for in establishing the CGWA boundaries include future changes in leakage rates from Prickly Pear Creek, or water management practices at the Section 23 gravel pit ponds (Figure 1-1). As noted in Section 2.2, both of these factors have the potential to alter future groundwater flow and contaminant migration patterns. Groundwater drainage at the gravel pits is believed to lower the groundwater table in Section 23 thus allowing groundwater flow and the groundwater plumes to pass northward beneath the creek near the ponds. Termination of the groundwater drainage could cause groundwater levels beneath the creek to rise and the selenium plume to track to the northwest instead of the north. Also noted in Section 2.2 is the effect of leakage from Prickly Pear Creek and associated groundwater mounding on groundwater flow and contaminant migration. A reduction in leakage from the creek, due to natural causes or water management practices, could cause the plumes to spread eastward beneath the creek further south than they currently do. Alternatively, an increase in creek leakage and groundwater

mounding would force the plumes further to the west. The potential for future plume spreading due to one or both of these factors has been accounted for in the proposed CGWA boundaries, and will be evaluated further in 2014 through use of the updated groundwater flow model.

4.4 PROPERTY OWNERSHIP WITHIN THE EAST VALLEY CGWA

Exhibit 4 shows property ownership within the East Valley CGWA as well as the groundwater plumes and CGWA boundaries. The properties shown on Exhibit 4 are tabulated in Appendix E, which shows parcel identification numbers for properties within the CGWA boundaries along with other relevant information. The majority of the CGWA falls under two primary property owners: the Montana Custodial Trust and the Prickly Pear Simmental Ranch. Custodial Trust property holdings within the CGWA include approximately 1,120 acres and represent 34% of the total CGWA acreage, including 693 acres or 58% of the more restrictive Subarea 1 property. In addition to the smelter property itself and surrounding acreage, the Custodial Trust owns all of Lamping Field within the CGWA. The second largest landowner, Prickly Pear Simmental Ranch, owns approximately 375 acres within the CGWA. Other landowners with property within the CGWA include Helena Sand and Gravel, Inc. (180 acres), the Helena Regional Airport (206 acres), and numerous smaller private property owners.

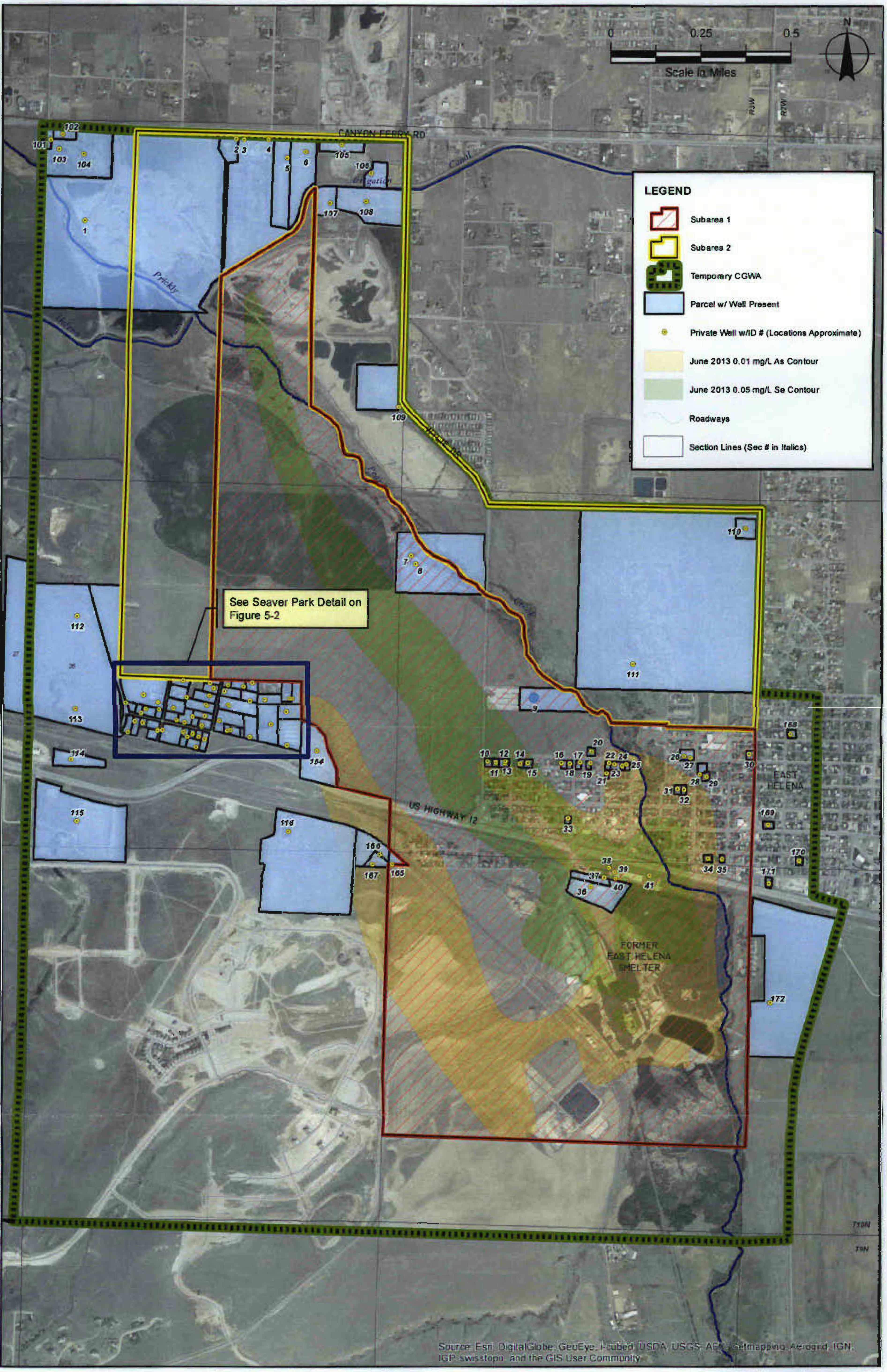
5.0 PROPOSED GROUNDWATER USAGE RESTRICTIONS

The following groundwater usage restrictions are recommended for the East Valley CGWA. These restrictions are designed to ensure compliance with the CGWA objectives of preventing unacceptable exposure to contaminants in groundwater and pumping-induced migration of contaminant plumes, while endeavoring to minimize adverse effects of the restrictions on the local community to the extent possible. The restrictions vary by subarea and are described below and summarized in Table 5-1.

5.1 SUBAREA 1 RESTRICTIONS

Subarea 1 includes those portions of the groundwater plumes where contaminant concentrations currently exceed State of Montana HHSs or where exceedances could occur with minor changes in the plume boundaries. Groundwater usage restrictions within Subarea 1 include a complete moratorium on all new water supply wells, including but not limited to: private, community or municipal water supply wells, irrigation wells and industrial use wells. These restrictions would apply within the lateral and vertical boundaries of Subarea 1 (Section 4). Groundwater monitoring wells, test wells and remediation wells associated with the East Helena Facility remediation program or other government administered hydrogeologic investigations would be allowed within Subarea 1, provided the proposed well(s) would not cause unacceptable contaminant exposure or contaminant migration.

Continued use of existing wells within Subarea 1 would be allowed, but only for their current uses and currently permitted usage rates (35 gpm or 10 acre-feet/year). Based on currently available information, a total of 35 private wells currently exist with the Subarea 1 boundaries, with 33 of these wells located within the City of East Helena boundaries. The majority of private wells located within East Helena are used for lawn irrigation only, although some are used for potable purposes including drinking water (see residential well sampling discussion, Section 1.2.3). Figures 5-1 and 5-2 show all private wells located within the CGWA and Table 5-2 lists the well use and water quality data where available. Existing wells would be subject to water quality monitoring requirements as described in Section 6. Replacement wells may be allowed in Subarea 1 if the replacement well is located in close proximity to, is completed within the same depth interval, and the proposed pumping rate and water usage is the same as the original well. Completion of replacement wells would be subject to approval by a technical advisory group (TAG) as described in Section 5.2, and would also require compliance with all local, state or other applicable rules, regulations, ordinances or statutes.



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Hydrometrics, Inc.
Consulting Scientists and Engineers

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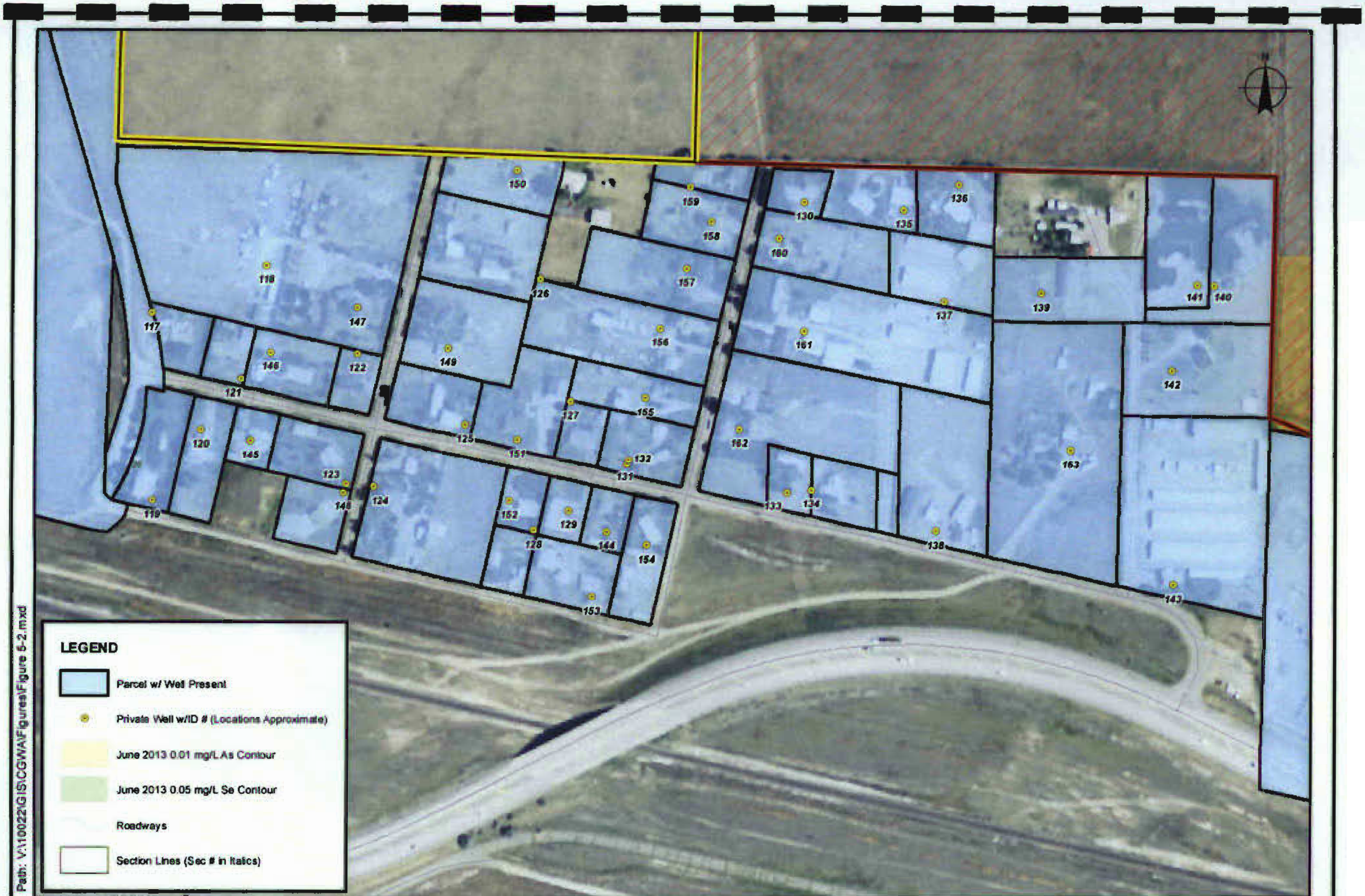
PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA

EXISTING WATER SUPPLY WELLS WITHIN CGWA BOUNDARIES

FIGURE 5-1



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PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA

EXISTING WATER SUPPLY WELLS WITHIN CGWA BOUNDARIES SEAVER PARK DETAIL

FIGURE 5-2

TABLE 5-1. PROPOSED GROUNDWATER USAGE RESTRICTIONS FOR EAST VALLEY CGWA

CGWA Component	Proposed Restrictions[1]	Notes
Permanent CGWA Subarea 1	No new wells allowed. Existing wells not affected. Replacement wells (exempt and non-exempt) allowed if general location, depth, pumping rate and use same as original well.	All replacement wells require approval of TAG and DNRC[1]. Non-exempt wells also subject to DNRC water rights permitting requirements[2].
Permanent CGWA Subarea 2	New wells (exempt[2] and non-exempt) allowed if approved by TAG. Existing wells not affected. Replacement wells (exempt[2] and non-exempt) allowed if approved by TAG.	Non-exempt new or replacement wells approved by TAG also subject to DNRC water rights permitting requirements.
Temporary CGWA	No restrictions on new wells or groundwater usage.	No restrictions allowed per CGWA regulations.

1. All new wells or replacement wells approved by the TAG are subject to all local state or federal regulations, laws and ordinances.
2. Exempt wells must meet requirements of MT Water Use Act; MCA 85-2-306 and 85-2-500.

TAG - Technical Advisory Group.

5.2 SUBAREA 2 RESTRICTIONS

Subarea 2 includes those areas outside of Subarea 1 where future shifts in the plume boundaries, due to groundwater pumping, changes in irrigation or other water usage practices, and/or East Helena Facility remediation activities, could change groundwater quality and would therefore require groundwater usage restrictions in the future. Construction of new wells would not be prohibited in Subarea 2, but would be subject to review and approval by a CGWA technical advisory group (TAG) and would also require compliance with all local, state or other applicable rules, regulations, ordinances or statutes.

Groundwater monitoring wells, test wells and remediation wells associated with the East Helena Facility remediation program or other government administered hydrogeologic investigations would not be subject to the CGWA permitting process, provided the proposed well(s) would not cause unacceptable contaminant exposure or plume spreading, but would still be subject to other well drilling and groundwater usage permitting requirements

TABLE 5-2. WATER QUALITY DATA FROM EXISTING WATER SUPPLY WELLS WITHIN CGWA BOUNDARIES

Well ID		Arsenic Concentrations (mg/L) - 2006-2013						Selenium Concentrations (mg/L) - 2006-2013					
(see Figure 5-1)						Exceedances						Exceedances	
	Well Use	N	Min	Max	Avg	#	%	N	Min	Max	Avg	#	%
1	Industrial	3	0.003	0.003	0.003	0	0%	3	<0.001	<0.001	NA	0	0%
2	Domestic	9	<0.002	<0.002	NA	0	0%	9	0.035	0.043	0.039	0	0%
3	Unknown	3	<0.002	<0.002	NA	0	0%	3	<0.001	<0.001	NA	0	0%
4	Domestic	8	<0.002	<0.002	NA	0	0%	8	0.026	0.037	0.031	0	0%
5	Domestic	5	<0.002	<0.002	NA	0	0%	5	<0.001	<0.001	NA	0	0%
6	Domestic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Out of Service	10	<0.002	<0.002	NA	0	0%	10	0.005	0.040	0.013	0	0%
8	Domestic	31	<0.002	<0.002	NA	0	0%	31	0.002	0.037	0.004	0	0%
9	Domestic	2	<0.002	<0.002	NA	0	0%	2	<0.001	<0.005	NA	0	0%
10	Out of Service	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	Out of Service	1	0.002	0.002	0.002	0	0%	1	0.007	0.007	0.007	0	0%
12	Out of Service	1	<0.002	<0.002	NA	0	0%	1	0.014	0.014	0.014	0	0%
13	Domestic	64	<0.002	0.005	0.002	0	0%	55	<0.005	0.029	0.019	0	0%
14	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	Domestic	60	<0.002	<0.002	NA	0	0%	52	<0.001	<0.005	0.001	0	0%
17	Irrigation	28	<0.002	<0.002	NA	0	0%	25	<0.001	<0.005	0.003	0	0%
18	Irrigation (No Pump)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
19	Domestic	12	<0.002	0.004	0.002	0	0%	10	<0.001	<0.005	NA	0	0%
20	Domestic	1	<0.002	<0.002	NA	0	0%	1	<0.005	<0.005	NA	0	0%
21	Domestic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
22	Domestic	11	<0.002	<0.002	NA	0	0%	10	<0.001	<0.005	NA	0	0%
23	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
24	Domestic	11	<0.002	0.003	0.002	0	0%	10	<0.001	<0.005	0.002	0	0%
25	Domestic	11	<0.002	<0.002	NA	0	0%	10	<0.001	<0.005	NA	0	0%
26	Domestic	11	<0.002	<0.002	NA	0	0%	10	0.003	0.012	0.008	0	0%
27	Out of Service	3	<0.002	<0.002	NA	0	0%	2	0.009	0.013	0.011	0	0%
28	Domestic	6	<0.002	<0.002	NA	0	0%	5	0.004	0.011	0.007	0	0%
29	Irrigation	6	<0.002	<0.002	NA	0	0%	5	0.006	0.013	0.010	0	0%
30	Irrigation	3	<0.002	<0.002	NA	0	0%	2	<0.005	<0.005	NA	0	0%
31	Irrigation	4	0.031	0.093	0.055	4	100%	3	0.011	0.019	0.015	0	0%
32	Out of Service	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
33	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
34	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
35	Out of Service	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
36	Industrial	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
37	Industrial	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
38	Industrial	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 5-2. WATER QUALITY DATA FROM EXISTING WATER SUPPLY WELLS WITHIN CGWA BOUNDARIES

Well ID (see Figure 5-1)	Well Use	Arsenic Concentrations (mg/L) - 2006-2013						Selenium Concentrations (mg/L) - 2006-2013					
						Exceedances						Exceedances	
		N	Min	Max	Avg	#	%	N	Min	Max	Avg	#	%
39	Industrial	6	<0.002	0.002	0.002	0	0%	5	<0.001	<0.005	0.004	0	0%
40	Industrial	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
41	Industrial	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
101	Domestic	8	0.002	0.002	0.002	0	0%	8	0.003	0.006	0.004	0	0%
102	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
103	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
104	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
105	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
106	Domestic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
107	Domestic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
108	Domestic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
109	Public Water Supply	13	<0.002	<0.002	<0.002	0	0%	13	<0.001	<0.005	NA	0	0%
110	Public Water Supply	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
111	Out of Use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
112	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
113	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
114	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
115	Domestic	2	0.004	0.005	0.005	0	0%	2	<0.001	0.001	0.001	0	0%
116	Domestic	8	0.014	0.017	0.016	8	100%	8	0.002	0.003	0.003	0	0%
117	Domestic	3	0.009	0.010	0.009	0	0%	3	0.003	0.004	0.003	0	0%
118	Domestic	2	0.005	0.005	0.005	0	0%	2	0.003	0.003	0.003	0	0%
119	Domestic	4	0.009	0.010	0.010	0	0%	3	0.003	0.004	0.004	0	0%
120	Domestic	2	0.008	0.009	0.009	0	0%	2	0.003	0.004	0.004	0	0%
121	Domestic	2	0.007	0.008	0.008	0	0%	2	0.004	0.004	0.004	0	0%
122	Domestic	2	0.008	0.009	0.009	0	0%	2	0.004	0.004	0.004	0	0%
123	Domestic	2	0.009	0.009	0.009	0	0%	2	0.002	0.002	0.002	0	0%
124	Domestic	2	0.008	0.009	0.009	0	0%	2	0.003	0.004	0.004	0	0%
125	Domestic	2	0.013	0.013	0.013	2	100%	2	0.002	0.002	0.002	0	0%
126	Domestic	2	0.009	0.009	0.009	0	0%	2	0.003	0.004	0.004	0	0%
127	Irrigation	2	0.010	0.010	0.010	0	0%	2	0.004	0.005	0.005	0	0%
	Domestic	1	<0.002	<0.002	<0.002	0	0%	1	<0.001	<0.001	<0.001	0	0%
128	Domestic	3	0.008	0.013	0.011	2	67%	3	0.003	0.004	0.003	0	0%
129	Domestic	2	0.004	0.005	0.005	0	0%	2	0.005	0.007	0.006	0	0%
130	Domestic	2	0.006	0.007	0.007	0	0%	2	0.007	0.008	0.008	0	0%
131	Domestic	2	0.010	0.010	0.010	0	0%	2	0.004	0.004	0.004	0	0%
132	Domestic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
133	Irrigation	1	0.013	0.013	0.013	1	100%	1	0.003	0.003	0.003	0	0%
	Domestic	1	<0.002	<0.002	<0.002	0	0%	1	<0.001	<0.001	<0.001	0	0%
134	Domestic	5	0.016	0.019	0.017	5	100%	5	0.002	0.003	0.002	0	0%

TABLE 5-2. WATER QUALITY DATA FROM EXISTING WATER SUPPLY WELLS WITHIN CGWA BOUNDARIES

Well ID		Arsenic Concentrations (mg/L) - 2006-2013						Selenium Concentrations (mg/L) - 2006-2013					
(see Figure 5-1)						Exceedances						Exceedances	
	Well Use	N	Min	Max	Avg	#	%	N	Min	Max	Avg	#	%
135	Domestic	2	0.007	0.007	0.007	0	0%	2	0.004	0.005	0.005	0	0%
136	Domestic	2	0.007	0.008	0.008	0	0%	2	0.002	0.002	0.002	0	0%
137	Domestic	2	0.007	0.008	0.008	0	0%	2	0.005	0.006	0.006	0	0%
138	Domestic	4	0.024	0.025	0.024	4	100%	3	0.002	0.003	0.003	0	0%
139	Domestic	4	0.006	0.007	0.007	0	0%	4	0.003	0.004	0.003	0	0%
140	Domestic	5	0.002	0.002	0.002	0	0%	5	<0.001	0.001	0.001	0	0%
141	Domestic	2	0.004	0.004	0.004	0	0%	2	0.002	0.002	0.002	0	0%
142	Domestic	6	0.006	0.006	0.006	0	0%	5	0.003	0.003	0.003	0	0%
143	Domestic	7	0.014	0.017	0.015	7	100%	6	0.005	0.010	0.007	0	0%
144	Domestic	1	0.009	0.009	0.009	0	0%	1	0.004	0.004	0.004	0	0%
145	Domestic	2	0.005	0.006	0.006	0	0%	2	0.002	0.004	0.003	0	0%
146	Domestic	2	0.007	0.008	0.008	0	0%	2	0.003	0.003	0.003	0	0%
147	Domestic	1	0.008	0.008	0.008	0	0%	1	0.003	0.003	0.003	0	0%
148	Domestic	2	0.006	0.007	0.007	0	0%	2	0.002	0.004	0.003	0	0%
149	Domestic	2	0.009	0.010	0.010	0	0%	2	0.003	0.003	0.003	0	0%
150	Domestic	4	0.009	0.010	0.010	0	0%	3	0.003	0.004	0.003	0	0%
151	Domestic	3	0.011	0.012	0.012	3	100%	3	0.002	0.003	0.002	0	0%
152	Domestic	3	0.009	0.010	0.009	0	0%	2	0.004	0.004	0.004	0	0%
153	Domestic	2	0.007	0.009	0.008	0	0%	2	0.006	0.006	0.006	0	0%
154	Domestic	2	0.011	0.011	0.011	2	100%	2	0.003	0.003	0.003	0	0%
155	Domestic	2	0.009	0.011	0.010	1	50%	2	0.004	0.005	0.005	0	0%
156	Domestic	2	0.009	0.010	0.010	0	0%	2	0.003	0.003	0.003	0	0%
157	Domestic	2	0.013	0.017	0.015	2	100%	2	0.003	0.004	0.004	0	0%
158	Irrigation	3	0.019	0.024	0.022	3	100%	2	0.005	0.006	0.006	0	0%
	Domestic	1	<0.002	<0.002	<0.002	0	0%	1	<0.001	<0.001	<0.001	0	0%
159	Domestic	2	0.010	0.010	0.010	0	0%	2	0.003	0.003	0.003	0	0%
160	Domestic	1	0.010	0.010	0.010	0	0%	1	0.013	0.013	0.013	0	0%
161	Domestic	3	0.010	0.011	0.010	1	33%	3	0.005	0.006	0.006	0	0%
162	Domestic	2	0.012	0.014	0.013	2	100%	2	0.002	0.003	0.003	0	0%
163	Domestic	2	0.009	0.009	0.009	0	0%	2	0.007	0.007	0.007	0	0%
164	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
165	Domestic	11	0.012	0.017	0.015	11	100%	9	0.001	0.005	0.002	0	0%
166	Domestic	8	0.013	0.017	0.015	8	100%	8	0.002	<0.005	0.003	0	0%
167	Domestic	10	0.015	0.018	0.017	10	100%	10	<0.001	<0.005	0.002	0	0%
168	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
169	Domestic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
170	Inactive	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
171	Domestic	8	<0.002	0.003	0.002	0	0	5	0.006	0.012	0.009	0	0%
172	Inactive	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

administered by DNRC. Wells drilled for the purposes of investigation or remediation will continue to be tracked in a project database and abandoned per State regulations (ARM 17.50.1312) when no longer needed.

Permit applications for new wells will be reviewed and approved by a CGWA TAG. The TAG membership will include appointees from the Lewis and Clark City-County Board of Health and WQPD, the EPA, and MDEQ/DNRC. Potential permittees will complete an application containing, at a minimum, the proposed well location, depth of completion, well construction details, proposed groundwater use, and proposed pumping rate and schedule. Information in the application will be reviewed by the TAG to determine whether the well poses a threat in terms of exposure to unacceptable levels of contaminants, or to spreading of contaminants. If approved, the permittee would be required to provide detailed lithologic and well completion logs recorded by a hydrogeologist, professional engineer, or other agreed upon qualified individual, provide physical means to obtain well water level measurements, allow access for collection of water level data and/or water quality sampling. Both exempt wells (wells with appropriations of 35 gpm or less and 10 acre-feet/year or less; MCA 85-2-306(3)) and non-exempt wells would require approval from the TAG and compliance with the Montana Water Use Act (MCA 85-2-306), with non-exempt wells subject to all water rights permitting requirements administered by the DNRC. All new wells in the CGWA will have to be completed in accordance with State of Montana well drilling and construction regulations provided in ARM 36.21.600.

As required by statute no groundwater usage restrictions or provisions would apply within the temporary CGWA boundaries, other than providing allowances for possible water level measurement, water quality testing and reporting requirements.

The groundwater usage restrictions outlined above are consistent with current rules regarding appropriation of groundwater within a controlled groundwater area as outlined in 85-2-506, 85-2-508 and 85-2-306 MCA. Additional details on the permit application, review and approval process for new wells in Subarea 2, and monitoring and reporting requirements within the Temporary CGWA, will be developed by project stakeholders external to the CGWA petitioning process.

6.0 MITIGATION OF APPLICABLE PETITIONING CRITERIA AND CGWA MONITORING

As noted in Section 1 and detailed in the referenced documents, extensive work has been completed to date to reduce environmental impacts from the former smelter and associated properties (the Facility), with additional remedial actions being implemented and/or planned to address groundwater contamination. The Custodial Trust is performing these remedial activities under the EPA-led RCRA Corrective Action program, as mandated by the First Modification to the Consent Decree (see Section 1.1.1). Various remedial actions are currently being evaluated for effectiveness at controlling contaminant sources and meeting remedy performance standards, which include achieving appropriate media cleanup standards in groundwater and reducing ongoing contaminant loading to groundwater from the former smelter site, to the extent practicable. These evaluations are being conducted as part of the Corrective Measures Study process and development/implementation of Interim Measures.

The Lewis and Clark City-County Board of Health administers an Institutional Control Program within the East Helena CERCLA site. The proposed CGWA will be included as a component of this program and is critical for preventing unacceptable exposure to contaminated groundwater and/or potential contaminant migration resulting from additional groundwater withdrawals, while the interim and final remedies are being implemented. Given the presence of additional contaminant source materials on the former smelter site, it is expected that the remedy performance phase of the project will extend for a number of years. However, the remedial action objectives include not only preventing further spreading of the groundwater plumes beyond their current boundaries, but also reducing the areal extent, duration, and/or usage restrictions associated with the CGWA in the future. Remedial activities completed to date and activities proposed in the next few years are summarized below along with applicable references where additional detail is provided. Consistent with the past few years (Hydrometrics, 2013), and as discussed below, groundwater monitoring will be implemented in the coming years to assess the effectiveness of remedial activities on downgradient groundwater quality, and to evaluate the need for additional groundwater remedies and/or modifications to the CGWA boundaries and/or provisions.

6.1 FORMER SMELTER REMEDIAL PROGRAM

ASARCO initiated remediation activities at the former smelter in the late 1980s when the smelter was still in operation. Initial actions focused on the process water circuit, including removal of leaking process water ponds and sumps, and removal of some of the associated contaminated soils. After the plant was shut down in 2001, remedial activities were performed pursuant to two interim measures work plans that included demolition and placement of material and debris in one of two RCRA Corrective Action Management Units (CAMUs), and construction of two slurry walls to isolate highly contaminated soils from groundwater, thereby reducing contaminant leaching to groundwater. Since it was established four years ago, the Custodial Trust has planned and implemented numerous investigations and corrective actions aimed at addressing remaining groundwater contamination related to the former smelter site. Studies that have been completed or are currently underway include: a Phase II RCRA Facility Investigation (RFI) (METG, 2011); development of a groundwater flow model (Newfields, 2014); completion of a baseline ecological risk assessment and a screening level human health risk assessment; continued delineation and characterization of the groundwater plumes; initiation of the Upper Lake Drawdown Test (Appendix A); preparation of a Corrective Measures Study work plan (CH2MHill, 2014); and additional technical studies, evaluations and activities. All work completed to date by the Custodial Trust is intended to support design, permitting and construction of interim and final corrective measures aimed at reducing the migration of contaminants in groundwater from the site.

In addition to the actions cited above, three interdependent Interim Measures (IMs) are currently being implemented by the Custodial Trust at the former smelter site, with additional measures to be implemented as warranted. The primary purpose of the IMs is to reduce the migration of contaminants in groundwater from the former smelter site in order to protect public health and the environment. The three IMs are being implemented in phases and are summarized as follows:

1. South Plant Hydraulic Control: The South Plant Hydraulic Control IM (SPHC IM) is intended to reduce the migration of inorganic contaminants in groundwater by reducing groundwater elevations and flux rates through the south portion of the former smelter. Lowering groundwater levels will reduce the interaction of the groundwater with contaminated plant site soils, and leaching of contaminants to groundwater.
2. Source Removal IM: The Source Removal IM is intended to reduce the mass loading of contaminants to groundwater by eliminating certain soils currently acting as contaminant sources to groundwater. Source removal is being considered in areas where contaminated soils are accessible for removal, source area volumes and depths are conducive to removal, and source removal is deemed cost effective, from a cost/benefit perspective, as determined by currently available information.
3. Evapotranspiration Site Cover: The Evapotranspiration (ET) Cover System IM is intended to minimize precipitation infiltration on the former smelter site and associated leaching of contaminants from unsaturated soils to the groundwater table. Boundaries for the ET Cover System are intended to encompass the former plant site where the majority of smelting and related activities occurred, and the most highly contaminated soils exist. The ET Cover System IM will also eliminate human and

ecological receptor exposure to, and stormwater runoff contact with, contaminated soil.

Following is a schedule of completed and planned activities.

Activities completed in **2012 and 2013** include:

- ET Cover System IM Preparation: Phase 1 and Phase 2 demolition of the buildings and infrastructure on the former smelter site was required to prepare the site for future construction of the ET Cover System. Phase 1 demolition was completed in July 2013 and Phase 2 demolition was completed in October 2013.
- SPHC IM: Relocation of utilities and infrastructure to accommodate construction of a Temporary Bypass for Prickly Pear Creek (PPC) (PPC Temporary Bypass): Construction of the PPC Temporary Bypass was required to route PPC flow around Smelter Dam, thereby dewatering the South Plant area and enabling demolition of Smelter Dam, removal of Tito Park Area (TPA) soils (see discussion below), and reconstruct the PPC channel in mostly dry conditions. Construction of the PPC Temporary Bypass began in July 2013 and was completed in October 2013.

Activities being completed in **2014** include:

- Tito Park Area Soil Removal IM: This work will remove contaminated soil from the TPA, consisting of Tito Park, Upper Ore Storage Area (UOSA), Acid Plant Sediment Drying Area (APSD Area), and Lower Lake. Excavated soils are being consolidated within the onsite Area of Contamination (AOC) in accordance with the IM Work Plan 2012. The earthwork will remove contaminated soil from an area that is susceptible to inundation and erosion due to potential future PPC flooding. In addition, removal of materials from the TPA is necessary to meet the functional needs of the PPC Realignment, support the development of wetland habitat in the PPC floodplain, and reduce the overall footprint of the final ET Cover System.
- ET Cover System IM, Interim Cover System (ICS) Construction: An interim soil cover will be placed over a portion of the former smelter plant site in 2014 in conjunction with the TPA Removal IM. The ICS will serve as a foundation layer for the final ET Cover System, as well as a temporary cover for the TPA excavated soils to be placed within the onsite AOC. Engineered fill placed for the ICS will establish grade for the ET Cover System and will protectively manage soil and sediment removed from the TPA and East Bench areas consolidated within the AOC. The ICS will be capped with native soil to prevent storm water from contacting contaminated soil and to enable runoff to be shed offsite to perimeter drainages. The ICS will be constructed in two phases, with ICS 1 occurring in 2014 and ICS 2 in 2015.

Work planned for future years includes ongoing groundwater monitoring as well as the following:

2015

- Demolition/abandonment of remaining site facilities and infrastructure to accommodate placement of the ET Cover system.
- Construction of Phase I of the ET Soil Cover System over the Interim Cover System.
- Begin construction of the realigned Prickly Pear Creek channel. The realigned channel will be the final phase of the South Plant Hydraulic Control IM, and is intended to permanently lower plant site groundwater levels thereby reducing the interaction of groundwater with contaminated soils, and provide a more naturally functioning stream/riparian system.
- Performance monitoring of IMs implemented to date, which will include evaluations of downgradient groundwater quality.

2016

- Complete construction of realigned Prickly Pear Creek channel.
- Complete construction of the subgrade and ET Cover over the former smelter plant site.
- Performance monitoring of IMs implemented to date, which will include evaluations of downgradient groundwater quality.

In summary, the Interim Measures outlined above are designed to reduce contaminant loading to groundwater and the downgradient migration of groundwater-borne contaminants. Although the full effect of these activities is difficult to predict with certainty, evaluations are currently underway to estimate the effects on downgradient groundwater quality, and groundwater monitoring will be conducted to provide actual performance data. The effectiveness of the Interim Measures as well as the need for additional corrective measures will continue to be evaluated, with 2014 activities to include development of a groundwater geochemical fate and transport model to predict the groundwater quality response to the proposed corrective measures and guide future corrective measures planning and design. As discussed below, annual groundwater quality monitoring will also be conducted throughout the proposed CGWA to document the effectiveness of the IM/CM activities, assess the need for additional corrective measures, and to determine if changes to the East Valley CGWA boundaries or provisions are warranted.

6.2 CGWA MONITORING PROGRAM

As described above, the primary objective of the former smelter cleanup program is to protect human health and the environment, with corrective measures being evaluated and implemented to address the continued migration of contaminants, primarily arsenic, selenium and trace metals, through groundwater from the former smelter. The Custodial Trust has been implementing an extensive groundwater characterization and monitoring program since 2010, with the monitoring program components outlined in annual monitoring plans (Hydrometrics, 2013). Primary components of the monitoring program from 2010 to 2013 included:

- Further delineation and characterization of the groundwater plumes emanating from the plant site into the East Valley area;
- Contaminant source delineation and characterization; and
- Tracking water quality in residential and public water supply wells in the East Valley area (and the proposed CGWA).

In 2014 and future years, the focus of the groundwater monitoring program will be to obtain data necessary to confirm the protection of human health, evaluate the effectiveness of ongoing interim remedial measures, and determine if additional interim and final corrective measures are necessary.

The current groundwater monitoring program includes seasonal monitoring at approximately 140 monitoring wells, with the monitoring well network extending from south of the former smelter to north of Canyon Ferry Road (Exhibit 1). Groundwater monitoring includes field measurements of groundwater levels, water temperature, specific conductance, pH, dissolved oxygen, turbidity and oxygen/reduction potential at each well. Groundwater samples are also collected at each well for laboratory analyses of the parameters shown in Table 6-1. All samples are collected and sampling results are reviewed in accordance with a rigorous QA/QC program as outlined in the project quality assurance project plan (Hydrometrics, 2011a) and data management plan (Hydrometrics, 2011b). Field measurements and laboratory analytical results are entered into a project database.

Groundwater monitoring associated with the cleanup activities being conducted under the First Modification to the Consent Decree and the EPA-led RCRA program will continue until all remedial action objectives have been satisfied. Given the scale of groundwater contamination at and downgradient of the former smelter site, it is expected that monitoring will be required for several years. Once the CGWA is designated, the monitoring program will also be designed to support implementation and administration of the CGWA, with the groundwater quality data incorporated into the project database (Appendix D), for use by the

Table 6-1. 2014 Groundwater Sample Analytical Parameter List – East Helena Facility

Parameter	Analytical Method (1)	Project Required Detection Limit (mg/L)
Physical Parameters		
pH	150.2/SM 4500H-B	0.1 s.u.
Specific Conductance	120.1/SM 2510B	1 µmhos/cm
TDS	SM 2540C	10
TSS	SM 2540D	10
Common Ions		
Alkalinity	SM 2320B	1
Bicarbonate	SM 2320B	1
Sulfate	300	1
Chloride	300.0/SM 4500CL-B	1
Calcium	215.1/200.7	5
Magnesium	242.1/200.7	5
Sodium	273.1/200.7	5
Potassium	258.1/200.7	5
Trace Constituents (Total and/or Dissolved) (2)(3)		
Antimony (Sb)	200.7/200.8	0.003
Arsenic (As)	200.8/SM 3114B	0.002
Beryllium (Be)	200.7/200.8	0.001
Cadmium (Cd)	200.7/200.8	0.001
Chromium (Cr)	200.7/200.8	0.001
Copper (Cu)	200.7/200.8	0.001
Iron (Fe)	200.7/200.8	0.02
Lead (Pb)	200.7/200.8	0.005
Manganese (Mn)	200.7/200.8	0.01
Mercury (Hg)	245.2/245.1/200.8/SM 3112B	0.001
Nickel (Ni)	200.7/200.8	0.01
Selenium (Se)	200.7/200.8/SM 3114B	0.001
Thallium (Tl)	200.7/200.8	0.001
Zinc (Zn)	200.7/200.8	0.01
Metal Speciation (Dissolved) (3)(4)		
Arsenic (As)	E 1632A Mod	0.002
Selenium (Se)	A 3114 B Mod	0.001
Field Parameters (5)		
Static Water Level	HF-SOP-10	0.01 ft
Water Temperature	HF-SOP-20	0.1 °C
Dissolved Oxygen (DO)	HF-SOP-22	0.01 mg/L
pH	HF-SOP-20	0.01 pH standard unit
Turbidity		0.1 NTU
ORP/Eh	HF-SOP-23	1 mV
Specific Conductance (SC)	HF-SOP-79	1 µmhos/cm

Notes:

(1) Analytical methods are from *Standard Methods for the Examination of Water and Wastewater* (SM) or EPA's *Methods for Chemical Analysis of Water and Waste* (1983).

(2) Private/residential well samples will be analyzed for both total and dissolved trace constituents; monitoring well samples will be analyzed for dissolved metals only

(3) Samples to be analyzed for dissolved constituents will be field-filtered through a 0.45 µm filter.

(4) Arsenic and selenium speciation will be analyzed at the monitoring wells scheduled for monthly monitoring.

(5) Field parameters should be measured in a flow cell in accordance with project SOPs.

technical advisory group in evaluating applications for new wells in Subarea 2 (or replacement wells in Subarea 1). The groundwater monitoring data will also be used for periodic reviews of the CGWA program, including the suitability of the CGWA boundaries and restrictions, so that changes can be made in response to changing groundwater conditions. Formal reviews of the CGWA program should occur at least every three years, with an appropriate schedule to be determined by the TAG in conjunction with the DNRC and other stakeholders.

6.3 TEMPORARY CGWA EVALUATION PROGRAM

As noted in Section 4, the primary purpose of the temporary component of the East Valley CGWA is to facilitate further study of potential sources of arsenic in the west arsenic area west of the former smelter (Figure 1-1). The Custodial Trust and Lewis and Clark County will jointly perform the necessary field investigations and data evaluations to further delineate the sources of arsenic to groundwater in this area and make recommendations regarding future management of the temporary CGWA. If arsenic in the west arsenic area is determined to be derived primarily from natural background sources (i.e., tertiary volcanoclastic sediments as is suggested by data collected to date), the recommendation would be to terminate the temporary portion of the CGWA. If it is determined that the former smelter is the primary source of arsenic to the area, then the recommendation would be to convert all or a portion of the temporary CGWA to a permanent CGWA.

The temporary CGWA evaluation will be implemented in phases to allow relevant existing information to be compiled and incorporated, and to accommodate potential funding mechanisms. The phases will include:

1. **Compile and Review Existing Information and Make Initial Determination:** Some groundwater data has previously been collected in the west arsenic area by the Custodial Trust and other entities (see Section 2.4.2). In addition, numerous studies have been conducted regarding the occurrence of naturally occurring arsenic in groundwater around the Helena Valley, as well as other similar intermontane basins in Montana and the interior west. As an initial step, all information and data relevant to the west arsenic area evaluation will be compiled and reviewed. Limited additional data collection will be performed as necessary in conjunction with the groundwater monitoring program outlined in Section 6.2. The west arsenic area information will be summarized in a technical memorandum, with conclusions on the source(s) of arsenic and recommendations for the temporary CGWA presented as warranted. If the existing information is not adequate for final determination of the arsenic source(s), additional data needs will be identified and recommendations for further evaluations made. Phase 1 of the evaluation will be funded by the Custodial Trust.

2. **Pursue Additional Funding for Further Evaluations if Necessary**: If additional evaluation is necessary, the Lewis and Clark County WQPD will pursue funding though the DNRC Resource Recovery Grant Program (RRGP). The County, in conjunction with the Custodial Trust, will develop a work plan for the additional source evaluations for use in the grant application. The grant application will be submitted by May 15, 2016, the next RRGP cycle.

3. **Conduct Additional Field Investigation/Evaluations if Necessary**: Utilizing the RRGP funds, additional field studies and other investigations will be conducted. The scope of the investigations will be dependent on the findings of the Phase 1 evaluation, but may include completion of additional test wells, groundwater testing and analyses to further define groundwater flow and chemical properties, geologic mapping and soil testing. Specialized testing would likely include groundwater isotopic analyses to delineate groundwater sources and flowpaths and for groundwater age dating. The evaluations may also include additional groundwater modeling using the calibrated groundwater flow and contaminant transport model developed for the proposed CGWA.

A preliminary schedule for the temporary CGWA evaluations is presented in Table 6-2. The schedule assumes that designation of the East Valley CGWA occurs by mid-2015, and is based in part on the RRGP grant schedule, with the next opportunity to submit grant applications being May 15, 2016. Based on this schedule, an initial duration of four years is requested for the temporary CGWA, with the option to extend the duration up to two additional years if necessary.

TABLE 6-2. PRELIMNARY SCHEDULE FOR EVALUATION OF TEMPORARY CONTROLLED GROUNDWATER AREA

MILESTONE	DATE(S)	NOTES
East Valley CGWA Designation	June 1, 2015	Estimated start date
Phase 1-Existing Data Compilation and Review	June 2015 – December 2015	May include additional data collection as necessary. Funded by Custodial Trust.
Preliminary Assessment/ Recommendations on Temporary CGWA	February 28, 2016	If possible, recommend discontinuing temporary CGWA, extending temporary CGWA for up to two more years, or converting to permanent CGWA. Otherwise, prepare work plan for additional investigation/evaluation.
Submit RRGP Grant Application	By May 15, 2016	If approved, grant funds available after July 1, 2017.
Conduct additional Evaluations	August 2017 – December 2018	Funded by RRGP grant.
Final Recommendations/ Determination on Temporary CGWA	March 2019	Recommend discontinuing temporary CGWA, extending temporary CGWA for up to two more years, or converting to permanent CGWA.

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APPENDIX A

UPPER LAKE DRAWDOWN TEST
TECHNICAL MEMORANDUM

Hydrometrics, Inc.

consulting scientists and engineers

MEMORANDUM

DATE: September 20, 2012

TO: Jim Ford, Montana Environmental Trust Group

FROM: Bob Anderson, Hydrometrics, Inc.
Mark Walker, Hydrometrics, Inc.

SUBJECT: Upper Lake Drawdown Test Technical Memorandum –DRAFT

EXECUTIVE SUMMARY

The Montana Environmental Trust Group is conducting an Upper Lake drawdown test at the former Asarco smelter site (the plant site) in East Helena, Montana. Upper Lake is a relatively large surface water feature at the south (topographically and hydrologically upgradient) margin of the plant site. Leakage from Upper Lake has long been recognized as a source of recharge to the plant site groundwater system, where the interaction of groundwater with metals-contaminated soils has negatively impacted groundwater quality. The purpose of the Upper Lake drawdown test is to simulate, at least partially, the effects of eliminating recharge from Upper Lake on plant site groundwater levels, flow rates, and contaminant loading to groundwater. This information is being used in planning and implementation of remedial measures for the site.

The Upper Lake drawdown test has involved three distinct phases, including passive lake dewatering achieved by shutting off the diversion inflow from Prickly Pear Creek, lowering Prickly Pear Creek adjacent to the plant site, and pumping from the lake to expedite lake level drawdown. The first phase of the test began on 11/1/2011 and continued through 3/26/12. The creek lowering phase overlapped with the passive dewatering phase and occurred from 12/21/11 through 2/24/12. The third (lake pumping) phase was initiated on 3/26/12 and continues to date. Data collection during the test has included continuous water level monitoring at a total of 35 groundwater and surface water sites instrumented with pressure sensitive transducers, and manual measurements at an additional 20 sites. The water level data is intended to quantify the groundwater level declines across the plant site, and determine effects of the lake drawdown on hydraulic gradients and groundwater flow rates across the plant site.

As of September 13, 2012, the water level in Upper Lake had declined by 4.9 feet since the November 1, 2011 test startup. Groundwater levels during this time have declined by four to

five feet in the south portion of the plant site, three to four feet in the central plant site, and four to six feet in the northwest portion of the plant site. Water level declines in the south plant site are attributable to the proximity of this area to Upper Lake while the larger declines in the northwest plant site are attributable to the Upper Lake drawdown, as well as a lack of flow in Wilson Ditch. The lack of ditch flow in 2012 is related to the Upper Lake drawdown test as Wilson Ditch is fed by a headgate on Upper Lake. Water levels in the northeast portion of the plant site (beneath the slag pile) declined by less than one foot, suggesting the shallow groundwater system in this area has limited interaction with water levels in Upper Lake and the south plant area.

Current plans for the East Helena Smelter site include permanent elimination or reduction of recharge from Upper Lake to the plant site groundwater system, lowering the water level in Prickly Pear Creek adjacent to the plant site by removing a small dam, excavation of contaminated soils in the south plant area, placement of a low permeability zone to further limit groundwater flow through the plant site, and possible elimination of Wilson Ditch. Collectively, these actions are referred to as the South Plant Hydraulic Control (SPHC) project. In order to assess the effectiveness of the proposed SPHC, information gained from the Upper Lake drawdown test to date was used to estimate total declines in groundwater levels expected through implementation of the SPHC. Projected water level declines range from approximately ten feet in the south plant area, four to five feet in the central plant area, and up to six feet in the northwest plant area. Groundwater levels in the northeast plant area (beneath the slag pile), are expected to decline by two feet or less. Lowering the water table will not only reduce the total groundwater flow rate or flux through the plant site, but will also significantly reduce the magnitude of groundwater interaction with the most highly contaminated soils on the plant site. These two effects should combine to reduce the load (pounds/day) of contaminants in plant site and downgradient groundwater

Additional information gained from the Upper Lake drawdown test to date includes identification of potential preferential groundwater flow paths through the plant site, portions of the plant site where groundwater is more closely connected to Prickly Pear Creek, and general groundwater flow patterns through the site. Following completion of the water level recovery phase of the test (Fall 2012), effects of the Upper Lake drawdown test and projected effects of the SPHC on groundwater levels, flow rates and patterns, and groundwater quality will be evaluated further.

1.0 INTRODUCTION

Upper Lake has previously been identified as a source of recharge to the Upper Aquifer, or unconfined groundwater system overlying the Tertiary ash/clay layer at the former East Helena smelter site (the plant site). Indications that Upper Lake provides recharge to the plant site groundwater system include its location at the extreme southern (upgradient) end of the plant site, and the elevated lake level resulting from construction of raised ground levels and berms around the lake perimeter. Although these physical attributes indicate that Upper Lake increases recharge to the plant site Upper Aquifer (as compared to pre-lake conditions), the magnitude of recharge attributable to Upper Lake has not previously been quantified. In order to assess the rate of groundwater recharge from Upper Lake to the plant site groundwater system, METG initiated an Upper Lake drawdown test to document the plant site groundwater system response to variations in the Upper Lake water level. The Upper Lake drawdown test was initiated in fall 2011 and continues to date. This technical memorandum describes the Upper Lake drawdown testing procedures and results to date. Interpretation of the test results is also presented along with preliminary implications of the potential effectiveness of the proposed South Plant Hydraulic Control (SPHC) interim measures. Additional data review and interpretation will occur following the water level recovery (partial lake refilling) phase of the test, scheduled to begin in October 2012.

1.1 DRAWDOWN TEST OBJECTIVES

Design and planning of the Upper Lake drawdown test is covered in two memoranda submitted to METG by Hydrometrics (dated August 5, 2011 and October 19, 2011), with subsequent input from the project team. Besides quantifying effects of Upper Lake dewatering on plant site groundwater levels, the drawdown test is also intended to provide additional information on the overall plant site hydrogeologic system. Specific objectives of the drawdown test as outlined in the August 5th memorandum include:

1. Quantify the Plant Site groundwater system response to lowering of the Upper Lake water level.

2. Identify potential preferential groundwater flow paths through the plant site based on the magnitude and timing of groundwater level responses in individual wells.

3. Refine plant site aquifer hydraulic conductivity estimates based on the groundwater level response to lake dewatering in various portions of the site, if test data allows.

This memorandum focuses on objective #1 to aid in planning and implementation of the SPHC activities. Objectives 2 and 3 are also discussed as relevant to the SPHC project, and will be evaluated further in support of other interim and corrective measures activities and as available information allows.

1.2 BACKGROUND

Upper Lake lies within the Prickly Pear Creek floodplain at the south end of the former smelter or plant site (Figure 1). The lake area and associated marsh system to the immediate south lie within an area of recent active channel migration, resulting in the lake/marsh area being largely underlain by alluvial sands and gravels. Based on available information, the sand/gravel is overlain by 2 to 5 feet of silt/clay. Since the lake/marsh area is part of the active creek floodplain, Prickly Pear Creek has meandered through the area in the recent past. Based on review of historic aerial photos and observations of the lake at its current drawn down level, two former creek channels are evident in the lake/marsh area as shown on Figure 1. Due to the relatively high permeability of former channel sediments, the channels may represent preferential flow paths for shallow groundwater through the lake/marsh area and northward through the plant site. One of these channels extends through the west half of the lake and projects northwestward through the west plant site while the second former channel traverses the east half of the lake and projects through Tito Park (Figure 1).

Upper Lake was initially formed by diversion of water from Prickly Pear Creek into what originally was most likely a large marsh complex with limited open water. The original lake was considerably smaller in size than its present day configuration, with the lake area (and elevation) increased through continued placement of fill north of the lake (Tito Park area), and construction of an earthen berm (east berm) between the lake and Prickly Pear Creek around 1985. These "improvements" were implemented in part to provide a suitable water source for operation of the Acid Plant and other facility processes. The Upper Lake water level is controlled by two large outlet culverts in the east berm, with outflow through the culverts returning to Prickly Pear Creek. During the irrigation season, lake water typically is also diverted into Wilson Ditch through a headgate on the west side of the lake. Figure 1 shows the present-day (pre-drawdown test) Upper Lake configuration and various features relevant to this discussion.

With enlargement and raising of the lake level during (and prior to) the mid-1980s, leakage from the lake to the plant site is expected to have increased due to the greater hydraulic gradient and wetted surface area of the lake. Regular dredging of sediments from the northwest portion of the lake (to facilitate pumping for plant make-up water) would also have increased the leakage rate as compared to current conditions. Since the 2001 plant shutdown, Upper Lake has partially filled in with fine grained (low permeability) sediments, reducing the rate of leakage as compared to pre-2001 conditions. Thus, the rate of leakage and groundwater recharge from Upper Lake to the plant site groundwater system has most likely varied over time.

1.3 DEVELOPMENT OF UPPER AND LOWER LAKE

The earliest records uncovered to date regarding Upper Lake include reference to 1938 and 1959 measurements of the lake depth, and various activities associated with sediment control from upstream placer mining activities. At that time, Upper Lake and Lower Lake were physically connected as one lake with the two sections referred to as the south and north lakes, respectively. In the 1930s, upstream placer mining operations on Prickly Pear Creek caused turbidity problems in the creek and the plant site water system. In 1934, a ten-foot wide ditch was excavated from Prickly Pear Creek to the south end of Upper Lake to utilize the lake as a settling basin. This resulted in infilling of Upper Lake with sediment and a reduction in the lake depth and area. This information shows that Upper Lake was a significant water feature as far back as the 1930s with the lake depth, surface area and lakebed conditions varying over time. These variations in lake conditions would have affected leakage from the lake to the plant site groundwater system over the past several decades.

In 1985, the inlet channel and diversion structure on Prickly Pear Creek were improved by Asarco to better control inflow to Upper Lake. The east berm and outflow culverts were also constructed at that time resulting in an increase in the normal operating level of the lake, and presumably increased leakage from the lake to the plant site groundwater system. With shutdown of the smelter in 2001 and cessation of lake dredging, siltation of the lake bottom increased, thereby causing a reduction in the rate of leakage from the lake.

Figure 2 includes a sequence of aerial photographs from 1955 to 2011 showing the Upper Lake expansion over time. Key points of interest in the photos include:

- In 1955, Upper Lake and Lower Lake were connected by a narrow channel. Upper Lake was significantly smaller in size and restricted to the far western portion of the current lake area as compared to the later photos.
- By 1964, the area between the two lakes had been filled in. The Upper Lake surface area is notably larger than in 1955.
- The 1976, 1978 and 1980 photos look very similar to 1964 with no significant changes apparent in Upper or Lower Lake.
- Between 1980 and 1987, the enlarged inlet channel and east berm become evident and the Upper Lake level increases as shown by the expanded surface area.
- Between 1987 and 2011 the surface area (and water level) in Upper Lake shows a steady increase, possibly due to siltation of the lake bottom after the 2001 plant shutdown.

This evolution of the Upper (and Lower) Lake surface area and water level has undoubtedly affected groundwater flow through the plant site over the past several decades.

1.4 GENERAL LAKE HYDROLOGY

Figure 3 shows the three general flow paths by which seepage exits Upper Lake. The first flow path is located in the northwest corner of the lake upgradient of the former acid plant. This location corresponds to one of the former creek channels noted in Figure 1 and is believed to represent a preferential flow path from Upper Lake to the plant site. Lake seepage along this flow path flows northwestward through the former acid plant area and associated contaminated soils. The second flow path occurs northward through Tito Park to Lower Lake. Although flow between the two lakes most likely occurs throughout Tito Park, the rate of flow is probably greatest along any preferential flow paths, such as the former creek channel shown in Figure 1, and in the eastern part of Tito Park where the hydraulic gradient would be greatest due to the shorter distance between the two lakes. Installation of the acid plant sediment drying area (APSD) slurry wall (Figure 3) has undoubtedly altered the direction and possibly the rate of recharge from Upper Lake to the plant site since construction of the slurry wall in 2006.

The third main route for seepage out of the lake is through the east berm to Prickly Pear Creek. Seepage through this area is potentially significant due to the presumably coarse and permeable nature of the fill material used to construct the berm, and the potentially high gradient from the lake to the creek. Under normal conditions, The Upper Lake water level is three to five feet higher than the adjacent creek level, resulting in hydraulic gradients on the order of 0.1 feet/feet from Upper Lake to the creek. Based on the east dike dimensions (350 feet long and 3 feet high below the water level) and an assumed hydraulic conductivity of 200 ft/day, seepage rates through the dike may be on the order of 100 gallons per minute (gpm) or more when the lake is at full pool, or about 3920 feet elevation. An additional component of direct seepage from the lake when at full pool is westward seepage into the tertiary sediments forming the west lake shoreline. This seepage component is expected to be relatively small due to the lower hydraulic conductivity of the tertiary sediments as compared to the alluvial sediments or fill material present in the other seepage areas.

Figure 4 shows a schematic cross section from south to north through the Upper Lake area (see cross section trace on Figure 3). Key points on this figure include the alluvial (Qal) gravel underlying Upper Lake, and the continuous silt/clay layer (lake sediments) separating Upper Lake from the underlying gravels. The documented thickness of the silt/clay layer ranges from about 60 inches at the deeper north end of the lake, to about 40 inches at piezometer ULM-PZ-1 near the head of Upper Lake. Based on available information, the low permeability lakebed sediments are believed to inhibit downward leakage of the lake water to the underlying groundwater system, or upward seepage into the lake. Therefore, recharge from the lake to the plant site groundwater system occurs primarily via seepage through the north lake shoreline. As shown in Figure 4, the composition of the lake shoreline varies from relatively high permeability fill material on the upper bank, to low permeability silt/clay on the lower portion of the bank. This causes the rate of leakage to decrease as the lake level drops below the fill/silt contact.

The lack of subsurface leakage into or out of Upper Lake (at least at lower lake levels) is confirmed by measurements recorded on July 11, 2012. At that time, the lake water level was relatively stable at 3915.75 feet, similar to that shown for 7/24/12 on Figure 4. Upper Lake was being dewatered through pumping at that time with the pumping rate at 30 gpm. Surface water inflow from a small creek into the south end of the lake was measured at 36 gpm. The close correlation between the creek inflow rate and the pumping outflow rate under steady state water level conditions suggests minimal seepage into or out of the lake was occurring at that time (evaporation is assumed to be negligible given the small surface area of the lake at that time). Based on the saturated conditions in the alluvial gravels immediately north of Upper Lake (i.e., well DH-20 in Figure 4), this information suggests that groundwater underflow through the alluvial gravels underlying Upper Lake may persist even after Upper Lake has been permanently dewatered.

2.0 UPPER LAKE DRAWDOWN TEST PROCEDURES

The Upper Lake drawdown test involved three distinct phases, including passive lake dewatering achieved by shutting off the diversion inflow from Prickly Pear Creek, temporarily lowering Prickly Pear Creek adjacent to the plant site, and pumping from the lake to expedite lake level drawdown. The drawdown test schedule and monitoring program are summarized below.

2.1 UPPER LAKE DRAWDOWN TEST SCHEDULE

The Upper Lake Drawdown Test was initiated in fall 2011 with background (pre-drawdown) water level monitoring conducted in October. Following background data collection, the "passive" dewatering phase of the test began on 11/01/11 when the inlet diversion from Prickly Pear Creek to Upper Lake was shut off. Immediately prior to closing the diversion gates, measured inflow to Upper Lake from the creek was 30 cfs (13,440 gpm), which represents about half of the creek flow above the diversion gate at that time. Following closure of the diversion gates about 20 gpm flow remained in the Upper Lake inlet channel due to minor leakage around the gates. The diversion gates have remained closed with about 20 gpm leakage or less since 11/01/11 (Table 1).

The second phase of the test included lowering the Prickly Pear Creek stage above the Smelter Dam to assess the plant site groundwater and Upper Lake level response. The creek level was lowered by as much as eight feet (3915 feet to 3907 feet elevation) by incrementally opening the lower gates on the smelter dam. The creek lowering phase began on 12/21/11 and ended (by closing the lower gates) on 2/24/12. The creek level at the smelter dam has remained at 3915 to 3916 feet since 2/24.

The third phase of the drawdown test involved pumping water from Upper Lake to expedite the lake drawdown. After several months of passive dewatering, the rate of lake level decline slowed considerably leading to the need for pumping. Pumping was initiated on March 26, 2012 with the primary pump intake located in the west half of Upper Lake and a secondary pump located in the east half of the lake. The primary pump has operated more or less continuously since 3/26/12 with relatively few interruptions. The secondary pump was operated on a periodic schedule (typically during normal working hours each day) from 3/26/12 through 4/9/12, after which use of the secondary pump was discontinued. For the

TABLE 1. UPPER LAKE DRAWDOWN TEST SCHEDULE

Test Phase/Milestone	Begin	End	Comments
Background Monitoring	10/1/11	10/31/11	Documents background water level trends leading up to test.
Shut Off Prickly Pear Creek Inflow	11/01/11		Closed PP Ck diversion to Upper Lake inlet channel
Passive Drawdown Phase	11/01/11	3/26/12	Prickly Pear Ck inlet diversion shut off and lake allowed to passively dewater through seepage to subsurface.
Prickly Pear Creek Drawdown Phase	12/21/11	2/24/12	Prickly Pear Creek stage lowered at smelter dam on 12/21/11 to assess effect on groundwater levels. Creek level raised back up on 2/24/12. PP Ck diversion inlet remains closed.
Upper Lake Pumping	3/26/12	Ongoing	Includes continuous pumping from Upper Lake to expedite lake dewatering with diversion inlet remaining closed.

majority of the pumping period, each pump typically discharged between 80 to 120 gpm, with the discharge water piped to an infiltration basin near Prickly Pear Creek. Currently, the primary pump is operating continuously at approximately 15 gpm to maintain a steady state lake level.

2.2 MONITORING PROGRAM

The drawdown test monitoring program is focused primarily on measurement of water levels throughout and peripheral to the plant site. Water levels are measured continuously at a total of approximately 35 groundwater and surface water sites instrumented with pressure sensitive transducers. The continuous water level data is augmented with bi-weekly manual measurements at an additional 20 sites. The water level data is intended to quantify the groundwater level declines across the plant site, and determine effects of the lake drawdown on hydraulic gradients and groundwater flow rates across the plant site. Figure 5 shows the drawdown test monitoring network.

3.0 DRAWDOWN TEST RESULTS

The drawdown test water level monitoring results (to date) are summarized below, with data evaluation and interpretation presented in the following section (Section 4.0). For discussion purposes, the water level data are discussed separately by area, including the south plant area or south zone (Tito Park, Upper Lake, Lower Lake and Phase I/II CAMU area), the central plant zone, and the north plant zone (Figure 5). Water level declines measured during the course of the drawdown test (10/31/11 to 9/13/12) are discussed for each area. The plant site water level changes measured since the start of the test are referred to as water level declines as opposed to water level drawdown, since the measured water level changes likely include some component of seasonal (and potentially longer-term) water level trends, in addition to any lake drawdown-induced water level changes. As discussed in the following section, water level data from late summer/fall 2012 as well as water level recovery data will be required prior to full evaluation of lake drawdown-induced groundwater level changes on portions of the plant site.

3.1 SOUTH PLANT AREA

Primary water level monitoring sites in the south plant area include Upper and Lower Lake, Prickly Pear Creek at (immediately upstream of) the smelter dam, and nine monitoring wells in and around Tito Park. In addition, all 11 CAMU monitoring wells (MW wells on Figure 5) are included in the south plant area for discussion purposes. The primary water level monitoring sites are described in Table 2.

Water level declines measured between 11/01/11 (when diversion inflow to Upper Lake was shut off) through 9/13/12 in the south plant area ranged from 5.10 feet at well APSD-9 (located immediately north of Upper Lake), to 0.93 feet at well APSD-8 (between Lower Lake and Prickly Pear Creek). Water level declines at other notable sites include 4.84 feet at Upper Lake, 3.46 feet at Lower Lake, 3.58 feet at well DH-20 (between Upper Lake and the Acid Plant area), and 3.29 feet in well DH-3 (west of Upper Lake). Hydrographs for select south zone wells are included in Figure 6.

As shown on Figure 6, south plant water levels responded very quickly to the onset of Upper Lake dewatering, especially at wells APSD-9 and APSD-10 along the north Upper Lake shoreline. By mid-November, the Upper Lake water level stabilized at about 3918 feet and remained stable through December, while Lower Lake and groundwater levels throughout the south plant area continued to decrease.

Lowering Prickly Pear Creek above the smelter dam as of 12/20/11 had a notable effect on water levels. Most notable is well APSD-8 (located between Lower Lake and the creek, Figure 5), which dropped about 3.5 feet during the creek lowering phase of the test and fully recovered within about a week after the creek level was raised back up on 2/24/12. As shown on Figure 6, water levels at all other sites were influenced by the creek lowering including well DH-20, located on the west side of the plant site. Interestingly, the Upper Lake water level showed very little response to creek lowering, indicating leakage from the lake to the creek through the east berm is minimal, at least at reduced lake levels of about 3918 feet or lower.

The Upper Lake water level was generally stable from mid-November (about two weeks after inflow to the lake was shut off) through mid-March. With the onset of pumping from the lake on March 26, 2012, the Upper Lake level again began to drop, followed by similar declines in Lower Lake and the south plant monitoring wells. As shown on Figure 6, Upper Lake, Lower Lake and groundwater within Tito Park (APSD wells on Figure 6) have all

TABLE 2. DRAWDOWN TEST WATER LEVEL MONITORING SITES AND WATER LEVEL DECLINES FROM 10/31/11 THROUGH 9/13/12

Monitoring Site	Location	Depth Below Ground Surface (feet)	Net Water Level Decline (feet) 10/31/11 -9/13/12
South Plant Site			
Upper Lake	South Plant Area	NA	4.84
Lower Lake	South Plant Area	NA	3.46
APSD-8	Between Lower Lake and PP Ck	15	0.93
APSD-9	Tito Park	16	5.10
APSD-10	Tito Park	16	4.99
APSD-12	Tito Park	15.5	3.79
DH-3	West of Upper Lake	54	3.29
DH-20	Northwest of Upper Lake	31	3.58
MW-6	Between Plant Site and Phase I CAMU	40	3.88
MW-11	West of Phase II CAMU	70	0.38
Central Plant Site			
DH-19R	Former Acid Plant	25	3.35
DH-4	North of Lower Lake	23	0.95
DH-42	Former Acid Plant	34	3.55
DH-2	West of Plant Site	65.5	3.62
DH-71	North of Former Acid Plant	34	3.78
DH-73	Former Zinc Plant area	48	3.52
DH-68	South end of slag pile	50	0.42
EH-204	West of Plant Site	65	5.48
North Plant Site			
DH-17	Northcentral Plant Site	41	5.18
DH-66	NW of Ore Storage Building	48	5.50
DH-49	North Plant Site	34	5.55
DH-51	North Plant Site	34	5.02
DH-6	Between slag pile and Highway 12	25	3.65
DH-15	Between slag pile and Highway 12	50	3.65

NA-Not Applicable

converged to a similar elevation of about 3915 feet. This convergence of water levels has greatly reduced the hydraulic gradient, and thus groundwater flow, through Tito Park.

3.2 CENTRAL PLANT AREA

The central plant area covers the majority of the former plant site including the acid plant, speiss-dross plant, and the majority of the slag pile (Figure 5). Primary water level monitoring sites in this area are listed in Table 2 with hydrographs for select sites shown in Figure 7. Water level declines between 10/31/11 and 9/13/12 in this area ranged from 5.48 feet at well EH-204 (west of the Lower Ore Storage area), to 0.42 feet at DH-68 (south end of slag pile). Significant water level declines were also recorded at well DH-71 (3.78 feet) located between the acid plant and lower ore storage area, DH-2 (3.62 feet), completed in tertiary sediments west of the plant site, and DH-42 (3.55 feet) completed in the former acid plant area. Generally, water level declines are greatest on the west side of the plant site compared to the east side (beneath the slag pile). In fact, the water level at slag pile well DH-68 showed virtually no response to the Upper Lake or Prickly Pear Creek drawdown (Figure 7). Likewise, water levels at well DH-4, also located on the east side of the plant and only a few tens of feet north of Lower Lake, has also shown minimal response to the Upper Lake dewatering although DH-4 did show some response to the creek lowering phase of the test (Figure 7). The general lack of water level response at DH-4 and DH-68 suggests limited hydraulic interaction between the south plant groundwater system and the east side of the plant site. The lack of hydraulic continuity to the north of Lower Lake has previously been noted by the steep hydraulic gradients mapped in this area. These results suggest that the SPHC may have a lesser impact on groundwater levels beneath the east portion of the site (beneath the slag pile) as compared to the south and west portions of the plant site.

Groundwater levels in the former acid plant area (DH-19R and DH-42, Figure 7) have declined about 3.5 feet as of 9/13/12 and continue to decline to date. Post-SPHC groundwater levels in this area are of particular interest since the former acid plant contains some of the highest subsurface soil contaminant concentrations on the site.

3.3 NORTH PLANT AREA

North zone wells are shown on Figure 5 and listed in Table 2. Hydrographs for select wells are shown in Figure 8. Groundwater levels in the northern portion of the plant site show a steady decline from prior to the onset of the Upper Lake drawdown through mid-September 2012, although water levels at all sites increased temporarily in June in response to spring runoff. Overall water level declines in this area range from 3.30 feet at wells DH-6/15 near Prickly Pear Creek, to 5.55 feet at DH-49 in the northwest corner of the site.

Besides being some of the largest water level declines recorded during the lake drawdown test, the 2012 north plant site water level trends are notable in their contrast from previous years. Figure 9 shows long-term water level trends at north plant site wells DH-66 and DH-17. Water levels in these wells, and throughout the northwest portion of the site, have historically been lowest in winter and spring, and highest during late summer and fall. In contrast, water levels on the east side of the plant site are typically highest in spring and early summer, consistent with Prickly Pear Creek water levels. Continuous water level hydrographs from several wells located immediately north and west of the plant site, including EH-205/210, SP-4, EH-60/61/103 (Figure 5), show a definite correlation in groundwater levels and the presence or absence of flow in Wilson Ditch (Figure 10). Therefore, the lack of a late summer water level rise in in the northwest plant site wells in 2012 is attributable to the lack of flow in Wilson Ditch. Thus, in evaluating results of the Upper Lake drawdown test and ramifications of the SPHC, the effects of lake removal and creek lowering as well as possible elimination of flow in Wilson Ditch must be taken into account.

One other potential influence on the 2012 water level trends and drawdown test results is the lack of precipitation during summer 2012. The lack of precipitation has undoubtedly had some influence on groundwater levels, along with dewatering of Upper Lake and Wilson Ditch. To assess the possibility that climatic conditions are a primary cause of the significant water level declines in the northwest plant site, long-term water levels from north plant site well DH-66 were plotted against corresponding water levels from County monitoring well "Airport N-N" located north of the plant site near the Helena Airport. The Airport N-N well is located near the Helena Valley irrigation canal and historically has exhibited similar summer season water level increases as the northwest plant site wells. As shown in Figure 11, 2012 water level trends at the Airport N-N well exhibit the same summer season increase as seen in previous years, while the DH-66 trend does not. The consistent trends at Airport N-N in 2012 suggest that climatic conditions have not significantly affected seasonal trends at this well, and climatic conditions most likely are not responsible for the lack of late summer water level increases in DH-66 and other northwest plant site wells. Thus, the Upper Lake drawdown and lack of flow in Wilson Ditch are the most likely causes of the significantly lower northwest plant site groundwater levels in 2012.

Groundwater levels in the north plant site showed no apparent response to lowering of Prickly Pear Creek above the smelter dam, although they do correlate closely with creek levels downstream of the dam. Wells DH-6/DH-15 exhibit a strong correlation with the Prickly Pear Creek water level due to their proximity to the creek. As shown in Figure 8, all the north area wells correlate fairly well with DH-6/15. For example, an increase in the creek level during January 2012 due to an ice jam just upstream of Highway 12 caused water levels to rise about one foot in DH-6/15, with a similar although more subdued response apparent in all the north plant site wells. The groundwater level response to spring runoff (June) is also apparent in the north plant site hydrographs. This information shows the close interaction of the north plant site groundwater with the segment of Prickly Pear Creek downstream of the Smelter Dam.

Figure 12 shows the magnitude of measured water level declines as of 9/13/12 throughout the plant site. As presented above, water level declines have been greatest (4 to 5 feet) in the south plant site (due to the proximity to Upper Lake), and in the north plant site (up to 6 feet) due in part to the lack of flow in Wilson Ditch. Water level declines in the 3 to 4-foot range extend from Lower Lake and Tito Park on the east, westward through the acid plant area and west of the plant site. Conversely, measured water level declines are less than one foot in the east plant site beneath the slag pile. With the possible exception of the north plant site, the water level patterns shown on Figure 12 highlight those areas most sensitive to the Upper Lake drawdown. These areas, namely the south and west portions of the plant site, are expected to show the greatest response in water level drawdown from the SPHC. Water level declines will also be greatest in the northwest portion of the site if recharge from Wilson Ditch is eliminated through the SPHC. The water level declines plotted on Figure 12 reflect the net change in water levels between 10/31/11 and 9/13/12. As such, effects of lowering Prickly Pear Creek at the smelter dam, which ended on 2/24/12, are not reflected in Figure 12. If the creek had remained at the lowered stage, measured water declines would have been greater than the currently measured levels.

4.0 EVALUATION OF TEST RESULTS

The drawdown test data collected to date has undergone a preliminary evaluation with respect to insights into the plant site groundwater system and implications for the SPHC activities. Projections of plant site groundwater levels under permanent lake dewatering and Prickly Pear Creek relocation/lowering as proposed under the SPHC program have been made, and possible effects on groundwater flow rates and patterns through the plant site assessed.

4.1 PROJECTED WATER LEVELS

Relocation and lowering of Prickly Pear Creek through removal of the smelter dam is a key component of the SPHC and will have significant impacts on south plant site groundwater levels. Although the creek lowering phase of the Upper Lake drawdown test lasted for only about two months (from 12/20/11 through 2/24/12), information obtained during that period provided insight into the combined effects of lake dewatering and creek lowering on groundwater levels. Figure 13 shows the south plant site hydrographs along with the Prickly Pear Creek stage at the smelter dam from 12/20/11 (start of creek lowering) through 7/24/12. During the latter half of the creek lowering phase (1/30/12 through 2/20/12), the creek level was maintained at a relatively steady elevation of about 3911 feet. Water levels at well APSD-8, located between the creek and Lower Lake, stabilized around 3913 feet during this period, or about 2 feet higher than the creek. Based on this relationship, it can be assumed that the APSD-8 water level will stabilize about 2 feet higher than the post-SPHC creek level of 3906 feet at the current dam location, or at about 3908 feet. In actuality, the APSD-8 water level may stabilize less than 2 feet above the creek level since the 2-foot difference recorded during the drawdown test was most likely affected by water levels in adjacent Lower Lake. With elimination of Lower Lake, water levels at APSD-8 will most likely stabilize less than 2 feet above the creek level. Therefore, the groundwater level at APSD-8 is estimated to be between 3906 and 3908 feet following lake dewatering and permanent creek lowering.

After raising the creek level back to normal dam operating levels (about 3915.5 feet), water levels in Lower Lake and the Tito Park wells continued to decline in response to the Upper Lake drawdown. As of July 2012, groundwater levels in the Tito Park area had all fallen to within 0.5 feet of the creek level (Figure 13). Therefore, with long-term elimination of groundwater recharge from Upper and Lower Lake, groundwater levels throughout the Tito Park area are expected to stabilize close to or slightly higher than the final Prickly Pear Creek water level. Projected overall post-SPHC water level declines are shown for select sites on Figure 12.

Figures 14 and 15 show two east-west schematic cross sections through the south plant area. Both cross sections show the site stratigraphy, the pre-drawdown test (10/31/11) groundwater levels, the 7/24/12 groundwater levels, and the range of projected post-SPHC groundwater levels. Figure 14 also shows total arsenic and selenium (where available) soil concentrations with depth. As shown on Figure 14 (and discussed above), groundwater levels to date have declined on the order of five feet from Upper Lake dewatering alone, with an additional five feet of decline expected from permanent lowering of the creek. The water level declines measured to date have already lowered the groundwater table below the zone of highest soil contaminant concentrations, and achieving the final projected groundwater levels would further dewater the contaminated soils. The Figure 15 cross section lies slightly north of Figure 14 and includes Lower Lake (note that cross section traces for Figures 14 through 17 are shown on an inset map on Figure 14). Following the Prickly Pear Creek relocation and lowering, groundwater levels are expected to stabilize near the bottom of Lower Lake.

It is important to note that the projected post-SPHC water levels in the south plant area are based on preliminary post-SPHC creek channel locations and elevations upstream of the current dam location. If final creek elevations or locations change appreciably from the preliminary plans, the post-SPHC groundwater levels may be affected. Also, water level drawdown in response to the temporary bypass channel may be different from that estimated for the final creek relocation. The greater distance of the proposed bypass channel from the plant site, as compared to the final creek channel location, may reduce the observed level of groundwater drawdown on the plant site while the temporary bypass is in operation.

Figure 16 shows similar information along a cross section extending from Upper Lake northwestward through the west side of the plant and the former acid plant. As expected, projected post-SPHC water level declines will be greatest in the south plant area and are expected to decrease overall to the north. Water level declines as of 9/13/12 have already dewatered some of the most highly contaminated soils in the acid plant area (see abandoned well DH-19, Figure 16), with additional water level declines expected in this area. As mentioned in the previous section, post-SPHC water levels in the northwest plant site will depend on the presence or absence of flow in Wilson Ditch in the future.

Figure 17 includes a cross section extending due north from Upper Lake through Lower Lake and the slag pile. In contrast to the significant drawdown projected in the south plant area, this figure also shows the lack of measured and projected groundwater drawdown on the east plant site beneath the slag pile. Also of note is the very steep hydraulic gradient between Lower Lake and well DH-4 to the immediate north. As previously mentioned, a zone of low permeability material is believed to be present in this area restricting northward flow from Lower Lake towards DH-4.

It should be noted that the projected water levels through the west side of the plant site and through the acid plant do not take into account potential effects of a low permeability zone or cutoff wall around the south plant area as proposed in the SPHC plans. Placement of a cutoff wall downgradient of the south plant could further reduce groundwater flow rates and water levels in the acid plant area depending on the system design, and on the magnitude of groundwater underflow from the Upper Lake area towards the plant site.

4.2 EFFECTS ON GROUNDWATER FLOW PATTERNS

In addition to changes in groundwater levels, potential alterations in groundwater flow patterns and rates have been evaluated from the preliminary drawdown test data. Figures 18 and 19 present the plant site groundwater potentiometric surface for October 2010 and July 24, 2012, respectively. Although the two maps show a similar overall pattern to the potentiometric surface, a few key differences are apparent. As expected, the most obvious differences occur in the south plant site. For instance, the 3920 foot potentiometric contour on the October 2010 map extends northward around the north shoreline of Upper Lake with the Upper Lake water level at 3920.6 feet (Figure 18). In July 2012 (Figure 19) the 3920 contour is located approximately 1700 feet further south. This change alone has resulted in a significant decrease in the hydraulic gradient through Tito Park and an apparent corresponding decrease in the groundwater flux.

Although much less dramatic, the potentiometric contours on the west plant site have also shifted southward from October 2010 to July 2012 due to the water level declines documented in this area. This pattern is evident in the 3900 and 3905 potentiometric contours. Although subtle, these patterns do reflect real changes in the acid plant area groundwater levels. Also of note is the lack of change in the potentiometric surface in the eastern portion of the plant site beneath the slag pile. This is consistent with previous observations suggesting relatively little change in groundwater levels in this area in response to the lake dewatering and creek lowering.

It should be noted that the July 2012 potentiometric surface only reflects the effects of partial dewatering of Upper Lake, and does not account for future creek lowering and placement of a low permeability zone downgradient of the south plant area. These components of the SPHC program will result in significant differences in the post-SPHC potentiometric surface as compared to the July 2012 surface. As previously noted, groundwater levels in the south plant area are expected to closely approximate the final creek levels following permanent lowering of the creek. This will effectively eliminate the northward "bulge" in the potentiometric surface caused by Upper and Lower Lake and the elevated creek level behind the smelter dam.

Another possible effect of the SPHC on plant site groundwater flow patterns is a more westward component of groundwater flow through the northern portion of the plant site. Currently, groundwater flows in a northwesterly direction beneath the slag pile and northwest portion of the site. With little impact expected for water levels in the eastern portion of the site and additional drawdown expected for the western portion of the site, groundwater flow in the north plant area may assume a more westerly orientation. Indications of an increased gradient towards the west can already be seen in the current drawdown test results. As shown on Figure 7, water level declines on the west plant site (see well DH-42, Figure 7), and the lack of response in well DH-68 located on the south portion of the slag pile, have resulted in a reversal in hydraulic gradients between these areas.

A third possible effect of the SPHC is a decrease in apparent westward flow from the south plant area towards the Phase I CAMU. Drawdown test water level trends at CAMU wells

MW-6, MW-2 and MW-3 correlate closely with those at south plant site monitoring well DH-20, while other CAMU wells (with the possible exception of MW-10) show no correlation. Figure 20 shows this relationship for select CAMU wells. Lowering the south plant groundwater levels should reduce or possibly eliminate potential westward flow in this area, depending on the post-SPHC groundwater levels on the south plant site.

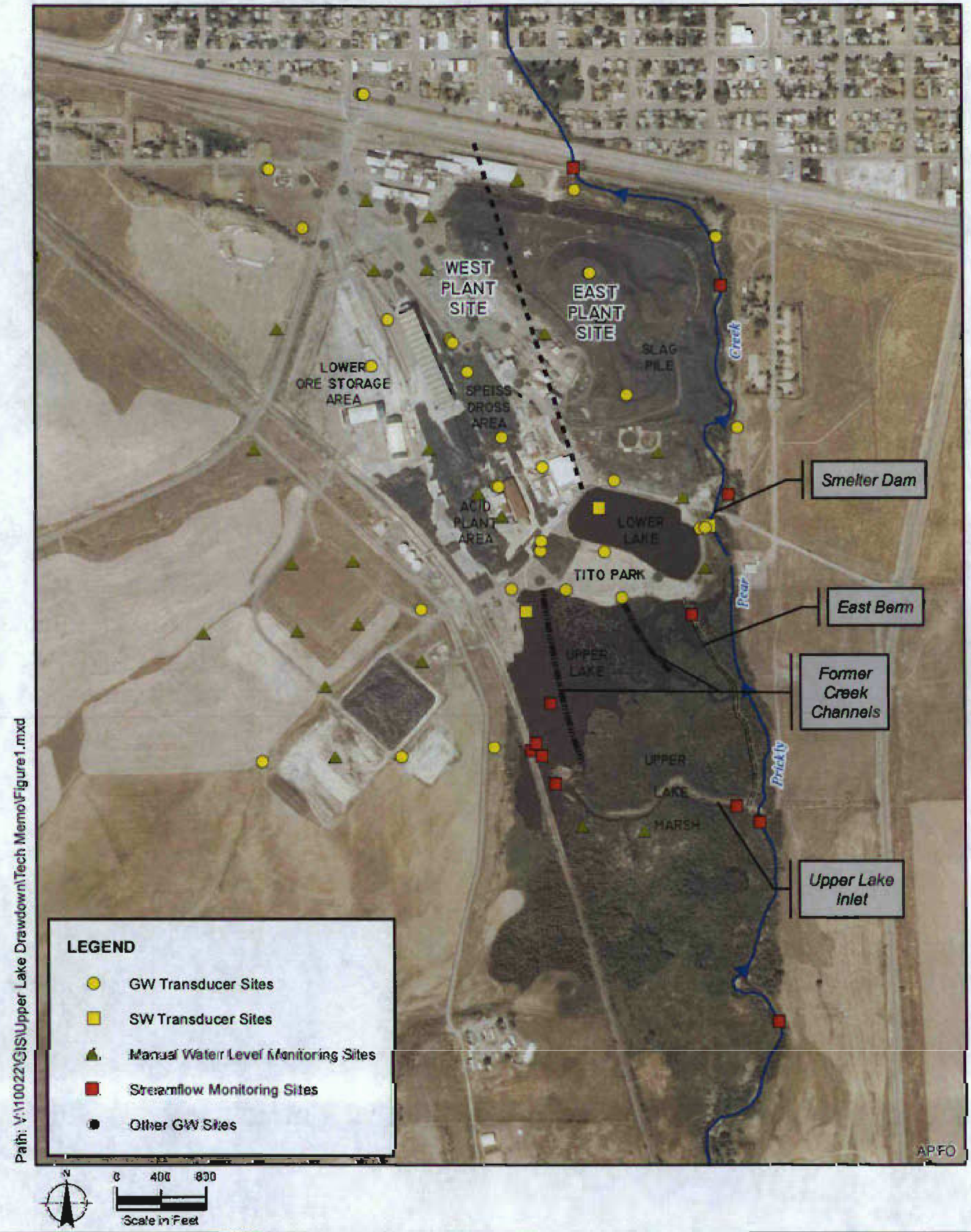
5.0 SUMMARY AND RECOMMENDATIONS

The Upper Lake drawdown test results to date show groundwater levels have declined on the order of 3 to 5 feet in the south, west and northwest plant areas, and less than a foot on the east side of the plant beneath the slag pile. As of mid-September, water levels continue to decline across the site. Water level declines of an additional five feet or more are expected in the south plant area in response to dewatering of Upper Lake and permanent lowering of Prickly Pear Creek under the SPHC project. The groundwater level declines already realized through the lake drawdown test have dropped the water table below the zone of highest soil contaminant levels in certain areas, with post-SPHC water level drawdown expected to further dewater contaminated soils in the south plant and acid plant areas. Lowering of the water table is not only expected to reduce contact between the plant site groundwater and soil contaminants, but should also reduce the rate of groundwater flow, or flux, through the plant site. Together, these two factors should result in a reduction of contaminant leaching to groundwater and contaminant loads, in pounds per day, emanating from the plant site.

Dewatering of Upper Lake/Lower Lake and lowering the Prickly Pear Creek level by approximately 8 feet at the current smelter dam location as proposed under the SPHC project will result in a more uniform potentiometric surface through the south plant area and eliminate the northward "bulge" in the potentiometric surface caused by Upper and Lower Lake. The result will be a reduction in seepage from the northwest portion of Upper Lake to the west plant site, and a reduction in seepage from the east and west ends of Lower Lake which currently provides recharge to Prickly Pear Creek and the west plant site, respectively. Other potential changes in the plant site groundwater flow patterns include an increased westerly component to groundwater flow in the northern portion of the site (due to greater effect on groundwater levels in the west plant area than the east), and a reduction in potential westward flow from the south plant site towards the Phase I CAMU cell. Effects on northwest plant site groundwater levels will depend in large part on future flow conditions in Wilson Ditch.

One outstanding question related to the Upper Lake drawdown test is the volume and fate of groundwater underflow beneath Upper Lake onto the plant site. The rate of groundwater underflow from beneath Upper Lake towards the plant site should be evaluated further to determine how this source may affect post-SPHC groundwater flow through the plant site. Depending on the results, appropriate measures could be incorporated into design of the low permeability zone/groundwater cutoff wall proposed in the SPHC to further reduce groundwater flow through the plant site, if necessary. Gaining a better understanding of this groundwater underflow component will also prove useful in assessing construction dewatering requirements for the SPHC.

Based on the findings to date, continuation of the pumping phase of the Upper Lake drawdown test through September 2012 is recommended. Continuing the test through September will provide a full year of drawdown test data, which will aid in discerning seasonal (and longer-term) water level trends from lake drawdown-induced effects. With cessation of pumping, the Upper Lake water level should recover from the current 3916 level to about 3918 feet. Plant site groundwater levels should be recorded during the lake recovery period to provide additional information on the groundwater response to lake dewatering. Groundwater level trends recorded during both the lake drawdown and recovery phase of the test will help delineate possible areas of increased permeability, preferential groundwater flow paths, and post-SPHC hydraulic gradients and groundwater fluxes through the site. Information presented in this memorandum can be updated following the water level recovery phase of the test. Based on information collected to date however, the Upper Lake drawdown test results indicate that the SPHC project will effectively lower plant site groundwater levels, thus reducing potential leaching of contaminants from soils to groundwater, and will most likely reduce overall groundwater flow rates through the plant site.



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PRIMARY SITE FEATURES
FOR UPPER LAKE DRAWDOWN TEST
EAST HELENA FACILITY

FIGURE

1

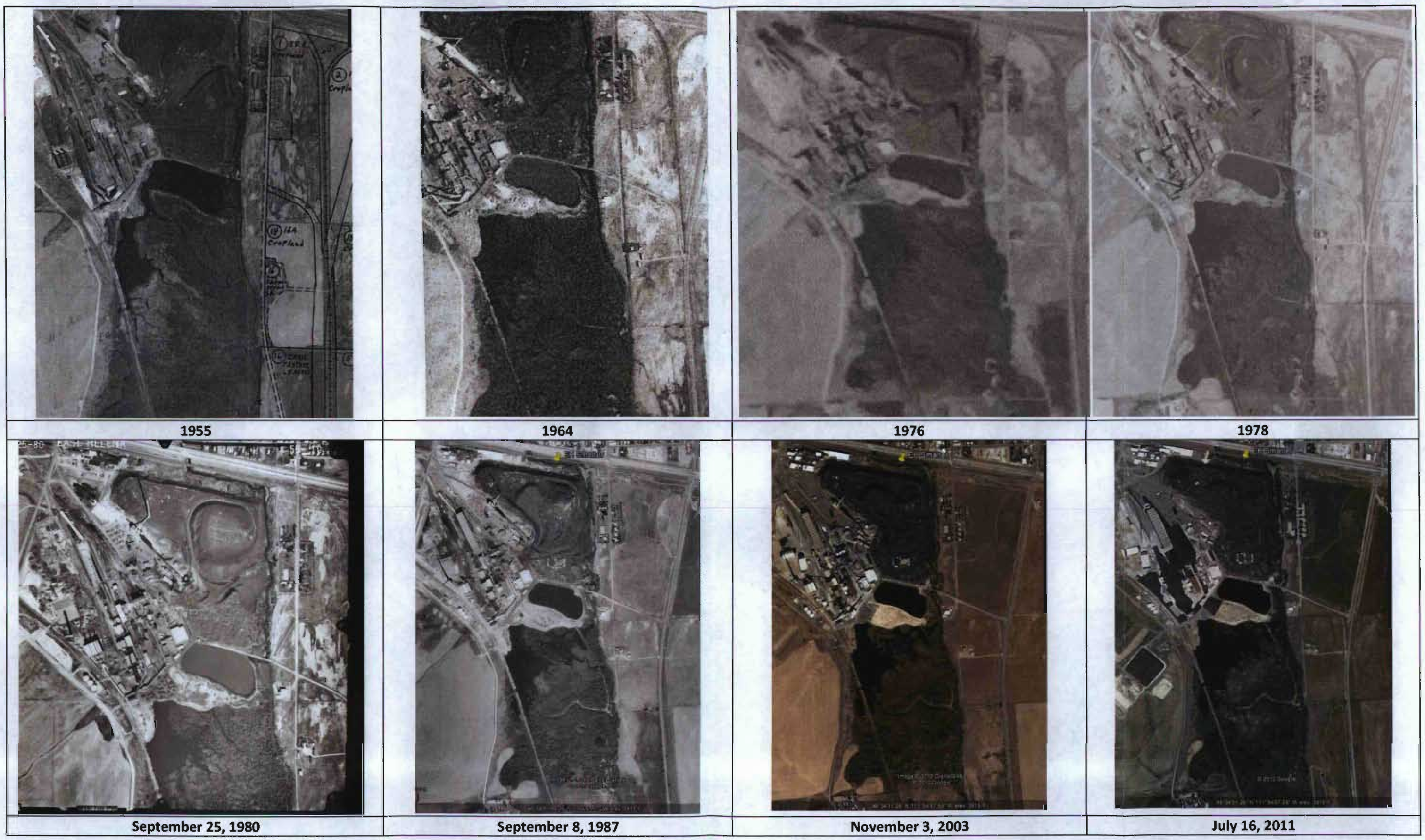
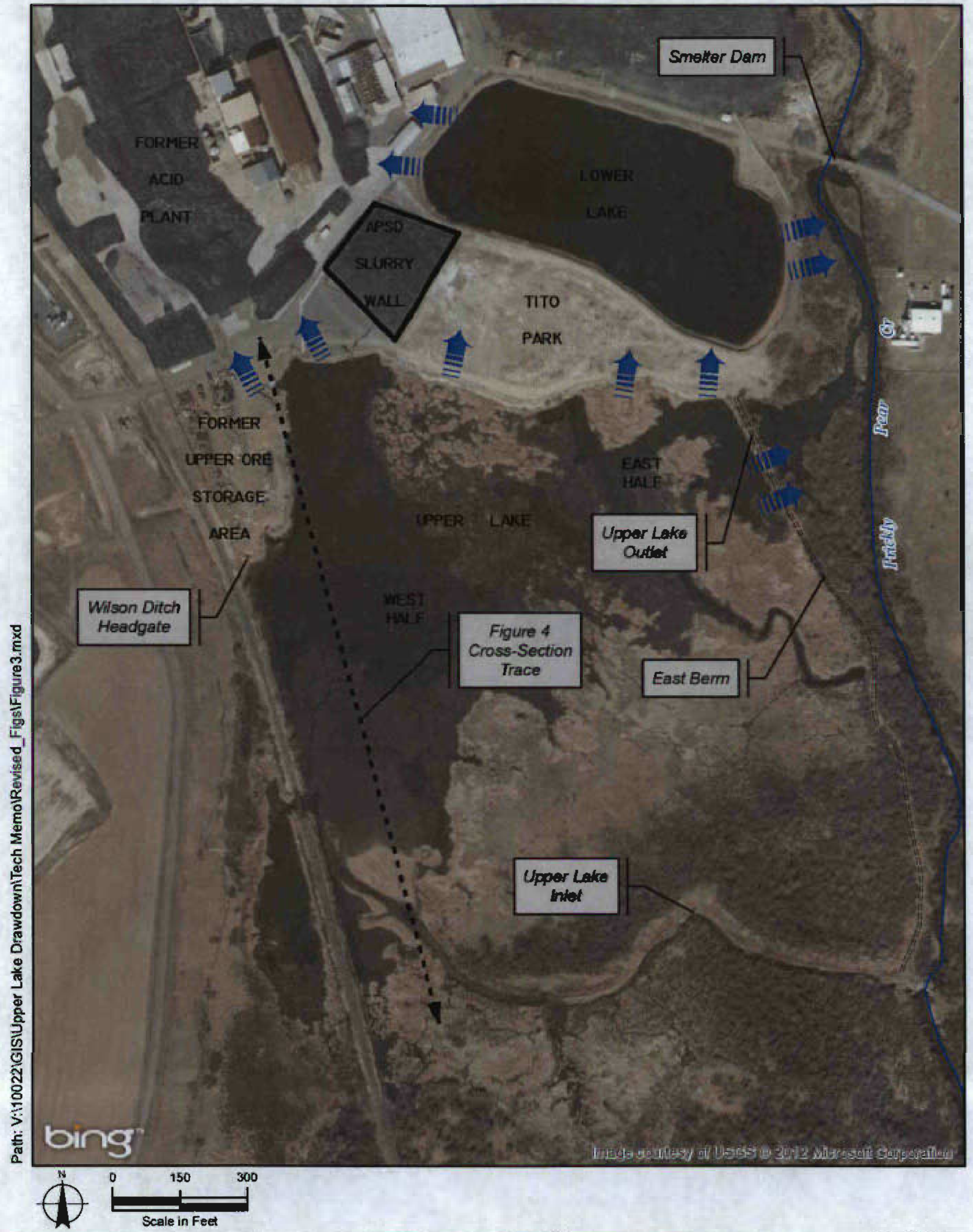


FIGURE 2. PROGRESSION OF UPPER LAKE EXPANSION SINCE 1955.



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PRIMARY UPPER (AND LOWER) LAKE LEAKAGE PATHWAYS
AT MAXIMUM LAKE LEVELS
EAST HELENA FACILITY

FIGURE
3

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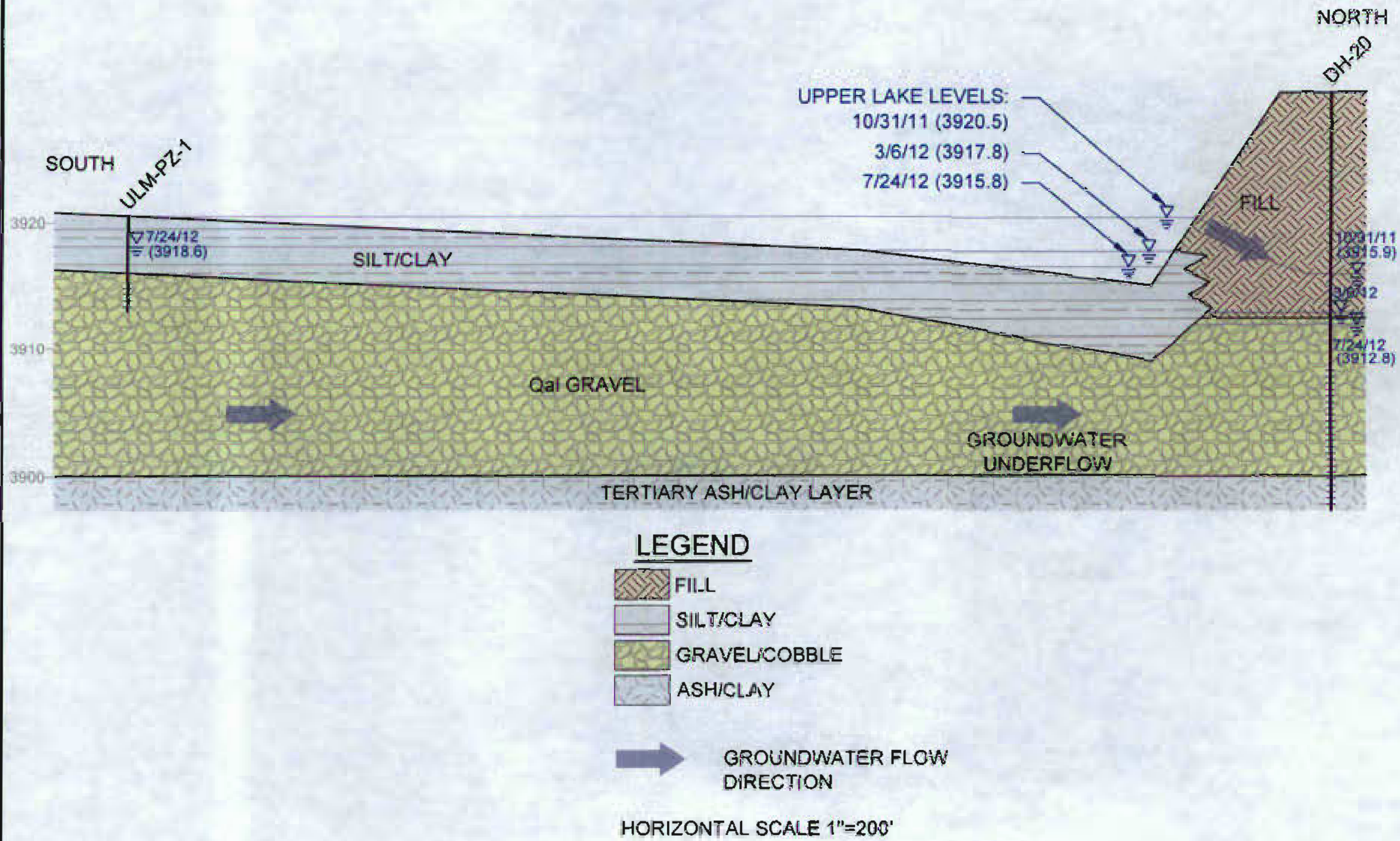

SCHEMATIC CROSS SECTION THROUGH UPPER LAKE - WEST HALF

FIGURE 4

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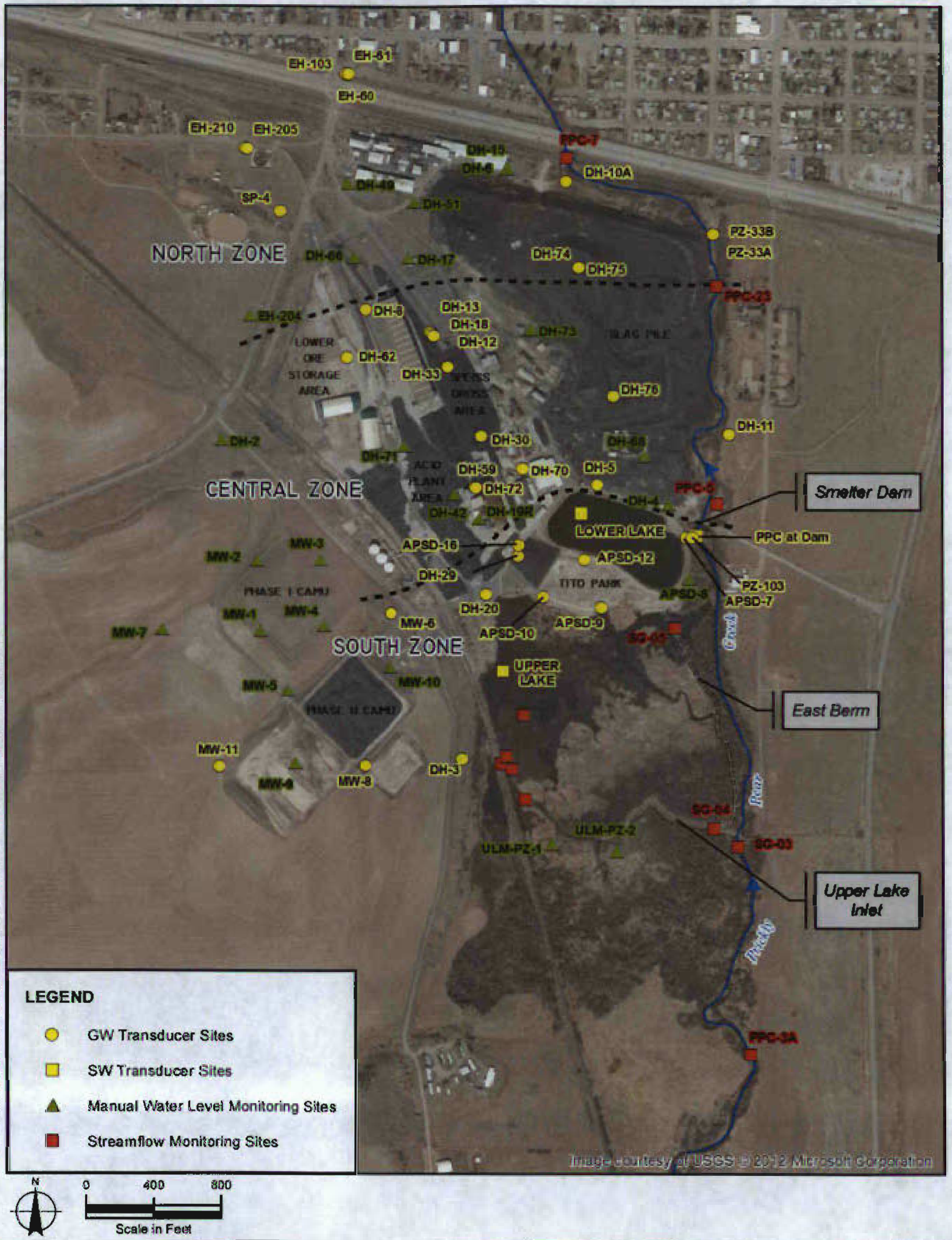

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WATER LEVEL MONITORING SITES FOR UPPER LAKE DRAWDOWN TEST EAST HELENA FACILITY

FIGURE 5

Figure 6. South Plant Site Groundwater Levels

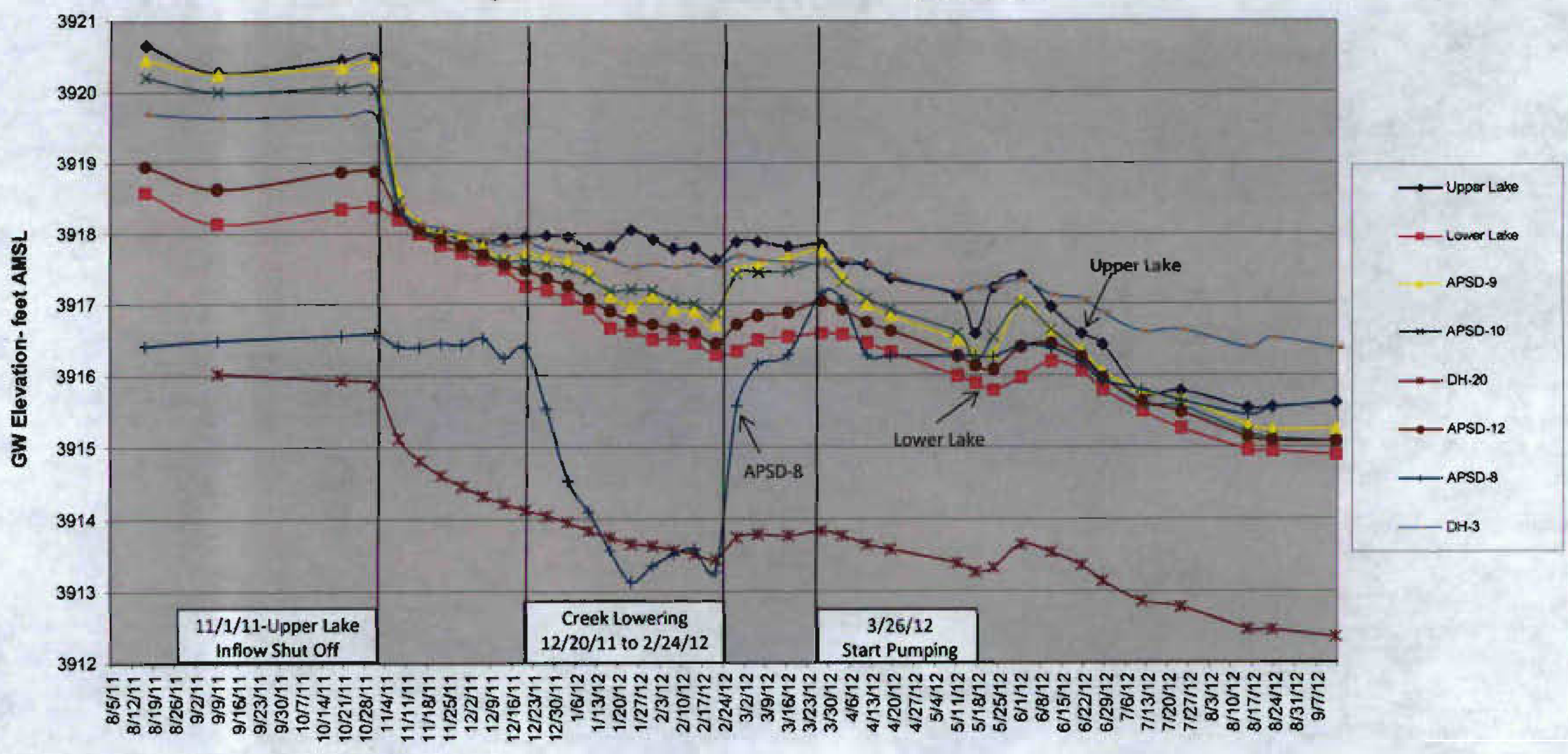
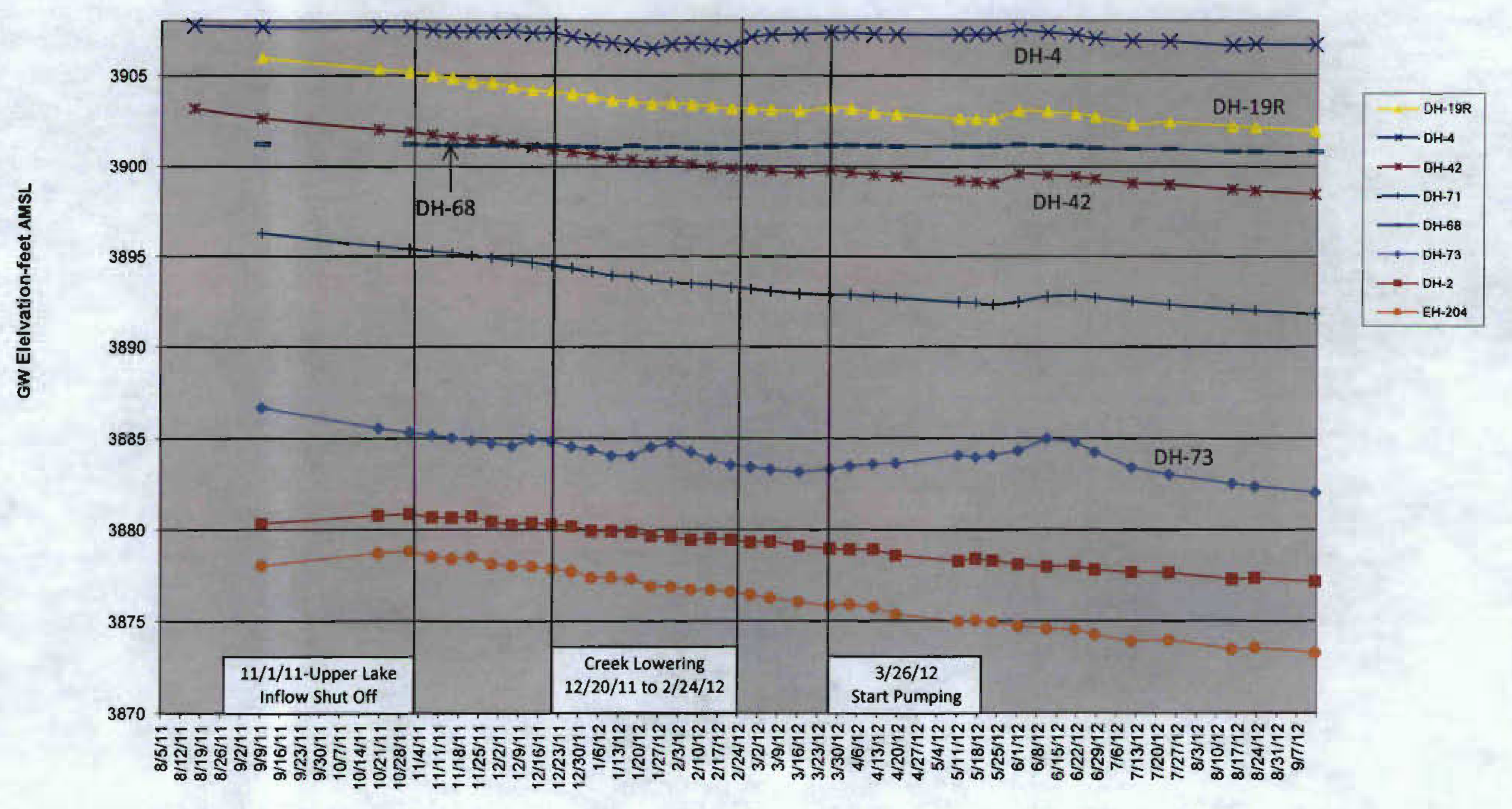


Figure 7. Central Plant Site Groundwater Levels



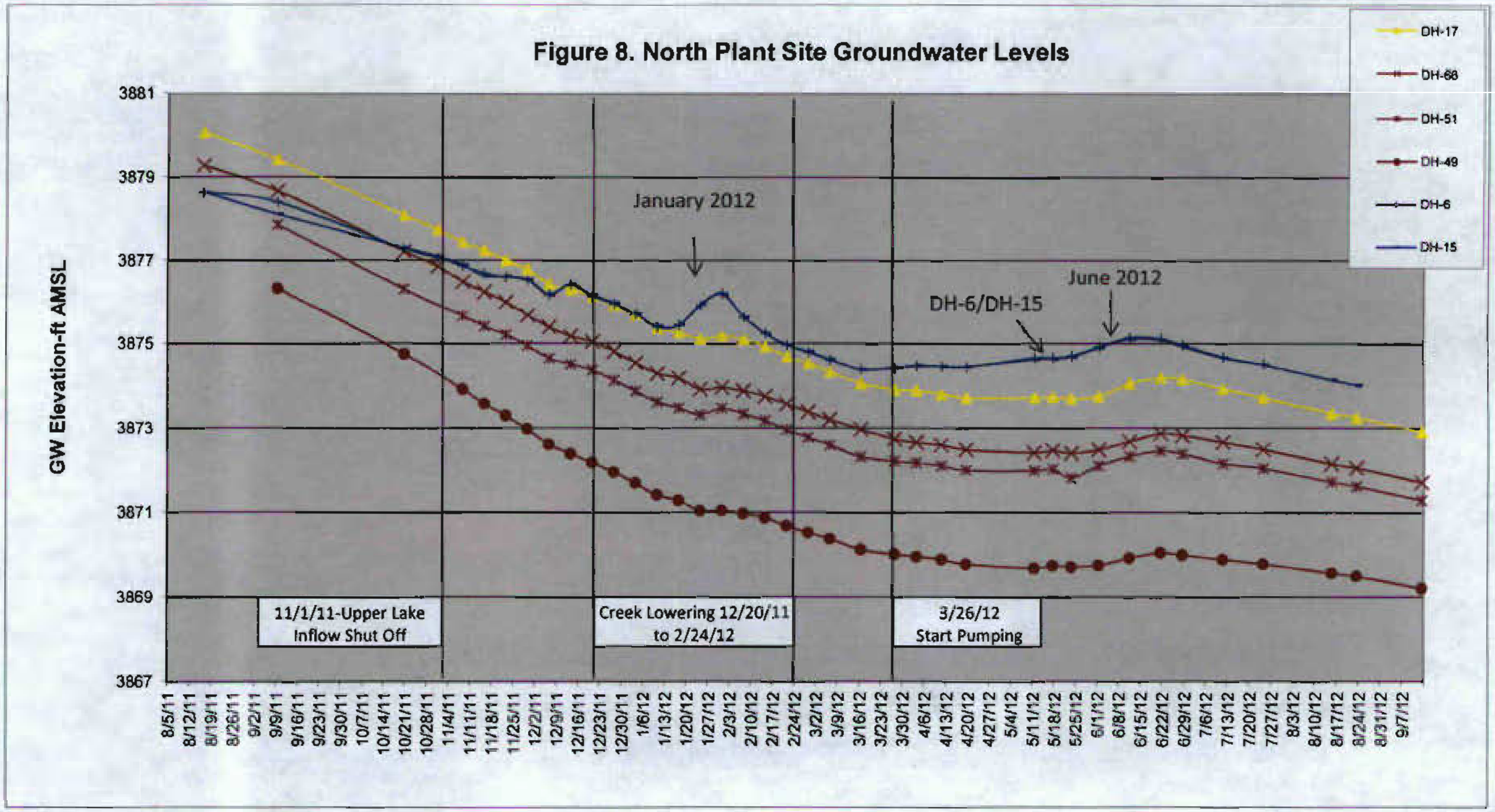


Figure 8. North Plant Site Groundwater Levels

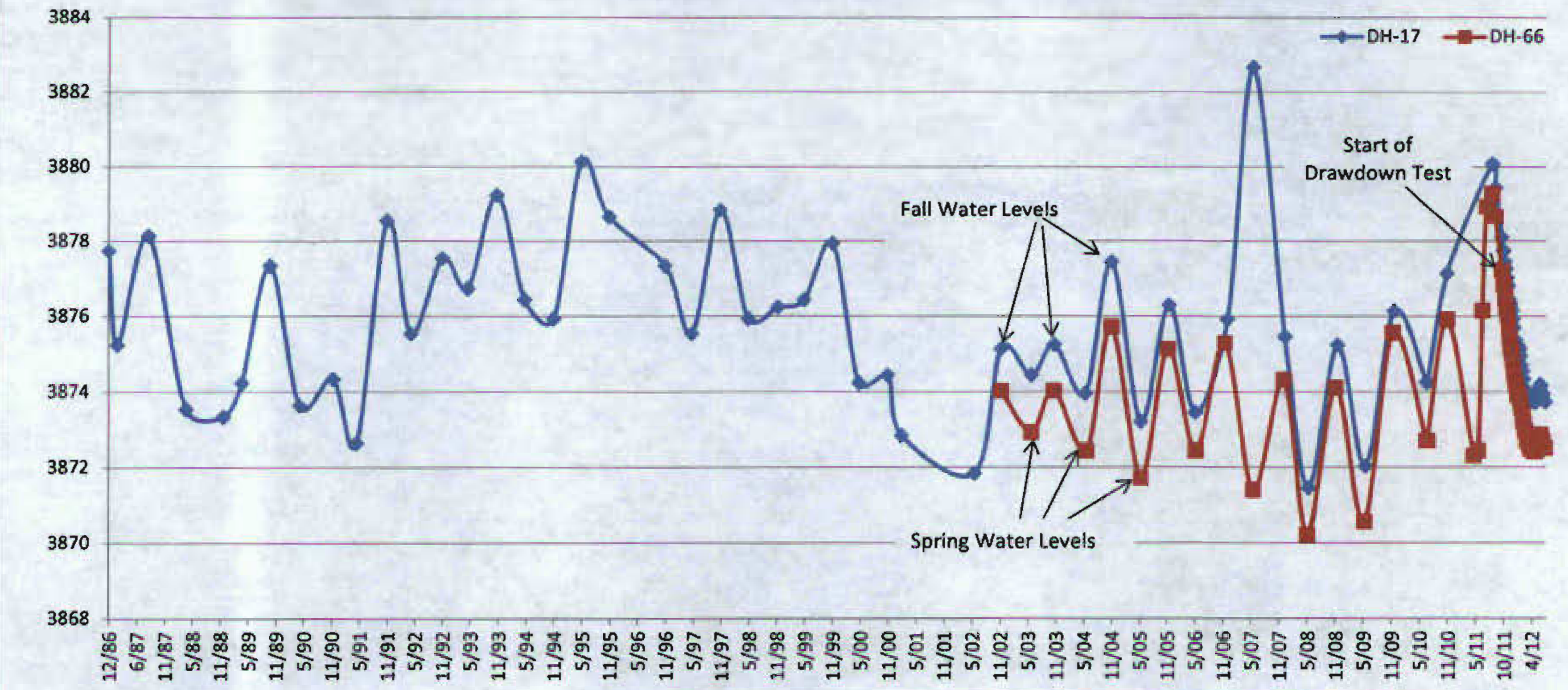
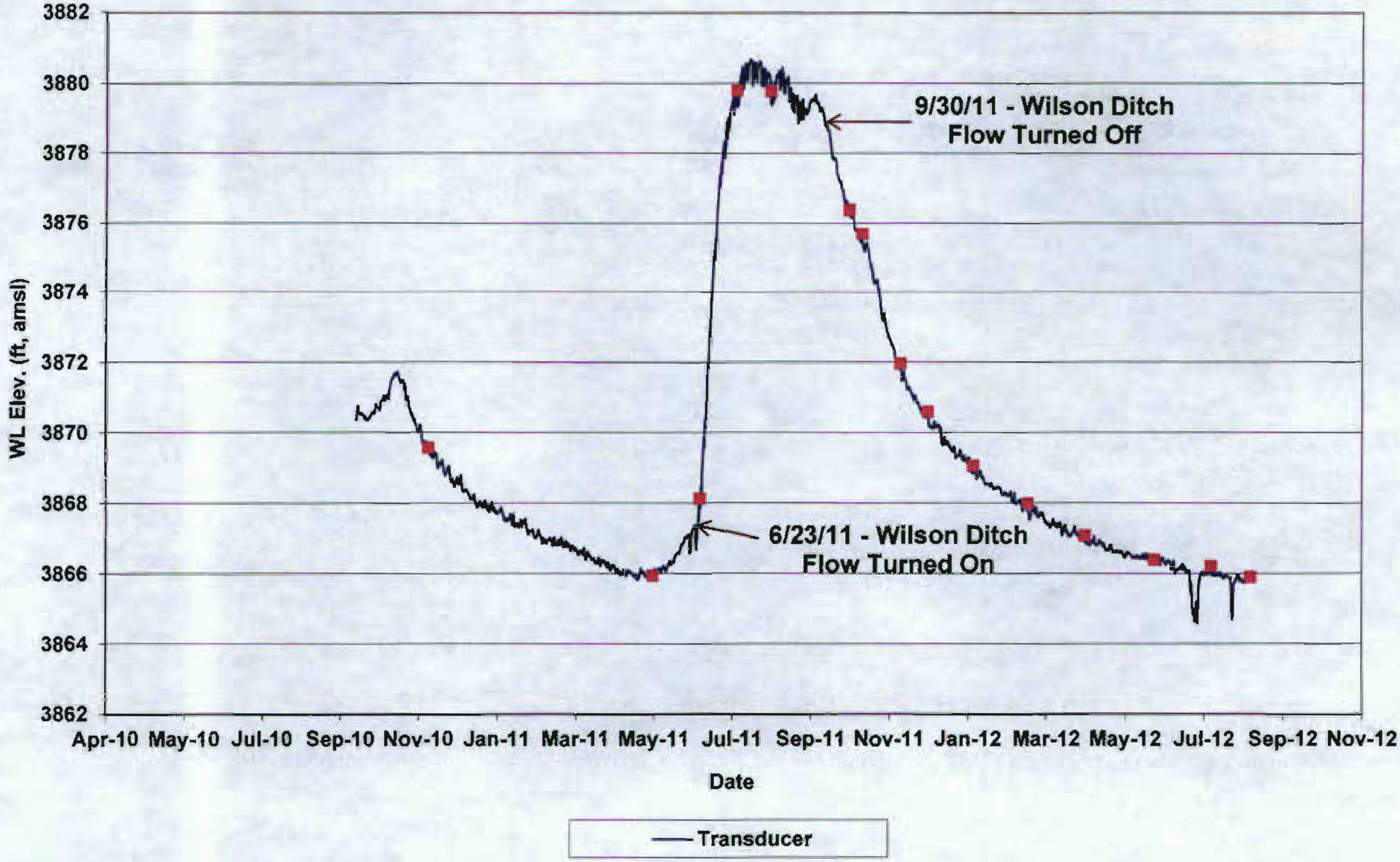


Figure 9. Long-Term Seasonal Trends in Select North Plant Site Wells

FIGURE 10. CONTINUOUS WATER LEVEL HYDROGRAPH FOR MONITORING WELL EH-210



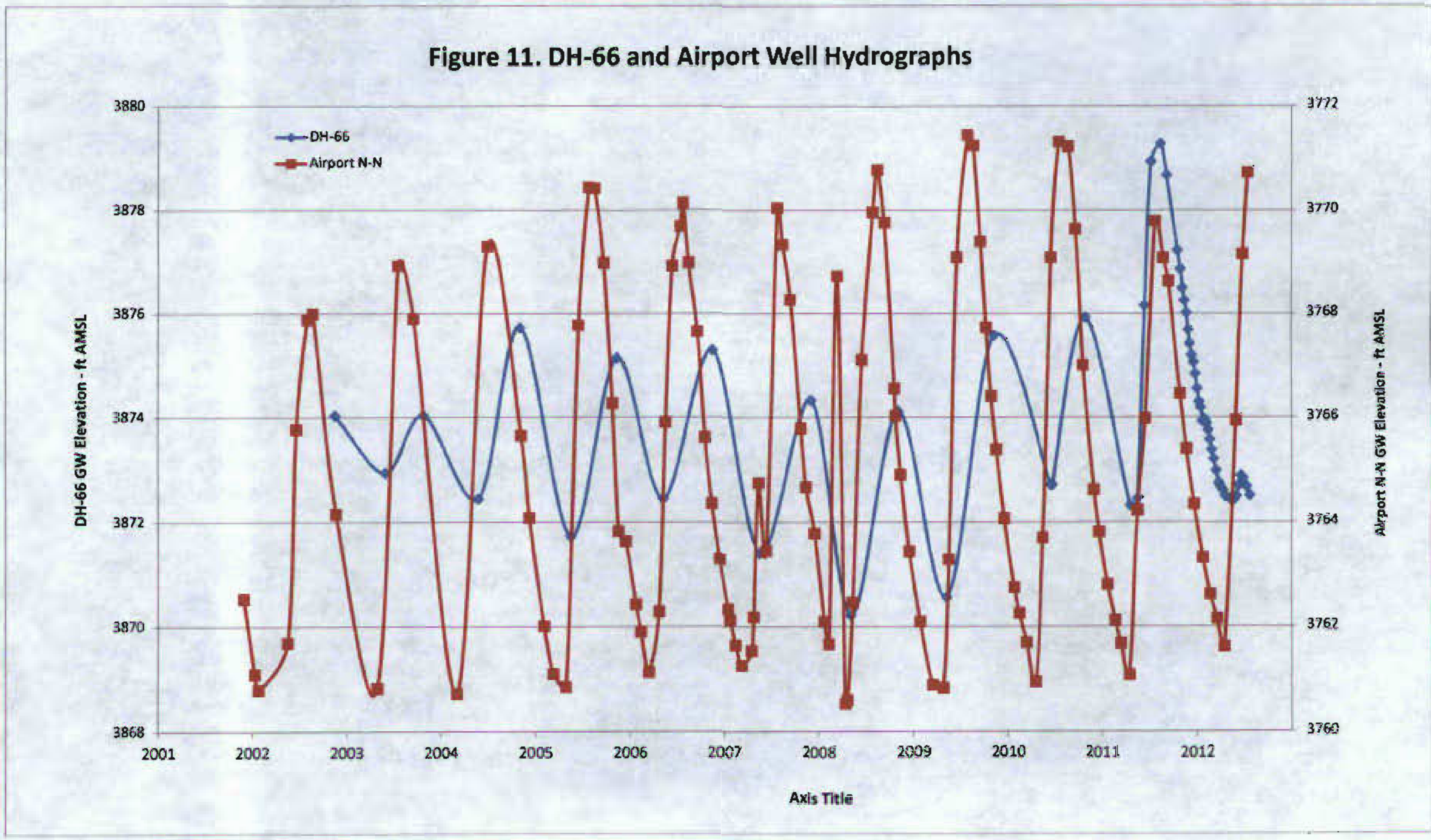
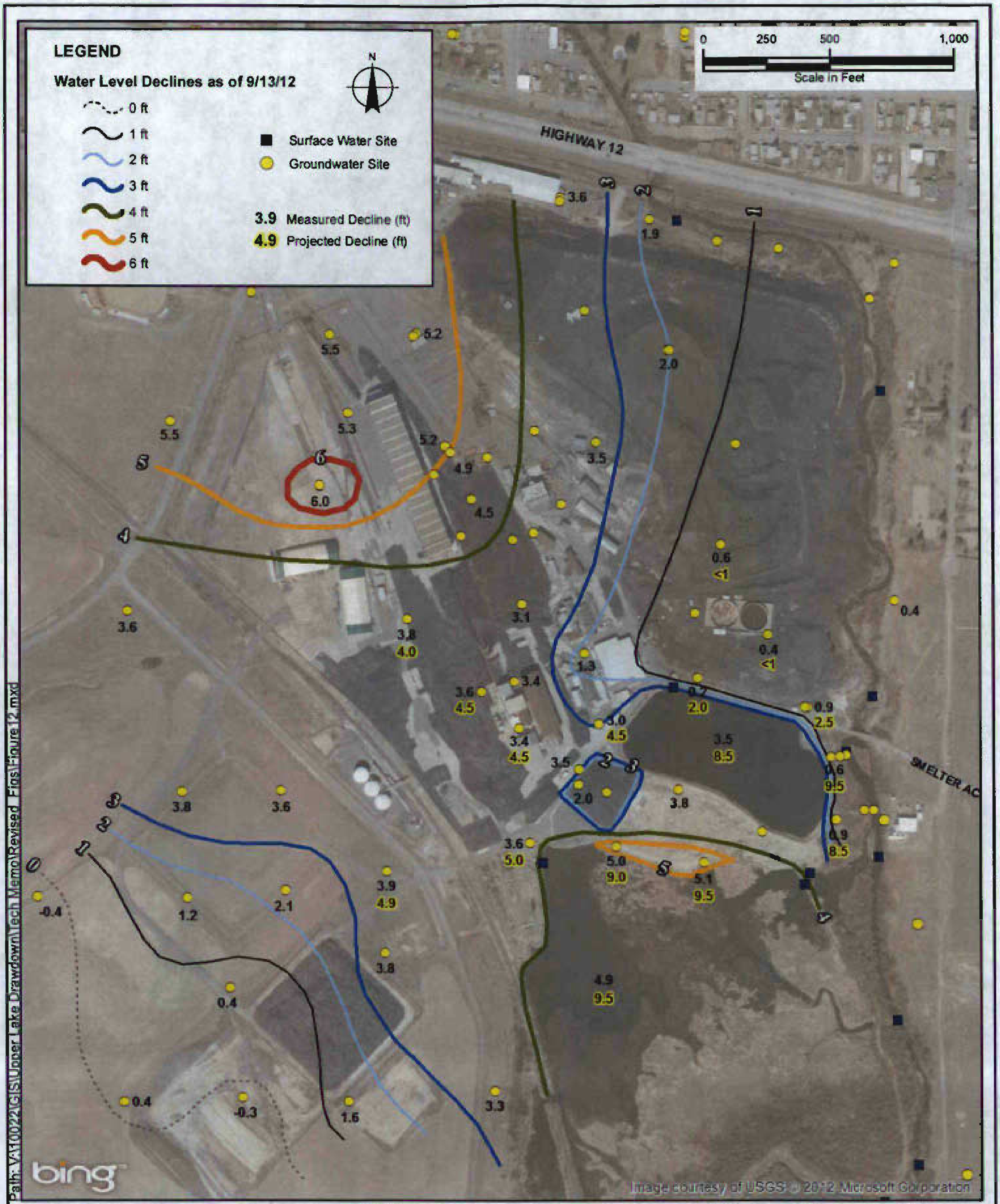


Figure 11. DH-66 and Airport Well Hydrographs
DH-66
Airport N-N
3880
3878
3876
3874
3872
3870
3868
3772
3770
3768
3766
3764
3762
3760
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
DH-66 GW Elevation - ft AMSL
Airport N-N GW Elevation - ft AMSL
Axis Title



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MEASURED WATER LEVEL DECLINES AS OF 9/13/12 AND PROJECTED DECLINES WITH PERMANENT CREEK LOWERING AND UPPER LAKE REMOVAL UPPER LAKE DRAWDOWN TEST - EAST HELENA FACILITY

FIGURE 12

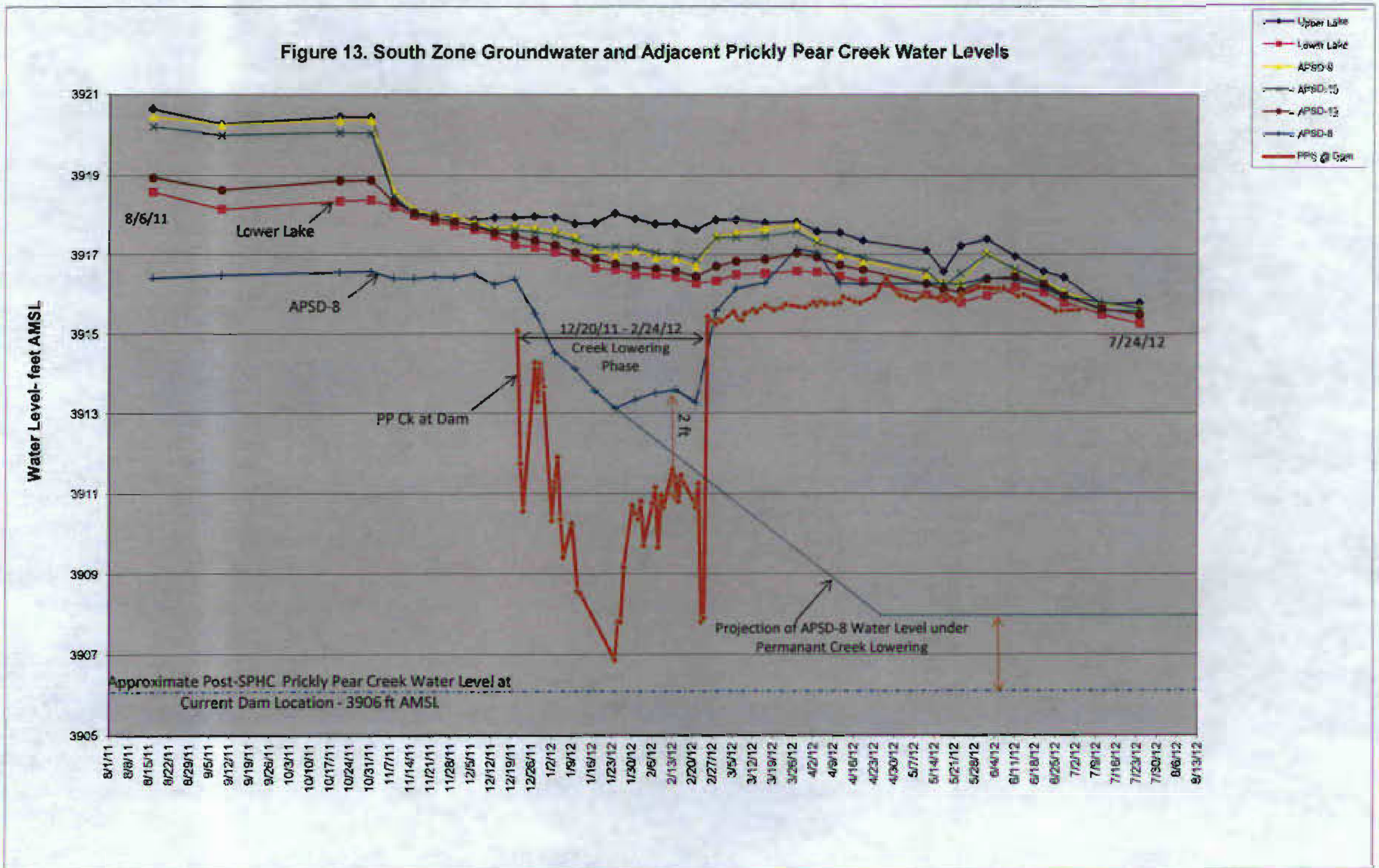

Figure 13. South Zone Groundwater and Adjacent Prickly Pear Creek Water Levels

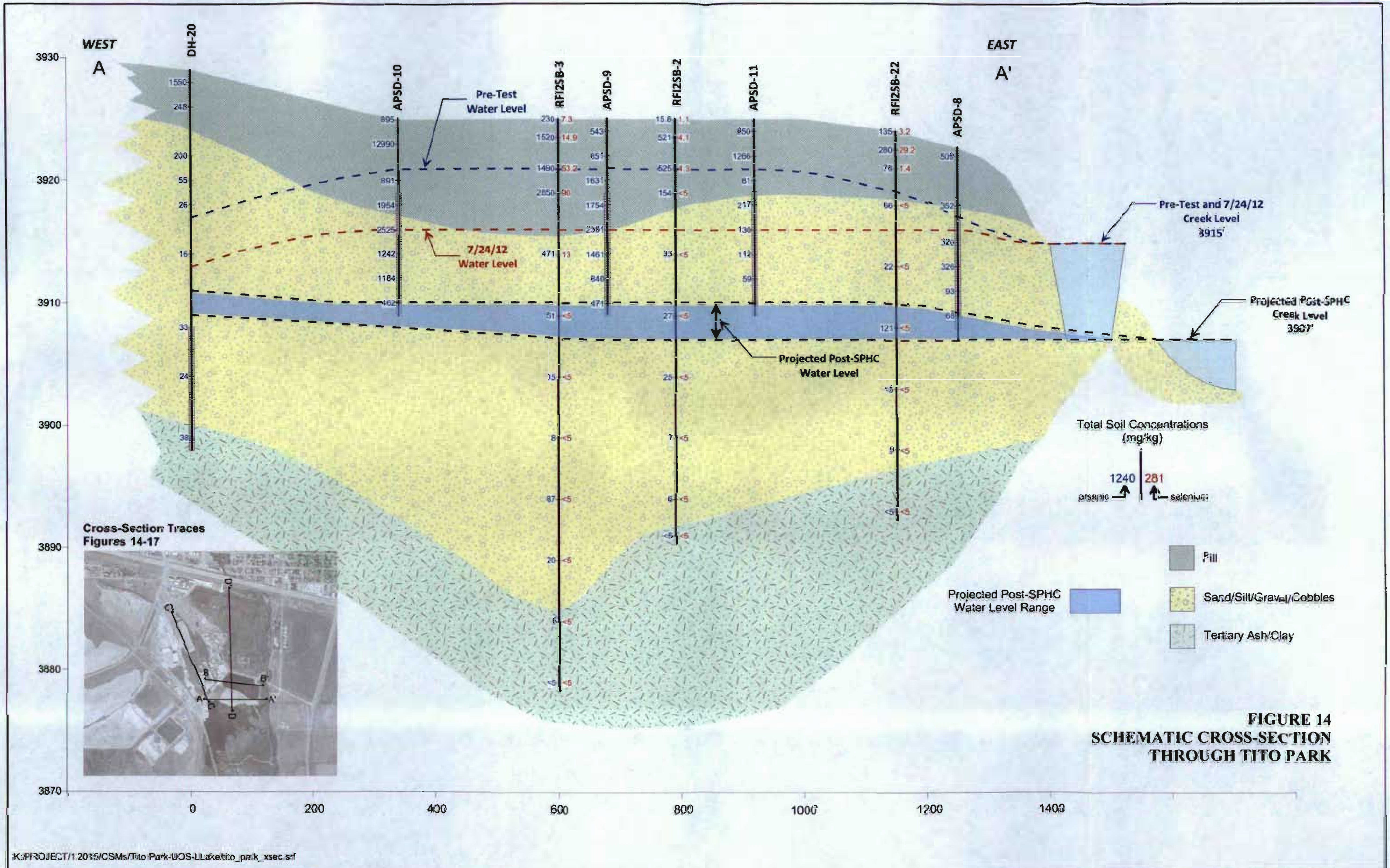

FIGURE 14
SCHEMATIC CROSS-SECTION THROUGH TITO PARK

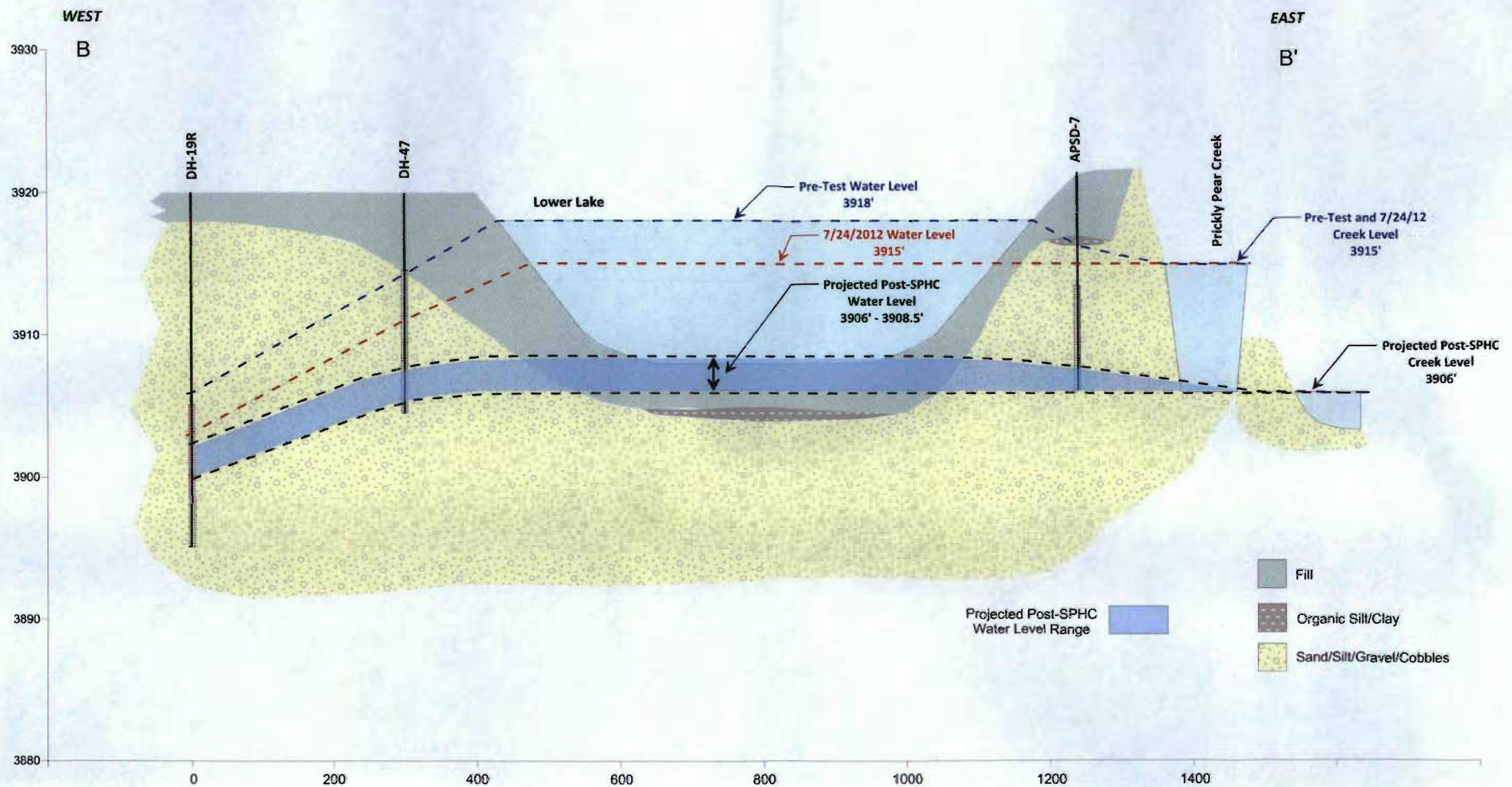

FIGURE 15
SCHEMATIC CROSS-SECTION
THROUGH LOWER LAKE

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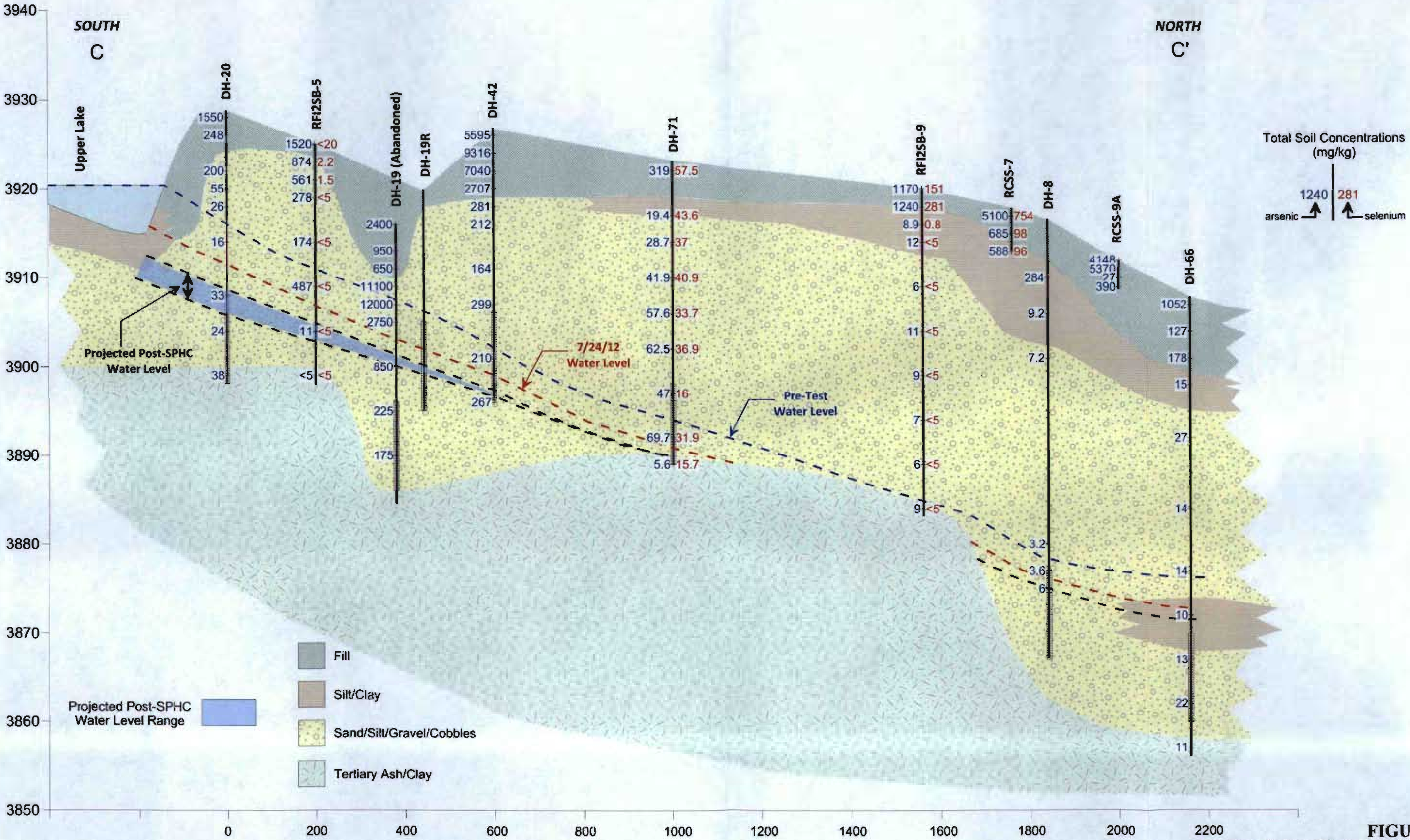

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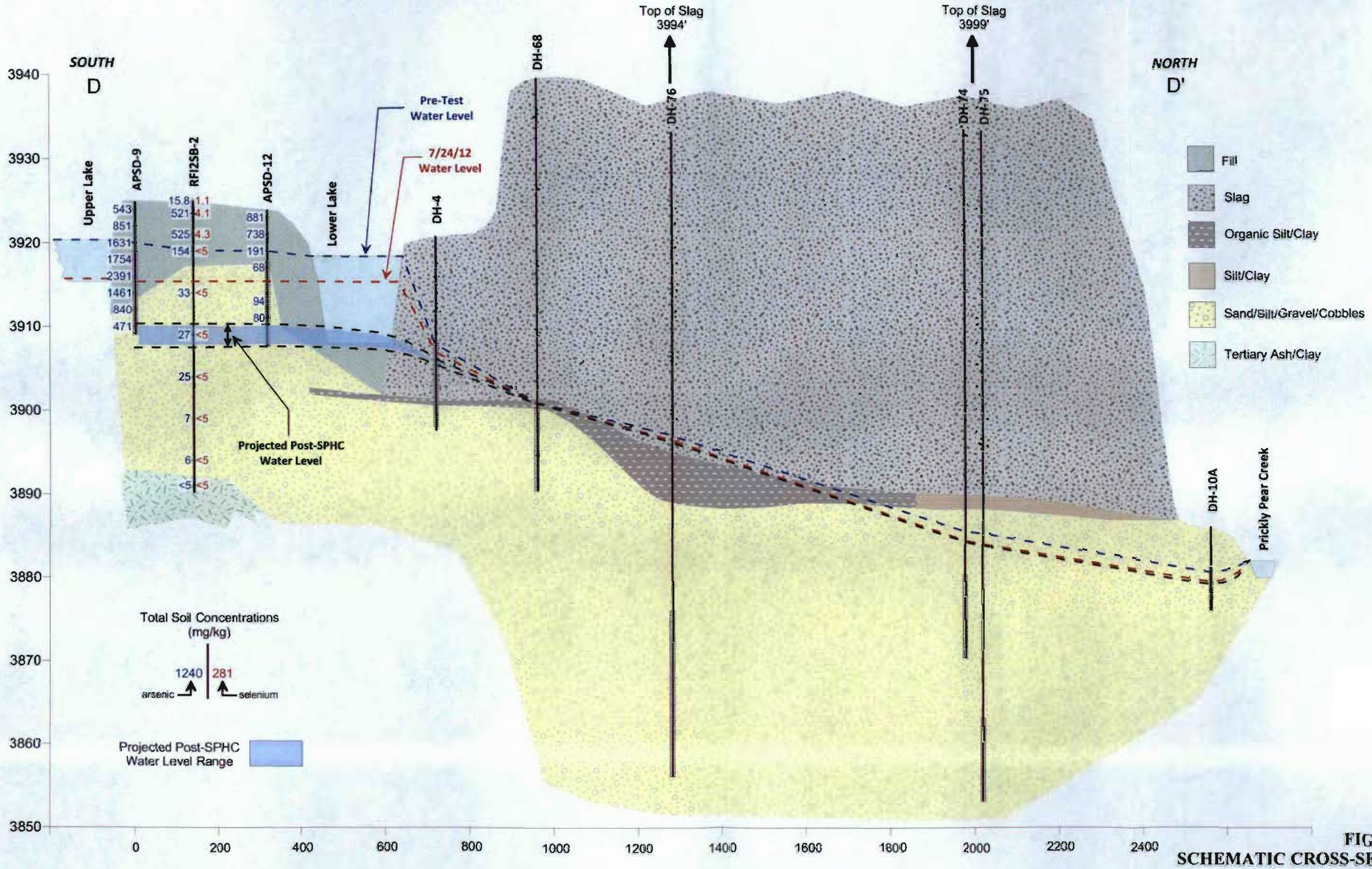
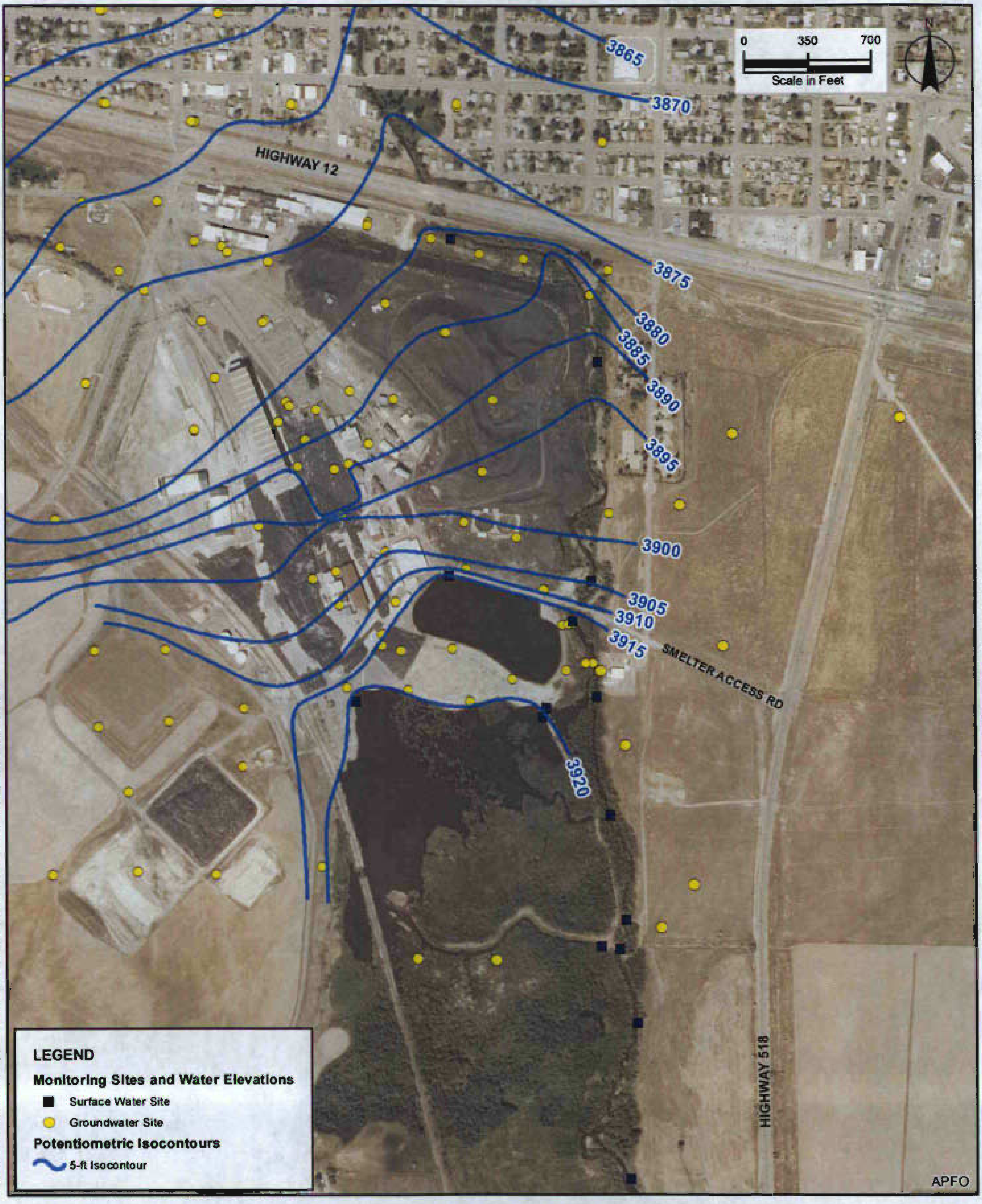
FIGURE 16
SCHEMATIC CROSS-SECTION
UPPER LAKE NORTHWEST
THROUGH WEST SE/LOSA AREA



K:/PROJECT/12015/CSMs/Tito Park-UOS-LLake/ulake_north_xsec.srf

FIGURE 17
SCHEMATIC CROSS-SECTION
UPPER LAKE NORTH
THROUGH SLAG PILE



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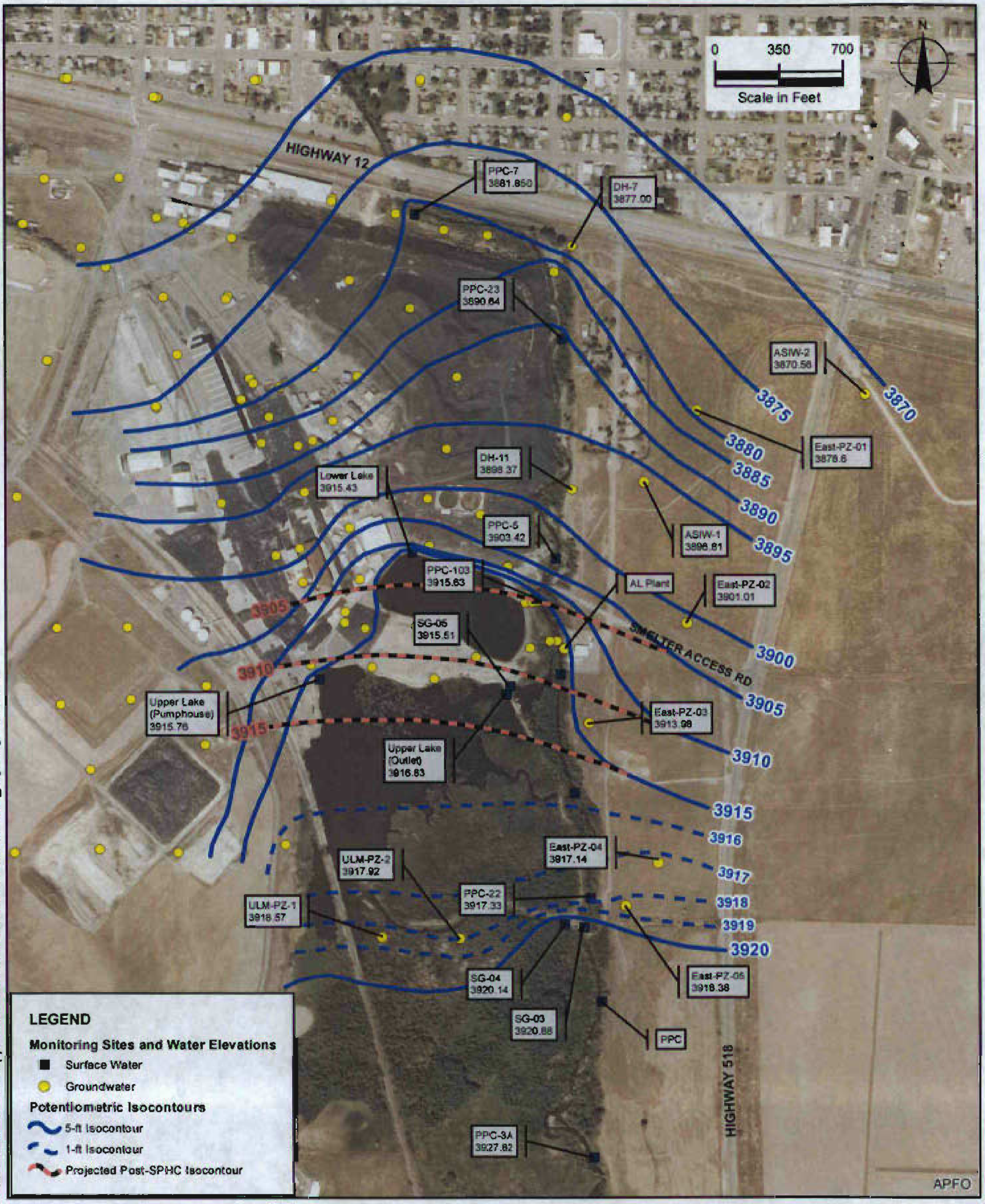
Hydrometrics, Inc. Consulting Scientists and Engineers Date Saved: 9/19/2012 3:15:11 PM	OCTOBER 2010 POTENTIOMETRIC MAP UPPER LAKE DRAWDOWN TEST EAST HELENA FACILITY	FIGURE 18



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JULY 24, 2012 POTENTIOMETRIC MAP
UPPER LAKE DRAWDOWN TEST
EAST HELENA FACILITY

FIGURE
19

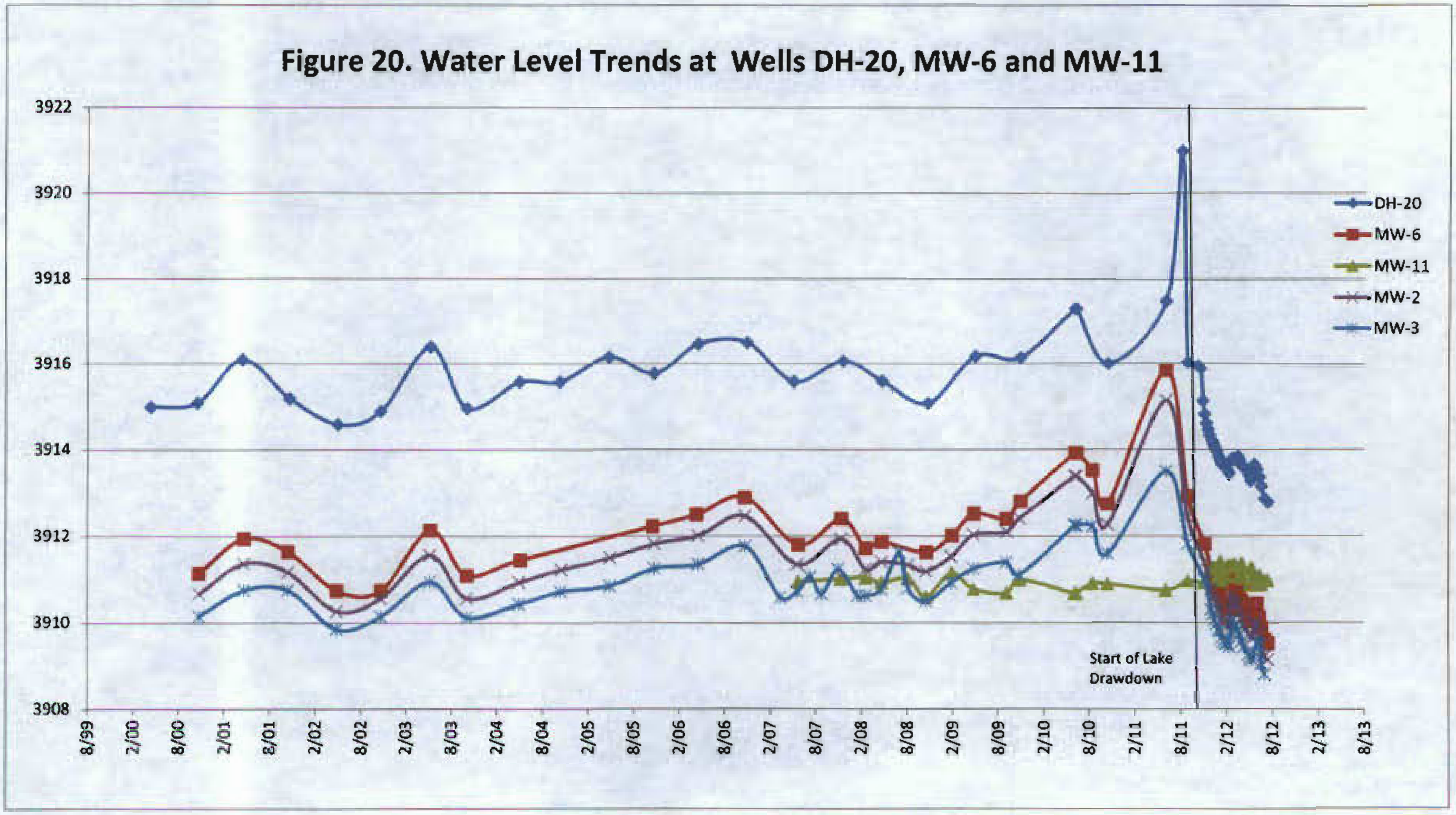


Figure 20. Water Level Trends at Wells DH-20, MW-6 and MW-11
3922
3920
3918
3916
3914
3912
3910
3908
DH-20
MW-6
MW-11
MW-2
MW-3
Start of Lake Drawdown
8/99
2/00
8/00
2/01
8/01
2/02
8/02
2/03
8/03
2/04
8/04
2/05
8/05
2/06
8/06
2/07
8/07
2/08
8/08
2/09
8/09
2/10
8/10
2/11
8/11
2/12
8/12
2/13
8/13

APPENDIX B

CONTROLLED GROUNDWATER AREA HYDROGEOLOGY

APPENDIX B

CONTROLLED GROUNDWATER AREA HYDROGEOLOGY

1.0 HYDROGEOLOGIC SETTING OF THE EAST VALLEY CONTROLLED GROUNDWATER AREA

This Appendix to the East Valley CGWA Petition is intended to supplement the information contained in Section 2.0 of the petition document. Since Appendix B is intended to present an overall picture of the CGWA hydrogeology, a substantial portion of the material presented in this Appendix reiterates the discussion in Section 2.0; however, expanded discussions are also presented for a number of topics, particularly the local geology and hydrostratigraphy, and the evaluation of non-facility related contaminant sources. Note that figures, tables, exhibits, and references cited in this Appendix refer primarily to those presented in the main petition document. Tables and figures that are specific to this Appendix are denoted with a "B" prefix (i.e., Table B-1, Figure B-1).

The hydrogeology or groundwater characteristics of the general area are relevant to the East Valley CGWA petition since they control the current extent of the contaminant plumes and ultimately the appropriate horizontal and vertical boundaries of the CGWA. The hydrogeology and groundwater characteristics of the proposed CGWA have been described in numerous reports. Groundwater flow and chemistry on and around the former smelter have been investigated as part of the RCRA Corrective Action Program currently being conducted by the Custodial Trust. Resulting information from these studies is best described in the Current Conditions/Release Assessment (CC/RA) Report (Hydrometrics, 1999), the Phase I RCRA Facility Investigation (RFI) report (Asarco Consulting, Inc., 2005), and the Phase II RFI report (METG, 2011). The East Helena Facility clean-up program has included extensive groundwater and surface water monitoring on a seasonal basis, with the 2014 monitoring program including groundwater level and/or groundwater quality sampling at 200 monitoring wells and piezometers. The East Helena Facility monitoring well network is shown in Exhibit 1 of the petition document.

The hydrogeology of the general Helena Valley area has been described in a number of previous reports including Briar and Madison (1992), Thamke (2000), and Swierc (2013). Previous studies have differentiated between the Helena Valley "valley-fill" aquifer, comprised of unconsolidated sands, gravels, silts and other granular material, and the underlying bedrock aquifer. The East Valley CGWA petition applies to the valley-fill aquifer and adjacent foothills. Following is a general description of the hydrogeology and groundwater quality of the Helena valley-fill aquifer followed by a more detailed discussion of the proposed CGWA hydrology.

1.1 REGIONAL HYDROGEOLOGY

The Helena valley-fill aquifer covers an area of approximately eight square miles within the Helena Valley basin. The valley-fill aquifer is comprised of Tertiary and Quaternary-age unconsolidated granular material ranging in size from cobble and boulder down to silt and clay. The unconsolidated valley-fill overlies bedrock at depth, with the valley-fill reaching 6,000 feet or more in thickness in the northeast portion of the Valley (Briar and Madison, 1992). The majority of valley fill is comprised of Tertiary age sediments with the upper 100 feet or more comprised of younger alluvium (Briar and Madison, 1992). The valley-fill aquifer serves as a drinking water source for the majority of Helena Valley residents through individual domestic wells, community wells, and public water supply wells.

Recharge to the valley-fill aquifer occurs from streamflow infiltration, leakage from irrigation ditches and canals, infiltration of excess irrigation water, inflow from the surrounding and underlying bedrock aquifer, and to a lesser extent direct precipitation. Inflow from the surrounding bedrock aquifer is the greatest source of recharge to the valley-fill aquifer basin-wide, with bedrock recharge accounting for about 46% of annual recharge (Briar and Madison, 1992). Recharge from irrigated fields accounts for about 31% of annual recharge, with stream leakage and irrigation canal/ditch leakage accounting for 15% and 8%, respectively. Briar and Madison (1992) measured streamflow losses (i.e., recharge to groundwater) in Prickly Pear Creek of 6 to 10 cfs (2,700 to 4,500 gpm) in the four-mile stream reach downstream (north) of the former smelter. As discussed below, this relatively high infiltration rate, 675 to 1,100 gpm per mile of stream, has direct implications for groundwater flow and contaminant plume migration in the proposed East Valley CGWA.

Groundwater flow directions in the valley-fill aquifer are generally from the north, west and south valley margins, towards Lake Helena, the regional groundwater drain in the northeast portion of the valley. As a result, the valley-fill potentiometric surface, or contour map of groundwater potential head, forms a more or less concentric pattern with the low point centered on Lake Helena. A generalized potentiometric map of the valley-fill aquifer, with the former smelter and approximate East Valley CGWA boundaries shown for reference, is included in Figure 2-1.

The Helena Valley fill material generally consists of relatively permeable sands, gravel and cobbles, with interlayered zones of less permeable silt and clay. The silt/clay layers are relatively thin (a few feet to 10 feet thick), and are laterally discontinuous. As such, the silt/clay layers inhibit but do not prevent vertical flow between the more extensive and more permeable coarser-grained water-bearing zones. This general stratigraphic pattern has been documented near and north of the East Helena Facility through borehole logging associated with the site investigations, and has direct bearing on contaminant plume migration and the proposed CGWA boundaries.

The valley-fill material is generally coarsest (cobble/gravel/coarse sand) along the valley margins where major drainages such as Tenmile Creek and Prickly Pear Creek enter the valley, and finest (fine sand/silt/clay) near the Lake Helena discharge point. This decrease in clast size is accompanied by a general decrease in the aquifer hydraulic conductivity (a measure of aquifer permeability or ability to transmit water). Briar and Madison (1992) report typical horizontal hydraulic conductivity values for the valley-fill aquifer on the order of 200 ft/day. This value compares well with results from aquifer testing conducted on similar materials on and near the former smelter. Vertical hydraulic conductivity values are estimated to be two to three orders of magnitude lower than horizontal hydraulic conductivity, due largely to the discontinuous silt/clay layers impeding vertical flow.

1.2 LOCAL HYDROGEOLOGY

Within the vicinity of the proposed CGWA, groundwater conditions are generally similar to the regional conditions described above. On and north of the former smelter (along the northward trajectory of the groundwater plumes), the valley-fill stratigraphy and hydrogeology has been documented through logging of more than 200 monitoring wells, piezometers (Exhibit 1), and soil borings, and review of well completion logs from private and public water supply wells in the area. The area of interest and key features for the local hydrogeology discussion (and the CGWA petition) are shown in Figure 1-1.

1.2.1 Geology and Hydrostratigraphy

The local geology, both surficial and subsurface, has a strong influence on groundwater flow and contaminant plume migration. Important features of the local geology include: an exposure of metasedimentary Spokane formation bedrock (Ys) west and northwest of the Facility, a large area of alluvium (Qa) extending along Prickly Pear Creek from the former smelter northward into the Helena Valley, the uplands or foothills comprised of fine grained Tertiary sediments south, east (OgS) and west (OgtS) of the Facility, and commingled alluvium and colluvium (Qac) intermediate to the Tertiary uplands and alluvium along the Prickly Pear Creek corridor. The surficial geology of the immediate area is shown in Figure 2-2.

__Younger (Quaternary) Alluvium and Mixed Alluvium/Colluvium__

Much of the CGWA including the former smelter is situated on recent unconsolidated alluvial/colluvial sediments that extend northward from the southern basin margin into the valley. The alluvium (Qa in Figure 2-2) represents relatively recent sediment deposition from Prickly Pear Creek and forms in part the upper primary groundwater-bearing unit in the CGWA. The recent alluvium consists of relatively clean sand and gravel with discontinuous silt/clay layers. Due to the relatively low silt content in the sand and gravel matrix, the recent alluvium has a relatively high permeability. The thickness of the alluvium ranges from about 20 feet in the south portion of the CGWA, to 100 feet or more in the north portion.

Distal from Prickly Pear Creek the alluvium grades to a heterogeneous mixture of alluvium and colluvium (Qac). The alluvium/colluvium contains a higher percentage of fine-grained silt and fine sand than the alluvium, with the fine sediment content increasing with distance from the creek. The alluvium/colluvium represents a mixture of fine grained sediment derived from the adjacent foothills, and coarser sediment associated with Prickly Pear Creek. The transition from alluvium along Prickly Pear Creek to a mixture of alluvium and colluvium in the direction of the foothills is best characterized as gradational and interfingering, as opposed to an abrupt change. The increase in fine sediment content with distance from the creek is evident in soil samples collected during monitoring well drilling in Lamping Field (Figure 1-1) and most likely influences groundwater flow and plume migration in the CGWA.

Older Quaternary/Tertiary Alluvium

Older alluvium of early Quaternary and late Tertiary age underlies the more recent alluvium. Based on drilling within the proposed CGWA, these sediments are weakly consolidated sand, silty sand and gravel with discontinuous silt layers. The thickness of this unit ranges up to about 30 feet on the former smelter site, and increases to 100 feet or more at the north end of the CGWA near Canyon Ferry Road (Figure 1-1). Overall, the older alluvium contains more fine-grained sediment and is more highly cemented with secondary mineral precipitates than the younger alluvium, resulting in a lower permeability. Briar and Madison (1992), however, note that the contact between these units is hard to discern from drill logs due to similar source materials and depositional environments for the different aged sediments. Both the older and younger alluvial sediments, along with the mixed alluvium/colluvium, represent primary water-bearing units in the valley-fill aquifer.

Tertiary Sediments

Tertiary-age sediments form the foothills south of East Helena and in the southwest portion of the CGWA (Figure 2-2). The Tertiary sediments (OgS) consist primarily of fine-grained sediments (silt/fine sand) deposited by streams, overland flow and wind. West and southwest of the former smelter, the Tertiary sediments contain significant volcanic ash and tuff beds (OgtS) partially or completely altered to clay. A laterally extensive weathered ash/clay unit underlies a good portion of the former smelter and surrounding area. As discussed below, the ash/clay unit plays an important role in groundwater flow while the volcaniclastic sediments affect the regional groundwater chemistry and distribution of arsenic in groundwater peripheral to the former smelter.

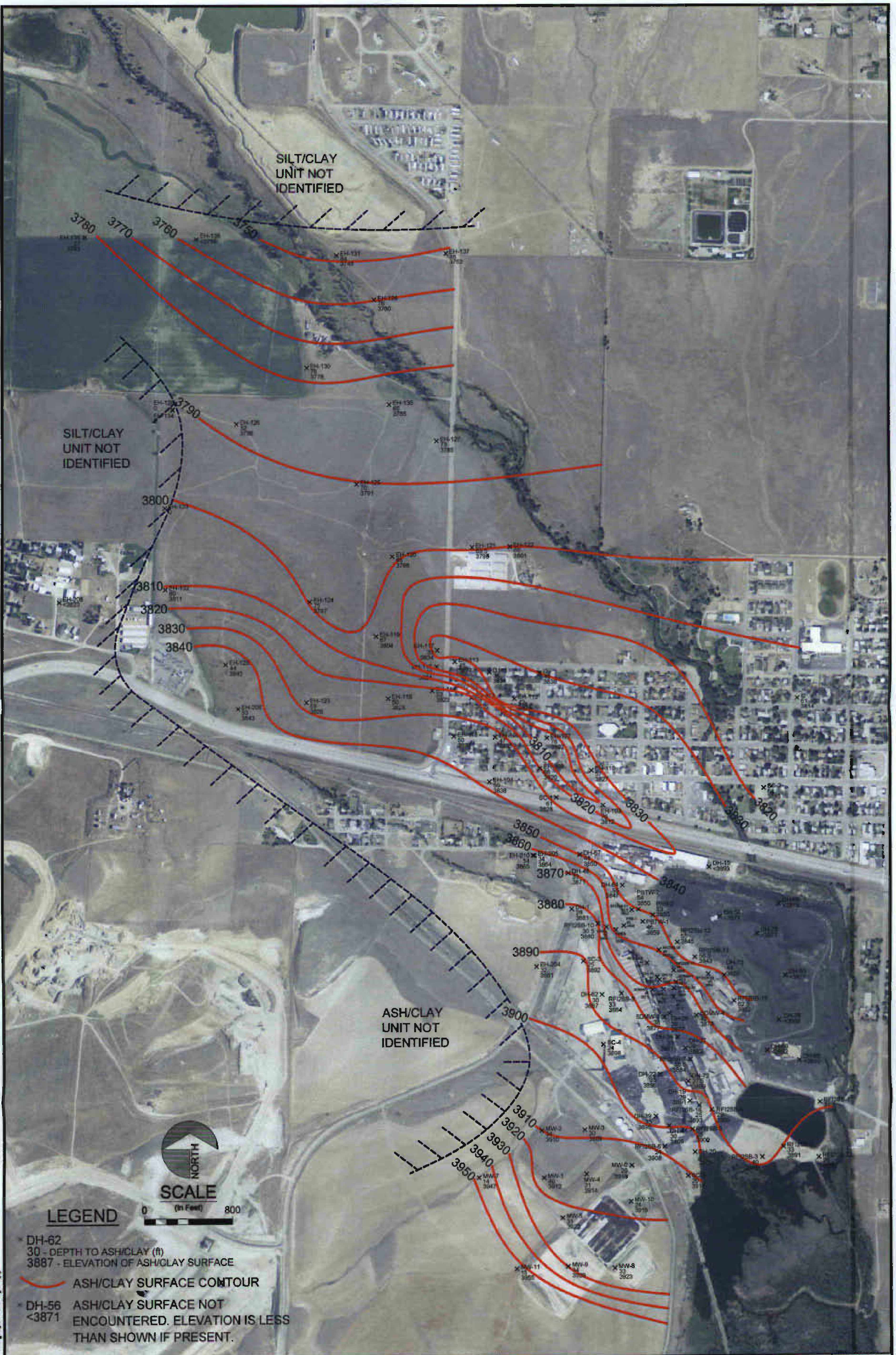
Based on the preceding description of the site stratigraphy, a number of hydrostratigraphic units have been identified within the proposed CGWA. A hydrostratigraphic unit is one or more stratigraphic units with similar hydrologic characteristics allowing for grouping into a single unit for purposes of describing groundwater occurrence and flow. The hydrostratigraphy forms the physical framework for groundwater flow and contaminant transport. Hydrostratigraphic units in the proposed CGWA include:

- **<u>Upper Aquifer</u>**: The Upper Aquifer is comprised of unconsolidated granular fill and alluvial/colluvial sediments extending from ground surface down to the top of the weathered Tertiary ash/clay layer. Granular fill on the former smelter includes earthen material (sand, gravel) and debris (slag, brick). The fill sits atop alluvial sediments (sand/silt/gravel) across most of the former smelter, and atop Tertiary ash/clay on the west side of the plant. Further west, the Upper Aquifer pinches out where the Tertiary sediment surface daylights and the fill/alluvium ends (see cross-sections B-B' and C-C' on Exhibit 2).

  The Upper Aquifer hydrostratigraphic unit extends from Upper Lake on the south end of the former smelter, northward through the East Helena area and into the Helena Valley. North of the plant site (in the Lamping Field area), the Upper Aquifer includes a number of silt layers at depths of about 30 to 35 feet bgs. In previous reports, the Upper Aquifer was divided into separate shallow and intermediate aquifers in this area based on the intervening silt layer. Based on more recent findings, these silt lenses are not continuous and thus do not represent a competent confining layer. Therefore, the entire granular package above the ash/clay layer near the site is now grouped as the Upper Aquifer.

- **<u>Tertiary Ash/Clay Confining Unit</u>**: Underlying the Upper Aquifer in the southern portion of the CGWA is a clay-rich low permeability unit inhibiting vertical groundwater flow. This confining unit, or aquitard, is comprised of the weathered Tertiary volcaniclastic sediments described above. In some locations in the foothills southwest of the Facility, the confining unit consists of tuffaceous sediments altered in-place to white clay. Throughout most areas, however, this unit consists of reworked volcanic ash and volcaniclastic sediments, eroded from higher elevation areas and redeposited in low lying areas, including the historic Prickly Pear Creek drainage bottom.

  Beneath the former smelter and portions of East Helena, the low permeability ash/clay unit occurs as a distinctive white clay with quartz crystals and highly weathered feldspar grains. Further north, however, (beneath and north of Lamping Field, Figure 1-1), the unit transitions to light brown to tan in color, and contains a higher percentage of silt. Based on extrapolation of well log data throughout the CGWA, the low permeability clay unit appears to be continuous from south of the former smelter northward through Lamping Field. The depth to the ash/clay confining unit increases from about 20 feet below ground surface at the south end of the former smelter, 50 feet bgs at the north end, and 80 feet bgs north of Lamping Field. The ash/clay unit has not been identified in monitoring wells completed to depths of 175 feet in the vicinity of Canyon Ferry Road. The documented areal extent of the ash/clay unit is shown in Figure B-1. Figure 2-3



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PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	MAP OF ASH/CLAY UNIT SURFACE PERIPHERAL TO PLANT SITE	FIGURE B-1

shows the cross sectional relationship between the Upper Aquifer and the ash/clay aquitard from the former smelter on the south, northward approximately three miles into the Helena Valley.

- **Deeper Groundwater System**: Besides the Upper Aquifer, groundwater in the southern portion of the CGWA, including the former smelter, occurs at depths below the ash/clay confining layer. Unlike the shallow aquifer which occurs as one continuous aquifer, the deeper groundwater occurs as multiple coarser-grained layers interspersed within and beneath the ash/clay unit. Because the deeper water bearing zones may have limited interconnectivity, they are referred to as the deep groundwater system as opposed to a single aquifer. These deeper water bearing zones are present within different materials at various depths. As described above, deeper groundwater has been encountered beneath the ash/clay unit where there is a transition from tight clays to coarser grained sediment intermixed with the ash/clay, which is evident at smelter monitoring wells DH-18, DH-62 and DH-72, and well EH-210 located immediately west of the smelter (Exhibit 1).

In the northern portion of the CGWA (north of Lamping Feld), the hydrostratigraphy changes due to the apparent absence of the ash/clay aquitard. As shown in Figure 2-3, the ash/clay layer has not been detected during monitoring well drilling or through review of private well completion logs in the northern portion of the CGWA (north of Section 26, Figure 1-1). Therefore, groundwater within the Upper Aquifer and deeper groundwater systems present in the southern portion of the CGWA apparently merges into a single, vertically continuous aquifer (the Helena Valley alluvial or valley fill aquifer) north of Lamping Field.

1.2.2 Groundwater Recharge/Discharge

The primary documented sources of groundwater recharge within the CGWA include leakage of surface water to groundwater and possibly inflow from the surrounding Tertiary sediment and bedrock uplands (Briar and Madison, 1992). Until recently, leakage from Upper Lake was a significant source of recharge to the Upper Aquifer at the former smelter site, with the Upper Lake seepage water flowing north-northwest through the smelter towards the Helena Valley. Historic releases of contaminants from former smelter operations, and ongoing leaching of contaminants to groundwater from the plant site soils, are primary mechanisms for contaminant transport and plume migration leading to this petition. As part of implementation of IMs, in the fall of 2011 the Custodial Trust began dewatering Upper Lake to determine if reducing recharge from the surface water bodies would lower groundwater elevations (Appendix A). Extensive monitoring of groundwater levels following dewatering of Upper Lake, and installation of a temporary bypass for Prickly Pear Creek in October 2013, shows that groundwater elevations have declined in response to these activities. Therefore, Upper Lake is to remain dewatered indefinitely to lower groundwater elevations and reduce groundwater flow through the contaminated former smelter site on a permanent basis.

Leakage from Prickly Pear Creek is another significant source of groundwater recharge in the CGWA. Groundwater/surface water interactions have been evaluated in a number of studies over the years, including METG (2011), Briar and Madison (1992), and Swierc (2013). Leakage from Prickly Pear Creek to groundwater is relatively insignificant adjacent to the former smelter, typically within the range of measurement error (METG, 2011). Downstream of the former smelter however, leakage from the creek to the groundwater system occurs on a year-round basis and represents a significant source of groundwater recharge. June 2013 streamflow monitoring by Hydrometrics (Table 2-1, Figure 2-4) shows a decrease in creek flow from 90 to 55 cfs between the Highway 12 bridge in East Helena (site PPC-7) to Canyon Ferry Road (site SG-16), a distance of roughly 3 miles. This represents a loss of about 35 cfs or 15,700 gpm, the majority of which recharges the underlying groundwater system. In September 2013, the measured streamflow loss was approximately 11 cfs across the same reach, or about 5,000 gpm (Table 2-1). Similarly, 2013 streamflow monitoring by Lewis and Clark County (unpublished data) showed consistent streamflow losses between the former smelter and Canyon Ferry Road. Using creek stage data collected from Tru-Track monitoring equipment, daily mean streamflow values from July 13 through November 7, 2013 showed an average loss of 11 cfs (approximately 5,000 gpm) from a monitoring station upstream of the former smelter (Kleffner Ranch) to Canyon Ferry Road. The maximum difference in daily mean discharge values from the Kleffner Ranch to Canyon Ferry Road sites in 2013 was a 30 cfs loss (about 13,500 gpm), and the minimum difference was 0.5 cfs (about 220 gpm).

Leakage and associated groundwater mounding beneath the creek imparts a strong influence on groundwater flow and contaminant plume migration patterns north of the former smelter. Potential changes in Prickly Pear Creek flow and leakage rates could result from: changes in current instream leasing agreements; relocation of Wilson Ditch (or other) points of diversion; reduced evapotranspiration due to partial dewatering of Upper Lake marsh; changing groundwater/ surface water interactions associated with lowering of the PPC channel adjacent to the former smelter; and future drought or other climatic conditions. All of these potential influences, some acting to increase and some decrease future streamflow, have the potential to influence future groundwater flow and plume migration patterns, and have been considered in development of the proposed CGWA boundaries.

Wilson Ditch is an unlined irrigation ditch which previously conveyed irrigation water from Upper Lake northwestward to the Burnham Ranch in the Helena Valley (Figure 2-4). Historically, leakage from Wilson Ditch recharged groundwater west of the former Smelter and along the west side of Lamping Field. In conjunction with the Upper Lake dewatering program, Wilson Ditch has not been operational since the end of the 2011 irrigation season, and use of the ditch to deliver Prickly Pear Creek water has been discontinued. Similar to Prickly Pear Creek, leakage from Wilson Ditch (Appendix A) resulted in seasonal groundwater mounding along the west side of the former smelter and Lamping Field, limiting the westward migration of the groundwater plumes in this area. The effects of the discontinued use of Wilson Ditch on future groundwater flow and plume migration patterns has been evaluated through various hydrologic analyses and groundwater flow modeling, and has been accounted for in establishing the proposed CGWA boundaries (Section 4).

Based on June 2010 synoptic streamflow monitoring, Wilson Ditch lost approximately 0.80 cfs (about 350 gpm) in the 3,600-foot long reach between the former smelter and Highway 12, and about 0.6 cfs (270 gpm) north of Highway 12 (Table B-1). Based on the 2010 data, total leakage from Wilson Ditch between the former smelter and the north end of Lamping Field was about 600 to 650 gpm during the irrigation season. The 2011 synoptic data for Wilson Ditch indicate total leakage of about 350 to 500 gpm between the former smelter and site WD-25 (about 600 feet north of Seaver Park).

Similar to Prickly Pear Creek, leakage from Wilson Ditch resulted in seasonal groundwater mounding along the west side of Lamping Field, limiting the westward migration of the groundwater plumes in this area. The effects of discontinuing the use of Wilson Ditch on future groundwater flow and plume migration patterns has been evaluated through various hydrologic analyses and groundwater flow modeling, and has been accounted for in establishing the proposed CGWA boundaries.

TABLE B-1. WILSON DITCH SYNOPTIC STREAMFLOW MEASUREMENTS

Site ID	Location	Flow- cfs			
		6/14/10	8/10/10	7/13/11	9/9/11
WD-2	At Plant Site Boundary	4.01	3.78	4.9	4.26
WD-4	Center of Manlove Subdivision	nm	3.13	4.6	3.5
WD-3	Immediately north of Highway 12	3.17	2.97	3.6	3.16
WD-25	Approximately 600 ft north of Seaver Park	nm	3.13	4.0	3.14
WD-26	2500 feet downstream (north) of WD-25	2.57	nm	nm	nm

Notes: Locations shown on Figure 2-4.
nm – not measured

As shown in Figure 2-4, the Helena Valley Irrigation Canal is located about two miles north of the former smelter and within the area of the groundwater plumes. Briar and Madison (1992) estimated an average leakage rate of 0.63 cfs (280 gpm) per mile for the Helena Valley Irrigation Canal based on synoptic streamflow measurements collected along the entire canal length. Hydrometrics collected synoptic streamflow measurements on the segment of canal crossing the groundwater plumes to better define canal leakage, and possible effects on groundwater flow and contaminant migration in the downgradient plume area. Seasonal flow measurements collected on the canal upstream (east), directly above, and downstream of the plumes in 2011 and 2012 are shown in Table B-2, with measurement sites shown on Figure 2-4. Differences in the upstream and downstream flow measurements were largely within the flow measurement margin of error (+/-10%), meaning the canal leakage rate (and associated groundwater recharge) in the vicinity of the plumes could not be quantified. However, the section of canal crossing the plume area is partially lined with asphaltic membrane, meaning that the actual leakage rate in this area is likely less than the 0.63 cfs/mile estimated for the entire 53 mile canal length.

TABLE B-2. HELENA VALLEY IRRIGATION CANAL MEASURED FLOWS NORTH OF EAST HELENA FACILITY

Date	Upstream Flow-cfs (Site HVIC-3)	Mid-Reach Flow-cfs (Site HVIC-1)	Downstream Flow-cfs (Site HVIC-2)	Difference
5/19/2011	NM	151	157	+4%
7/18/2011	NM	158	153	-3%
9/9/2011	NM	130	127	-2%
6/12/2012	185	NM	191	+3%
7/23/2012	162	NM	174	+5%

Notes: Flow locations shown on Figure 2-4.
Measurement error estimated to be +/-10%.

1.2.3 Groundwater Flow Patterns

Figure 2-5 shows a map of the valley-fill aquifer potentiometric surface within the proposed CGWA. The map was produced from groundwater level measurements from the more than 200 monitoring wells and piezometers included in the East Helena Facility groundwater monitoring program, and surveyed stage elevations along Prickly Pear Creek. Consistent with the regional potentiometric surface and groundwater flow patterns (Figure 2-1), the local groundwater flow direction is generally from the valley margin on the south, northward towards the Helena Valley and ultimately towards Lake Helena, the regional groundwater drain. Primary points of interest in the local potentiometric map include:

- The effect of leakage from Prickly Pear Creek on the potentiometric surface is evident from the map. The northward bulge in the potentiometric surface extending from the former smelter northward through Lamping Field (to about the 3820 potentiometric contour) represents groundwater mounding due to leakage from the creek. This northwestward-oriented groundwater mound or ridge influences groundwater flow directions along the west side of the creek, and is responsible in part for the northwestward groundwater plume trajectory.

- North of the 3820 potentiometric contour, groundwater mounding is greatly reduced. The reduced mounding could indicate a reduction in creek leakage, but is believed to primarily be the result of groundwater drainage associated with a nearby gravel pit. As shown on Figure 2-5, a perimeter drain is located along the gravel pit floor, presumably to lower the adjacent water table to facilitate prior mining operations (the pit is no longer active). Based on field measurements, the perimeter drain flow rate has varied from 2 to 3 cfs (900 to 1350 gpm) perennially. Groundwater drainage through the perimeter trench is believed to be responsible, at least in part, for dissipation of the groundwater mound in this area, which in turn imparts controls on the selenium plume orientation. Dissipation of the groundwater mound causes the groundwater flow direction (and the selenium plume) to veer northward beneath the creek. As a consequence, future changes in the gravel pit groundwater drain system may have implications for future plume migration patterns, and has been considered in development of the proposed CGWA boundaries.
- As shown on both the local potentiometric map (Figure 2-5) and the regional Helena Valley aquifer map (Figure 2-1), groundwater west and southwest of the former smelter flows in a northeasterly direction. This influx of groundwater from the southwest acts to buttress groundwater flow on and north of the former smelter (i.e., in Lamping Field), limiting westward groundwater flow and plume migration, even in the absence of Wilson Ditch leakage. The groundwater flow from the southwest is also believed to contribute to the elevated arsenic concentrations in the vicinity of the proposed CGWA as discussed below.

The area hydrogeology as described above, coupled with the groundwater chemistry and plume information presented below, forms the framework for the East Valley CGWA boundaries and provisions outlined in the following sections.

1.3 FORMER SMELTER GROUNDWATER PLUMES

As noted above, two groundwater plumes, one containing elevated concentrations of arsenic and the other selenium, originate from the former East Helena smelter (former smelter) and extend north-northwest towards the Helena Valley (Figure 2-6). The groundwater plumes originate from leaching of contaminants (i.e., arsenic and selenium) from plant site soils and/or smelter debris or smelting byproducts. Once partitioned from soil to groundwater, the contaminants migrate with groundwater following the general direction of groundwater flow.

The rate and spatial extent of contaminant migration (i.e., spatial extent of plumes), is based on the source mass, source status (historic or current), groundwater flow rates, patterns and mixing with other groundwater sources (dilution/dispersion), and the chemical behavior of the contaminant (attenuation). Generally, arsenic is considered to be a "non-conservative" contaminant meaning it readily adsorbs to soil or precipitates out of solution as a secondary mineral, whereas selenium is more conservative and tends not to adsorb or precipitate from solution. These distinctive geochemical characteristics explain the relatively limited extent of the arsenic plume, extending approximately 1,500 feet north of Highway 12 (based on the 10 µg/L arsenic MCL contour), as compared to the selenium plume which extends more than 3 miles northwest of Highway 12 (based on the 50 µg/L selenium MCL contour, Figure 2-6).

The groundwater plume patterns, particularly the larger selenium plume, closely mimic the general groundwater flow patterns. As shown in Figure 2-6, the selenium plume is relatively long and narrow, extending about 15,000 feet north of Highway 12 and only 1,500 feet wide at its maximum. The plume extends to the north-northwest through Lamping Field paralleling Prickly Pear Creek for most of its length, before turning due north and crossing under the creek. The plume migration pattern through and north of Lamping Field is largely controlled by leakage from and associated groundwater mounding beneath Prickly Pear Creek. Near the Wylie Drive gravel pits, the groundwater mound beneath the creek dissipates, due at least in part to a groundwater drainage trench associated with the gravel pits (Figure 2-5). Dissipation of the groundwater mound in this area allows the groundwater to flow in a more northerly direction (towards the Lake Helena regional groundwater drain) resulting in the northward turn in the selenium plume.

Also shown on Figure 2-6 is an additional area of elevated arsenic west of the former smelter referred to as the west arsenic area plume. The west arsenic plume is believed to be attributable, at least in part, to source(s) other than the former smelter. Based on current information, the most likely source appears to be naturally occurring "background" arsenic originating from the Tertiary volcaniclastic sediments, with possible contributions, either current or historic, from the former smelter and related features.

1.3.1 Plume Status

Of primary interest to the East Helena site cleanup as well as the CGWA is the current status of the plumes in terms of their stability (i.e., are the plumes advancing, receding or in equilibrium). The groundwater arsenic plume originating from the former smelter was identified during the earliest environmental investigations at the site in the early 1980s. Since that time, groundwater sampling has been conducted under various programs, typically at a minimum frequency of semiannually, with additional monitoring wells installed as part of ongoing efforts to track and monitor the contaminant plume. Thus, a significant data record for groundwater arsenic concentrations has been established and the status of the arsenic plume is relatively well-defined. While the plume has expanded into East Helena over time, the current extent as defined by the 10 µg/L MCL contour on Figure 2-6 has remained relatively stable for the past eight to ten years. The primary (highest concentration) arsenic plume extending into the northwest corner of East Helena (Figure 2-6) is characterized by substantial decreases in groundwater arsenic concentration over very short distances; near the leading edge of the plume, current data indicates arsenic concentrations decrease from nearly 5 mg/L to less than 0.002 mg/L over a distance of approximately 500 feet. This behavior is likely due to strong attenuation of arsenic through adsorption and/or coprecipitation reactions with aquifer material, which has been identified as a key control on arsenic fate and transport at the site through adsorption and leach testing, as well as through examination of arsenic trends and spatial distribution in groundwater. Although some expansion of the groundwater arsenic plume may occur in the future, and trends within the plume will likely vary, in general the overall extent of the plume should be constrained as a result of geochemical attenuation.

The groundwater selenium plume originating at the former smelter was identified more recently than the arsenic plume, and much of the recent site investigation work at the site has been focused on characterizing the nature and extent of selenium concentrations in groundwater. In contrast with arsenic, selenium is generally relatively mobile in groundwater, with limited attenuation except under highly reducing conditions. This mobility has resulted in the generation of the long and narrow selenium plume, extending from the plant site more than 1.5 miles northwest of U.S. Highway 12 as noted above and shown on Figure 2-6. Data collected over the last five to seven years has defined the spatial extent of the groundwater selenium plume, and the area where the 50 µg/L MCL is exceeded has remained consistent over that period. However, the period of record for selenium in groundwater is significantly shorter than that for arsenic, so the uncertainty regarding the selenium plume status is therefore greater. In addition, data from monitoring wells throughout the selenium plume (both closer to the former smelter and further downgradient) have shown significant seasonal variability in selenium concentrations, likely due to slight shifts in plume direction related to seasonal water level fluctuations. Given the overall mobility demonstrated by selenium in the groundwater system, some additional plume expansion is possible. Remedial measures (interim and corrective measures) intended to mitigate migration of both arsenic and selenium from the plant site are outlined in Section 6.

1.4 CONTAMINANT SOURCES

The primary groundwater contaminants of concern for the East Valley CGWA are arsenic and selenium. Contaminated soils on the former smelter property are a significant source of selenium loading to groundwater, and the only identified source of selenium loading to groundwater within the proposed CGWA, although the presence of other unidentified sources is possible. Extensive site investigation has also documented significant arsenic loading to groundwater from the former smelter soils. Unlike selenium however, the former smelter is not believed to be the only source of arsenic contamination within the proposed CGWA; west of the smelter site, some arsenic loading to groundwater is believed to occur via naturally occurring arsenic in the Tertiary sediment uplands. Following is a summary of smelter and non-smelter related contaminant sources affecting water quality within the CGWA.

1.4.1 Former Smelter-Related Contaminant Sources

The groundwater plume maps (Figure 2-6), along with the groundwater potentiometric map and flow patterns (Figure 2-5) clearly convey the relationship of the main groundwater plumes to the former smelter. Groundwater originating on and south of the former smelter flows north/northwestward through contaminated plant site soils, releasing soil-borne contaminants to groundwater. Contaminant source areas on the former smelter have been characterized through a number of studies including the Comprehensive RI/FS (Hydrometrics, 1990), the Phase I RFI (ACI, 2005), and the Phase II RFI (METG, 2011). Documented groundwater contaminant source areas, either current or historic, include: acid plant area soils; speiss/dross area soils; and the South Plant including Tito Park and the Acid Plant sediment drying area. Other potential contaminant source areas include the west plant site where the highest selenium groundwater concentrations (up to 7 mg/L) within the CGWA originate, and the slag pile, although the magnitude and/or mechanisms for contaminant loading from these source areas is not as well documented. Once released to groundwater, the contaminants travel with groundwater to the north/northwest, resulting in the current arsenic and selenium smelter plume configurations shown in Figure 2-6. The general relationship of the downgradient groundwater plumes and the former smelter source areas is well documented, and is the focus of the current East Helena Facility CMS cleanup program.

1.4.2 Non-Facility Related Contaminant Sources

In addition to the downgradient arsenic and selenium plumes associated with the former smelter is an area of elevated groundwater arsenic concentrations west of the smelter (west arsenic plume or area, Figure 2-6). Despite its proximity to the former smelter, the elevated arsenic concentrations west of the former smelter are believed to be related, at least in part, to other sources. Evaluation of potential source(s) of the west arsenic area plume has included review of groundwater flow patterns and water level trends, review of groundwater chemistry, and groundwater flow particle tacking through use of the smelter cleanup project numerical groundwater flow model. Although much smaller in magnitude than the contaminant plumes originating from the former smelter, arsenic loading from the west arsenic area contributes to groundwater quality exceedances in the southwestern portion of the CGWA, and delineation of the CGWA boundaries. The west arsenic area is also of importance since it is believed to be a contributing factor to elevated arsenic concentrations in several private water wells in and around the Seaver Park subdivision. Following is a discussion of points of evidence indicating the west arsenic plume is derived, at least in part, from non-smelter related sources.

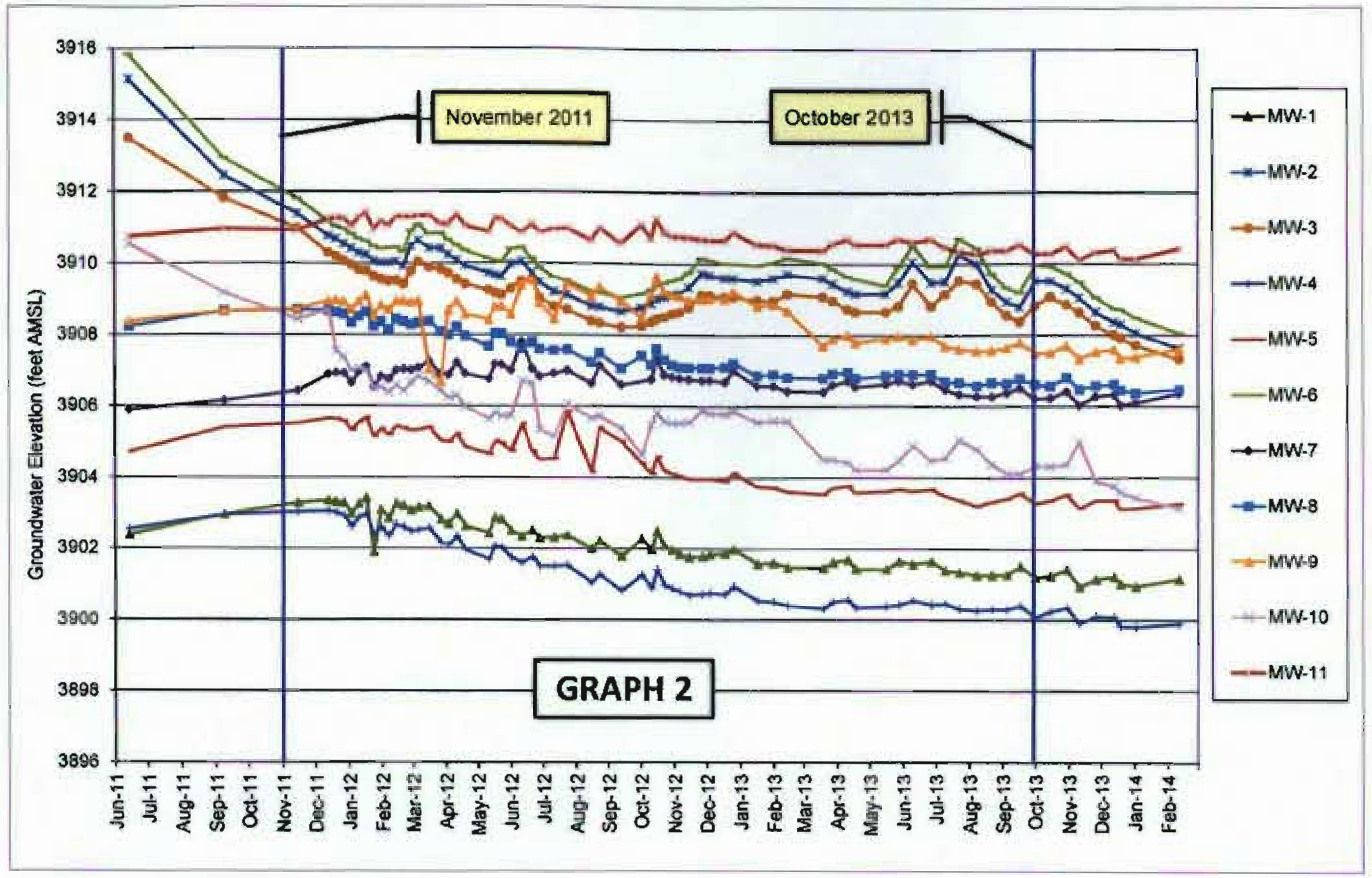
1.4.2.1 Groundwater Flow Patterns and Hydrographs

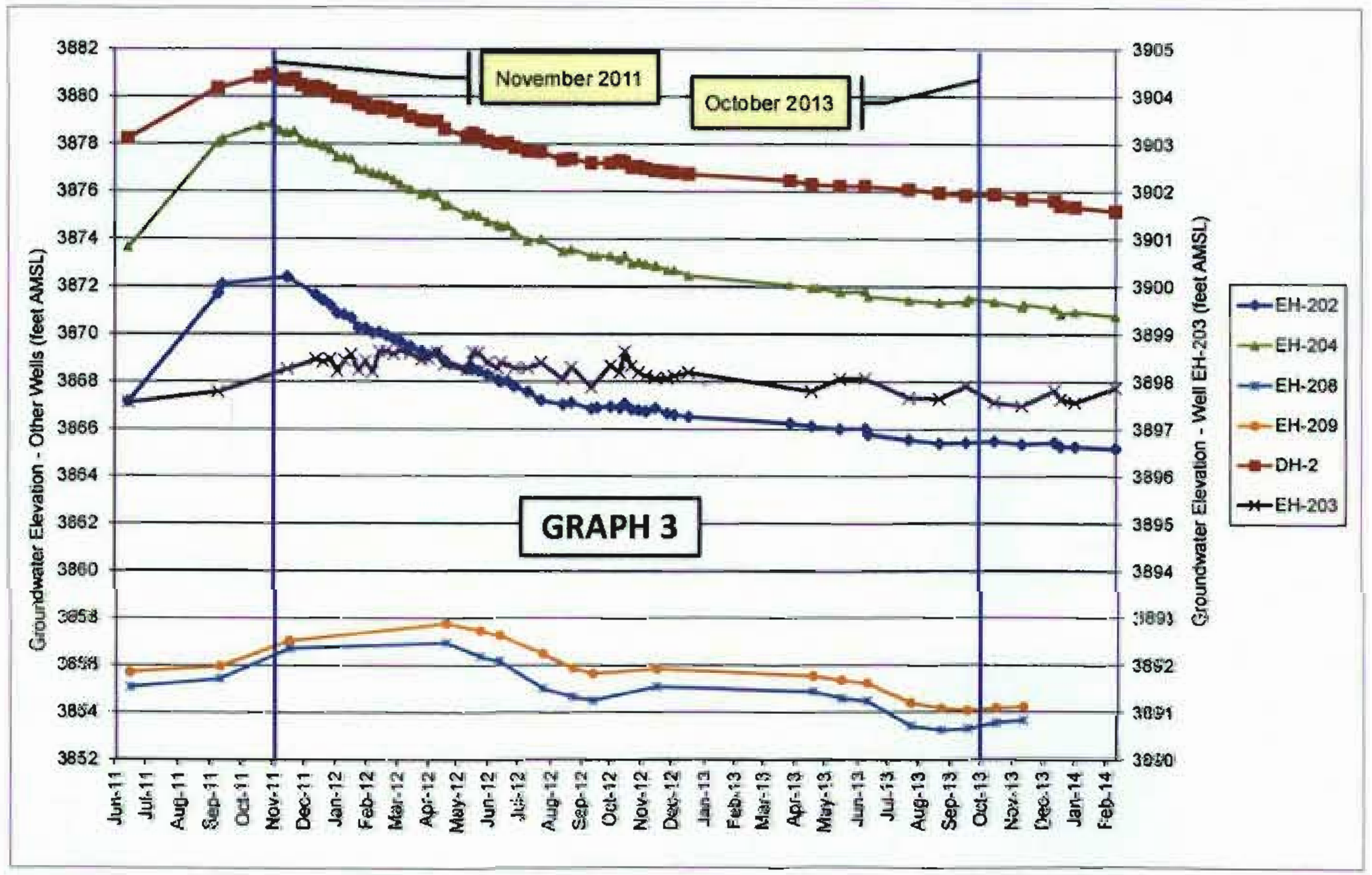
Groundwater levels have been recorded on and around the former smelter as part of the regular groundwater monitoring program and the Upper Lake drawdown test (Appendix A). The groundwater level data, plotted as groundwater elevation versus time (i.e., hydrographs), can be used to identify areas with similar water level fluctuation patterns, indicating potential hydraulic connections between different wells or areas. Of particular interest in delineating the source(s) of arsenic west of the smelter is the correlation between the smelter well hydrographs and those in the west arsenic area. A close correlation between the smelter and west arsenic area water level trends could indicate a hydrologic connection, and potential arsenic transport, from the former smelter to the west. Figure B-2 shows groundwater level hydrographs for Upper Lake, smelter monitoring wells DH-20 and DH-71, and a number of wells located west of the smelter. Representative groundwater arsenic concentrations are also shown for the wells on Figure B-2. The smelter wells are completed in Prickly Pear Creek alluvial sediments while the west area wells are completed in Tertiary sediments.

As shown on Figure B-2, water level trends at most west area wells differ from the water level trends at Upper Lake and the smelter wells. Graph 1 on Figure B-2 includes hydrographs for Upper Lake and the smelter wells which all show a distinct water level decline with the onset of Upper Lake dewatering in November 2011, and with diversion of Prickly Pear Creek in October 2013. Water level fluctuations between these points are attributable to temporary changes in the Upper Lake and/or Prickly Pear Creek water levels (Appendix A). These hydrographs represent the smelter plant site water level signature. Graph 2 includes hydrographs for 8 of the 11 CAMU area monitoring wells, which all exhibit a different pattern than the smelter wells. Water levels at these wells do not follow the distinctive pattern of declining water levels with the November 2011 onset of Upper Lake dewatering or October 2013 creek diversion, or the intermediate water level patterns. The Graph 2 wells show little or no overall change in groundwater levels from mid-2011 through early 2014, suggesting little or no interaction with the plant site groundwater system, despite the presence of arsenic in all of these wells. For example, monitoring well MW-11 water levels have been relatively unchanged since the onset of Upper Lake dewatering, while arsenic concentrations at this well have been 15 to 19 µg/L since the well was installed in May 2007.

In addition to the smelter hydrographs, Graph 1 includes CAMU area wells MW-2, MW-3, and MW-6 which show trends similar to the smelter wells. These trends suggest a possible hydrologic connection between south plant site groundwater and groundwater in the vicinity of MW-2, -3 and -6. Since completion in 2000, arsenic concentrations at MW-2 and -3 have consistently been in the 8 to 14 µg/L range, while concentrations at MW-6 have varied from 16 to 200 ug/L over time (current concentration about 50 ug/L). Although water level patterns at all three wells are similar to the smelter hydrographs, the arsenic concentrations suggest that water quality influences from the plant site may be limited to MW-6.

Graph 3 includes hydrographs for monitoring wells DH-2 and EH-202, -203 and -204 located along the west side of the former smelter, and wells EH-208 and -209 located further to the northwest near Seaver Park (Figure B-2). Although hydrographs from wells DH-2, EH-202 and EH-204 show a decrease in water levels after the November 2011 onset of Upper Lake dewatering, the succeeding water levels do not correlate closely with the plant site hydrographs.





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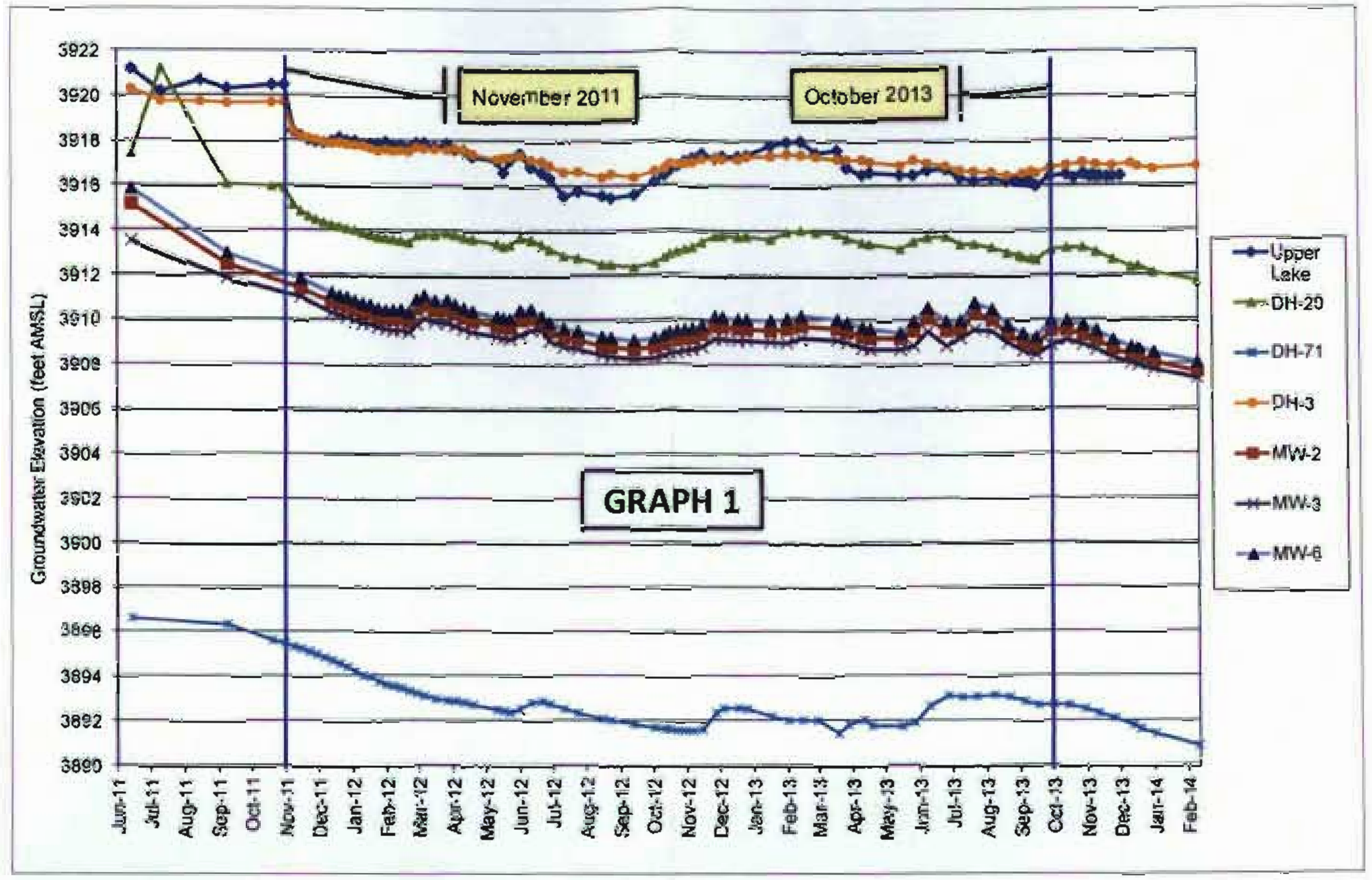
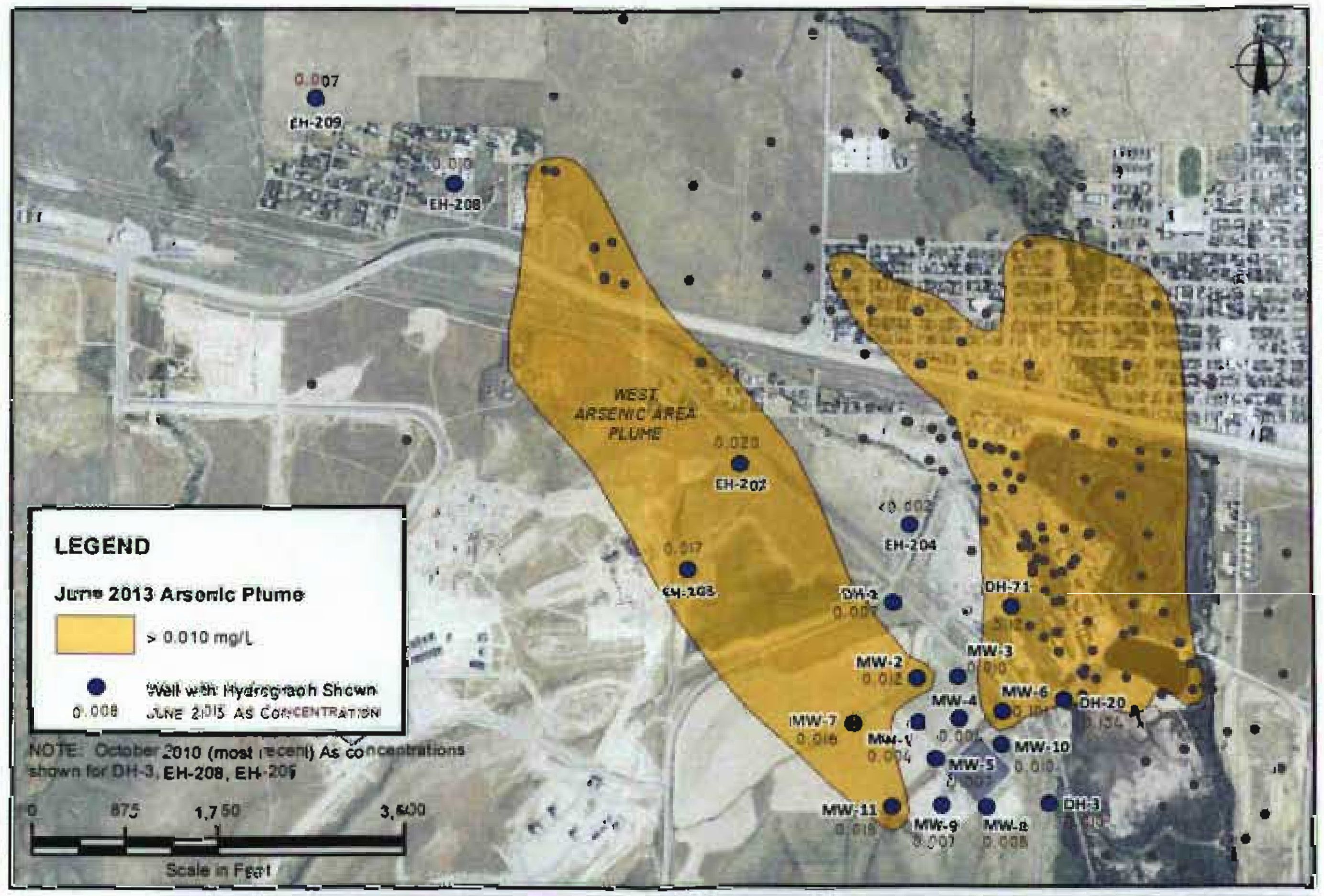




PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	GROUNDWATER HYDROGRAPHS ON AND WEST OF THE FORMER SMELTER	FIGURE B-2

This information suggests a potential although attenuated hydrologic connection between these wells and the plant site. It should also be noted that arsenic concentrations in wells DH-2 and EH-204 are relatively low (less than 10 μg/L; see Figure B-2). The hydrograph from monitoring well EH-203, located further to the south and west, shows no correlation with the plant site hydrographs, despite arsenic concentrations consistently in the 16 μg/L range at this well. Finally, the hydrographs from Seaver Park area wells EH-208 and -209 show no apparent correlation with the Upper Lake or plant site groundwater hydrographs. Although arsenic concentrations in these two wells are equal to or less than 10 μg/L, a number of private wells in this area do contain arsenic concentrations greater than the 10 μg/L human health standard.

In summary, the water level data described above shows that some wells located west of the plant site exhibit similar water level trends as Upper Lake and the smelter wells, while the majority of these wells do not. Furthermore, arsenic concentrations west of the former smelter show no correlation with the water level trends, with several wells exhibiting no correlation with the smelter well hydrographs containing the highest arsenic concentrations in the area (i.e., MW-11, EH-203). This information suggests that, although groundwater from the former smelter may be influencing water quality immediately west of the site (i.e., MW-6), water quality throughout most of this area is influenced by other source(s). The presence of a separate source of arsenic west of the former smelter is supported by the geochemistry data and groundwater modeling results as discussed below.

1.4.2.2 <u>Groundwater Chemistry Evaluation</u>

Exhibit 3 shows a comparison of general groundwater geochemistry within and surrounding the former smelter, using Stiff diagrams to summarize major ion composition. Stiff diagrams provide a visual means of comparing the relative proportions of various major ions in a groundwater sample (calcium, magnesium, sodium, potassium, chloride, bicarbonate, and sulfate) by plotting concentrations of these constituents along parallel axes, and creating a polygon from the plotted points. Major ion concentrations are typically plotted in units of milliequivalents per liter (meq/L). The shape of the resulting polygon allows visual comparison of water quality types (i.e., which major ions are predominant) spatially and/or temporally. Exhibit 3 was constructed using groundwater data collected prior to October 2011, when water level manipulations were initiated in Upper Lake on the south end of the plant site, potentially altering groundwater flow directions. In general, most of the Stiff diagrams depicted on Exhibit 3 show major ion chemistry observed from August 2009 through September 2011, with most samples collected in October 2010.

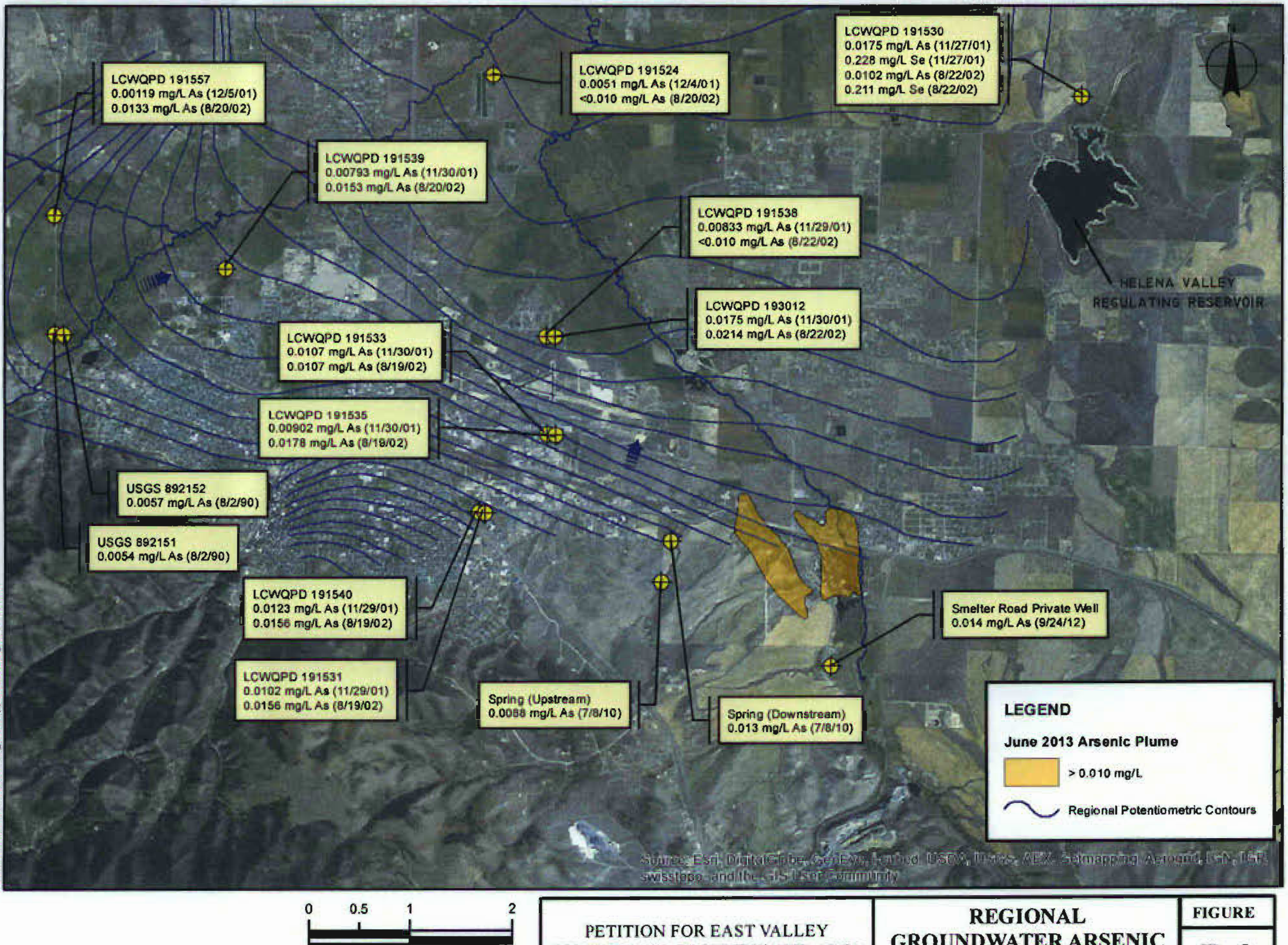
While there is no "standard" classification system for water types and Stiff diagram polygon shapes, the diagrams shown on Exhibit 3 closely follow the scheme developed for the Helena Valley by the Lewis and Clark County Water Quality Protection District (Swierc, 2013). Different water types, illustrated by different Stiff diagram polygon shapes, are emphasized on

Exhibit 3 by the use of different fill colors. Exhibit 3 also shows the outlines of the June 2013 arsenic plume at the MCL level (10 µg/L), and the June 2013 selenium plume at the MCL level (50 µg/L), along with a surficial geologic map.

Exhibit 3 indicates that multiple water types are present in the vicinity of the former smelter, representing a mixture of ambient groundwater quality from various aquifers and historically-impacted groundwater from the plant site. To the west, multiple monitoring wells show a magnesium-calcium bicarbonate water type, including wells EH-200, EH-201, EH-209, and EH-139. This water type (shown in purple on Exhibit 3) is typical of water derived from Spokane formation bedrock, as shown by the comparison with the Stiff diagram for a Spokane formation well reported in Thamke (2000). A spring located in the drainage southwest of wells EH-200 and EH-201 (the R&D Spring) also showed the magnesium-calcium bicarbonate water type in July 2010, along with a detectable arsenic concentration of 9 µg/L. A selection of LCCWQPD wells located west of the former smelter show mixed water types, with no consistent major ion proportions apparent (yellow polygons on Exhibit 3). These wells have all shown arsenic concentrations exceeding the 10 µg/L human health standard during past monitoring events (Figure B-3).

As previously discussed, arsenic concentrations in monitoring wells and private wells within the west arsenic area typically range from about 10 to 20 µg/L. Concentrations of this magnitude persist south (upgradient) of the facility as well, based on data from monitoring well DH-3 (Figure 2-7) and a private well on Smelter Road (Figure B-3). With the exception of CAMU well MW-6 (which shows a hydrograph similar to plant site wells as discussed above), arsenic concentrations in west arsenic area wells are also remarkably consistent over time, showing little seasonal or other long-term variability.

Mixed water types are present in the western arsenic area (Exhibit 3), including calcium-magnesium bicarbonate (green polygons), mixed cation bicarbonate (tan polygons), and mixed cation bicarbonate-sulfate (red polygons). Two of the CAMU wells display more unusual Stiff diagram shapes: well MW-7 shows a sodium bicarbonate signature (light blue), and well MW-11 shows a mixed cation (sodium-calcium) and mixed anion (bicarbonate-sulfate) type. The most prevalent water chemistry type in the western arsenic area appears to be the mixed cation bicarbonate and mixed cation bicarbonate-sulfate types (tan and red polygons). While the major ion data summarized on Exhibit 3 is not conclusive regarding the source of arsenic west of the former smelter, the differing water types, with most distinct from the smelter groundwater signature, and the presence of arsenic concentrations consistently above the 10 µg/L MCL as far south as the Smelter Road private well and as far west as monitoring well EH-203 (Figure 2-7), support the presence of a "background" component to the observed distribution of arsenic in groundwater.



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PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	REGIONAL GROUNDWATER ARSENIC CONCENTRATIONS	FIGURE B-3

1.4.2.3 Numerical Model Simulations

In addition to the hydrologic and geochemical data analyses, the numerical groundwater flow model was used to evaluate the source of arsenic west of the former smelter. Using the three dimensional transient flow model (Newfields, 2014), various model simulations were run to assess the source of groundwater in the west arsenic area. Reverse particle tracking was used to simulate groundwater flowpaths to the west area wells with elevated arsenic concentrations. For all of the wells west of the smelter, the model results show that the source of groundwater to these wells, including the CAMU area monitoring wells, is from southwest of the wells and not from the former smelter (Figure B-4). The full groundwater modeling results are included in Appendix C.

In summary, a considerable volume of data and information indicates a source of arsenic in groundwater west of the former smelter, including the Seaver Park area, other than the former smelter property. Evidence includes:

- Elevated arsenic concentrations in west area monitoring wells exhibiting no correlation in water level trends with smelter site monitoring wells, suggesting a lack of groundwater interaction between these wells;
- Elevated arsenic concentrations in west area monitoring wells with differing general groundwater chemistry than smelter site wells, suggesting a different source of recharge, and arsenic, to these wells; and
- Numerical groundwater modelling results indicating that all wells west of the former smelter are recharged by groundwater originating from the southwest, not from the former smelter site to the east.

Finally, the most compelling evidence for a non-smelter related source of arsenic in the west arsenic plume area is the presence of elevated arsenic concentrations in groundwater hydrologically upgradient of the former smelter, including monitoring well DH-3 located on the west side of Upper Lake (9 to 14 μg/L, Figure 2-7), a Smelter Road residential well located south of the former smelter (9 to 16 μg/L, Figure 2-7), and the R&D spring located southwest of the former smelter (9 μg/L, Figure B-3).

Source: NAIP, 2011; METG, 2011

0 Feet 2,200

NewFields

Particle Track

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

- Ditch
- Facility Boundary
- Lumping Field
- Burnham Ranch
- Model Domain

FIGURE B-4
2011 REVERSE PARTICLE TRACKS
FORMER ASARCO EAST HELENA FACILITY
EAST HELENA, MONTANA

APPENDIX C

NUMERICAL GROUNDWATER FLOW MODEL EVALUATIONS

NewFields
Perspective. Vision. Solutions.

Technical Memorandum

To:	Bob Anderson, Hydrometrics	Project:	350.0024
From:	Cam Stringer and Joel Jacobson	cc:	Lauri Gorton, METG
Tel:	(406) 549-8270		
Date:	July 16, 2014		

Subject: Advective transport modeling to support petition for a Controlled Groundwater Area Application, East Helena Site

1.0 INTRODUCTION

This memorandum documents modeling performed to support a petition for a Controlled Groundwater Area downgradient of the former Asarco smelter (Facility) located near the City of East Helena, Montana. Groundwater monitoring in and around the Facility has delineated areas of elevated arsenic and selenium that extend north and northwestward from the Facility (METG, 2011). Particle tracking techniques were used to evaluate potential flow paths and assist in delineation of buffer zones around the existing arsenic and selenium plumes that may be necessary to protect human health and the environment. AMEC (2012) and NewFields (2013) document the design and calibration of a groundwater flow model that was used as the base for work described below.

Objectives of the work described in this memorandum include:

- Determine if detectable concentrations of arsenic in wells west of the Facility are wholly or in part attributable to contamination from the Facility.
- Determine the potential vertical extent of elevated selenium concentrations north of Lamping Field.
- Evaluate the potential effects of removing Wilson Ditch on selenium and arsenic plume migration.
- Perform capture zone analysis for hypothetical wells placed near the selenium plume to help define a buffer zone around the plume.

Referenced figures are attached.

2.0 GENERAL METHODS

Three steady-state groundwater flow simulations were used for the evaluation. The simulations were calibrated to groundwater elevation data representing the period simulated. The simulations are summarized below:

- Pre-slurry wall – Calibrated to average 2002 to 2005 groundwater elevations representing the period after plant shutdown and before construction of the Acid Plant and Speiss/Dross slurry walls;

- 2011 – Calibrated to average 2011 groundwater elevations, representing an exceptionally high spring runoff year and conditions prior to Upper Lake drawdown and with Wilson Ditch still in operation; and
- 2013 – Calibrated to average of January through August groundwater elevations representing post-Upper Lake drawdown period with Wilson Ditch turned off.

In addition, a transient predictive simulation representing flow conditions for the next 20 years was used to assess the affects turning off Wilson Ditch on selenium plume migration downgradient of the Facility. The transient simulation is based on a combination of predictive scenarios described in NewFields (2014). The current conditions scenario from NewFields (2014) was run for 1 year, followed by the bypass construction scenario for 2 years, followed by Prickly Pear Creek realignment scenario for 17 years.

The different simulations were used to evaluate potential changes in flow and advective transport related to changes in groundwater flow conditions over time.

Particle tracking techniques were used to evaluate potential changes to the selenium plume over time and help define a buffer area around the plume. The purpose of the buffer zone is to account for uncertainty in the exact extent of the plume and potential effects of new pumping wells installed nearby on plume migration.

MODPATH (Pollock, 1994) was used for particle tracking analysis. MODPATH is a three-dimensional particle tracking code that uses groundwater velocity vector fields generated from MODFLOW head output to simulate advective transport in a groundwater system. Advective transport is the bulk movement of a solute through the aquifer at the average linear velocity of groundwater. Advective transport modeling by particle tracking does not take into account the effects of dispersion, adsorption, or biodegradation, and assumes that dissolved contaminants move at the same velocity as groundwater. Particle tracking involves tracing the movement of infinitely small imaginary particles in a groundwater flow field based on groundwater velocities and direction. Particles are given a starting location and traced for a defined time period. The movement of each particle produces a path line (particle track), a general term used to refer to a groundwater flow path (Anderson and Woessner, 1992).

There are two types of particle tracking, reverse and forward. In reverse particle tracking, particles are placed in a flow field and tracked backward (opposite direction of groundwater flow) along path lines to a source. Reverse particle tracking can be used to help identify sources of groundwater or contamination to a well. For example, particles may be placed in a flow field at the location of a screened interval for a well and the model run using reverse particle tracking. The resulting path lines indicate the source of groundwater for the well. In forward particle tracking, particles are placed in a flow field and tracked forward in the direction of groundwater flow. Forward particle tracking is useful for predicting the direction and three-dimensional path of groundwater flow or contamination movement. For example, if a spill were to occur at a given location, the hypothetical particles could be placed in a flow field around the source and the model run using forward particle tracking. The resulting path lines would show the likely path of contaminant transport away from the source.

3.0 RESULTS

The following subsections describe particle tracking simulations and results.

3.1 Potential Westward Flow from the Facility

Several monitoring and residential wells west and northwest of the Facility exhibit arsenic concentrations greater than 0.005 milligrams per liter (mg/L) with some wells exceeding 0.01 mg/L, the maximum contaminant level (MCL) drinking water standard. The locations of these wells are shown on **Figure 1**. Previous studies have documented the presence of naturally occurring arsenic in this area is related to Tertiary volcanoclastic sediments, as well as other potential sources unrelated to the Facility. It is currently unclear to what degree, if any, current or historic Facility operations may contribute to elevated arsenic concentrations to the west.

Reverse particle tracking was used to evaluate potential sources of water to wells west and northwest of the Facility with arsenic concentrations greater than 0.005 mg/L. Particles were placed in the model at the approximate midpoint of the screened interval for these wells and tracked upgradient until they reached a boundary condition or unsaturated layer.

Results indicate that most groundwater in wells west of the Facility originates from Tertiary foothills southwest and west of the Facility and not from contaminant source areas at the Facility (**Figures 1** through **3**). Groundwater in well EH-142 appears to be partially derived from Prickly Pear Creek (pre-slurry wall and 2011; **Figures 1** and **2**) and recharge within the Helena Valley (2013; **Figure 3**); however, based on selenium detected in samples from this well, it is likely that some water is derived from the Facility. Particle tracks suggest that groundwater in wells EH-132, EH-139, and EH-123 originated primarily from Wilson Ditch when the ditch was operating (although EH-132 and EH-123 receive some water from Tertiary foothills) and from Tertiary foothills after the ditch is turned off. Wells MW-2, MW-3, and MW-6 responded to dewatering of Upper Lake, suggesting a potential connection between groundwater at the Facility and groundwater in these wells (Hydrometrics, 2012). However, particle tracks indicate that the source of groundwater in this area is derived at least in part from Tertiary foothills southwest of the Facility (inset in **Figures 1** through **3**).

3.2 Vertical Extent of the Selenium Plume

The vertical extent of selenium contamination in and north of Lamping Field is not fully defined. Low permeability Tertiary-age ash material south of Lamping Field (METG, 2011) prevents contamination from moving downward. However, this material has not been observed north of Lamping Field, and data suggest that contamination is able to migrate vertically in this area. In addition, lithologic logs from wells north of Lamping Field show a 10- to 20-foot thick high permeability gravel seam between 150 and 170 feet below ground surface (bgs). Wells in this gravel seam contain elevated selenium concentrations, suggesting that the gravel seam acts as a preferential flow path. No data are available to evaluate if selenium is present in groundwater deeper than these wells.

Forward particle tracking was used to evaluate the potential vertical extent of the selenium plume. Particles were placed in Layers 2 and 3 (alluvial material in the Facility) in potential source areas on the west side of the Facility (Speiss-dross, Acid Plant, and West selenium hot spot areas), where measured selenium concentrations are highest (> 1 mg/L). Particles were then traced through the aquifer for 30 years (the approximate maximum time that selenium contamination may have been present). To evaluate the effect of Wilson Ditch on vertical plume migration, both the 2011 and 2013 simulations were run.

Results suggest that selenium originating from the Facility is not present below approximately 180 feet bgs north of Lamping Field. Particle tracks are present in Layers 2 and 3 of the model with the majority of particle tracks in Layer 3 (**Figures 4** through **6**) and there are no particle tracks in Layers 1, 4, 5, and 6. Results from the 2011 and 2013 simulation were similar, suggesting leakage from Wilson Ditch did not have an appreciable effect on vertical plume migration.

These results are reflective of the model set up. The numerical model was based on the conceptual model which assumes the gravel seam (Layer 3) is relatively thin (10-20 feet) and is as deep as the bottom of the well screens in this area (i.e., EH-144D). This inhibits vertical movement of contaminated groundwater in the model. The model is capable of simulating observed heads in domestic wells and the EH-144 well set, which adds confidence to results in the upper three layers of the model.

3.3 POTENTIAL EFFECTS OF WILSON DITCH REMOVAL

Wilson Ditch historically operated and leaked water to the aquifer seasonally, which created seasonal groundwater mounding (up to 10 feet) that influenced groundwater flow and potentially affected selenium plume migration. Wilson Ditch was turned off indefinitely in October 2011. As a result, groundwater elevations decreased in the area and have remained relatively constant. In addition, selenium concentrations in wells west of the historical selenium plume have shown slight increases in concentration suggesting the plume may be migrating further to the west.

Forward particle tracking was performed using the 2011 and 2013 simulations to evaluate the potential effects of removing Wilson Ditch on groundwater flow and the selenium plume. Particles were released in Layers 1, 2, and 3 (unconsolidated alluvium) from all potential source areas in the Facility including the Slag Pile, West Selenium Area, Former Speiss/Dross Area, Former Acid Plant Area, and the South Plant.

In general, particle tracks in the 2013 simulation are shifted about 500 feet west compared to those from the 2011 simulation, when Wilson Ditch was not operating. North of the Facility, near highway 12, particle tracks shift to the west by approximately 500 feet in the 2013 simulation, when Wilson ditch is turned off (**Figure 7**). In the area around Lamping Field, particle tracks in the 2013 simulation shift approximately 250 feet and 500 feet, respectively, from those from the 2011 simulation (**Figure 7**). This is consistent with observed changes in concentrations in wells in the Lamping Field area and indicates that buffer zones considered for the Controlled Groundwater Area should be large enough to encompass this potential westward shift in groundwater flow/contaminants.

Additional forward particle tracking was performed to evaluate how much further the selenium plume could shift in the future. Particles were run through transient predictive scenarios described in NewFields (2014) assuming a year of current conditions followed by 2 years of the Prickly Pear Creek bypass channel in place, followed by 17 years following construction of the Realignment construction. Results (**Figure 7**) indicate that particles northwest of the Facility in Lamping Field shift to the west approximately 800 to 900 feet. Further north, near Prickly Pear Creek, particles shift to the west approximately 1,500 feet.

3.4 Potential Effects of New Pumping Wells

Future growth in the Helena Valley may require installing new water supply wells (domestic, production, and irrigation). It is important to determine where these wells may be located so pumping does not affect plume migration and the new wells are not contaminated.

Reverse particle tracking was used to delineate a buffer zone around the existing extent of the selenium plume such that any new wells (domestic or production) would not impact the plume. Domestic wells were placed in Layers 1, 2, and 3 and production wells were placed in Layers 1 through 4 outside of the existing selenium plume and particles were traced upgradient to determine the source of groundwater in these wells. If particle tracks originated in the plume, wells were moved laterally away from the plume until source water for the well did not come from within the plume. Because contamination moves vertically, not all groundwater from wells in Layers 1 and 2 of the model receive water from the plume; however, a conservative approach was used and it was assumed selenium contamination is present in layers 1through 4. Domestic wells were simulated with a pumping rate equivalent to 10 acre-feet per year (the maximum annual diversion volume allowed for an exempt well in Montana) and production wells were simulated with a pumping rate of 350 gallons per minute (565 acre-feet per year).

Figures 8 and **9** show the placement of hypothetical domestic and productions wells, respectively, resulting from the analysis. These results suggest that new domestic wells should be installed at least 250 feet away from the estimated extent of the selenium plume in the upgradient direction of groundwater flow and 500 feet away in the downgradient direction. New production wells should be installed at least 700 feet away from the extent of the selenium plume.

Figures 10 and **11** show recommended buffer zones for domestic and production wells, respectively. These buffer zones take into account the results of particle tracking shown in **Figures 8** and **9.** The buffer zones also take into account the potential shift of the selenium plume to the west discussed in **Section 3.3.** The distance from the edge of the selenium plume to the edge of the buffer zones fluctuates because of variability in the amount of leakage from Prickly Pear Creek to groundwater and variability in hydraulic conductivity in the aquifer. Based on results of the analysis, if a new well is completed within the buffer zones, and pumped at rates described above, it may be impacted by the selenium or arsenic plumes; if a new well is completed outside of the buffer zones, it likely will not be impacted by the plumes.

4.0 MODEL LIMITATIONS

Models are simplifications of complex systems and in all modeling exercises some model parameters are not well quantified due to a lack of data which ultimately leads to uncertainty in model predictions. The primary objective of the modeling exercise described in this memorandum was to support a petition for a Controlled Groundwater Area necessary to protect human health and the environment.

The ability of the model to predict changes in advective transport over time is limited based on uncertainty in the conceptual model and groundwater flow models (AMEC, 2012; NewFields, 2014). Where data are missing or insufficient to characterize variability in the system, conservative assumptions were made in developing model inputs based on literature values.

Calibration results demonstrate that the model is capable of simulating groundwater flow within the model area under steady-state and transient conditions and advective transport calibrations demonstrate that the model is capable of simulating flow directions under steady-state conditions.

5.0 SUMMARY AND CONCLUSIONS

Key findings of the analysis described above are summarized below:

- Most groundwater intercepted by wells west of the Facility originates from Tertiary material/bedrock southwest and west of the Facility (**Figures 1** through **3**).
- The model predicts that selenium contamination is not present below approximately 180 feet bgs north of Lamping Field. This result reflects the current conceptual model upon which the numerical model is based (**Figures 5** and **6**).
- Model results suggest that the selenium plume may shift up to 500 feet to the west if Wilson Ditch is not operated in the future (**Figure 7**).
- New domestic wells should not be installed within 250 feet of the current extent of the selenium plume (**Figure 10**) and new production wells should not be installed within 700 feet of the current extent of the selenium plume (**Figure 11**).

6.0 REFERENCES

AMEC Environment & Infrastructure, Inc. (AMEC), 2012. Draft Initial Flow Model Design and Calibration, East Helena Site. East Helena, Lewis and Clark County, Montana. Prepared for: Montana Environmental Trust Group, LLC. October.

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

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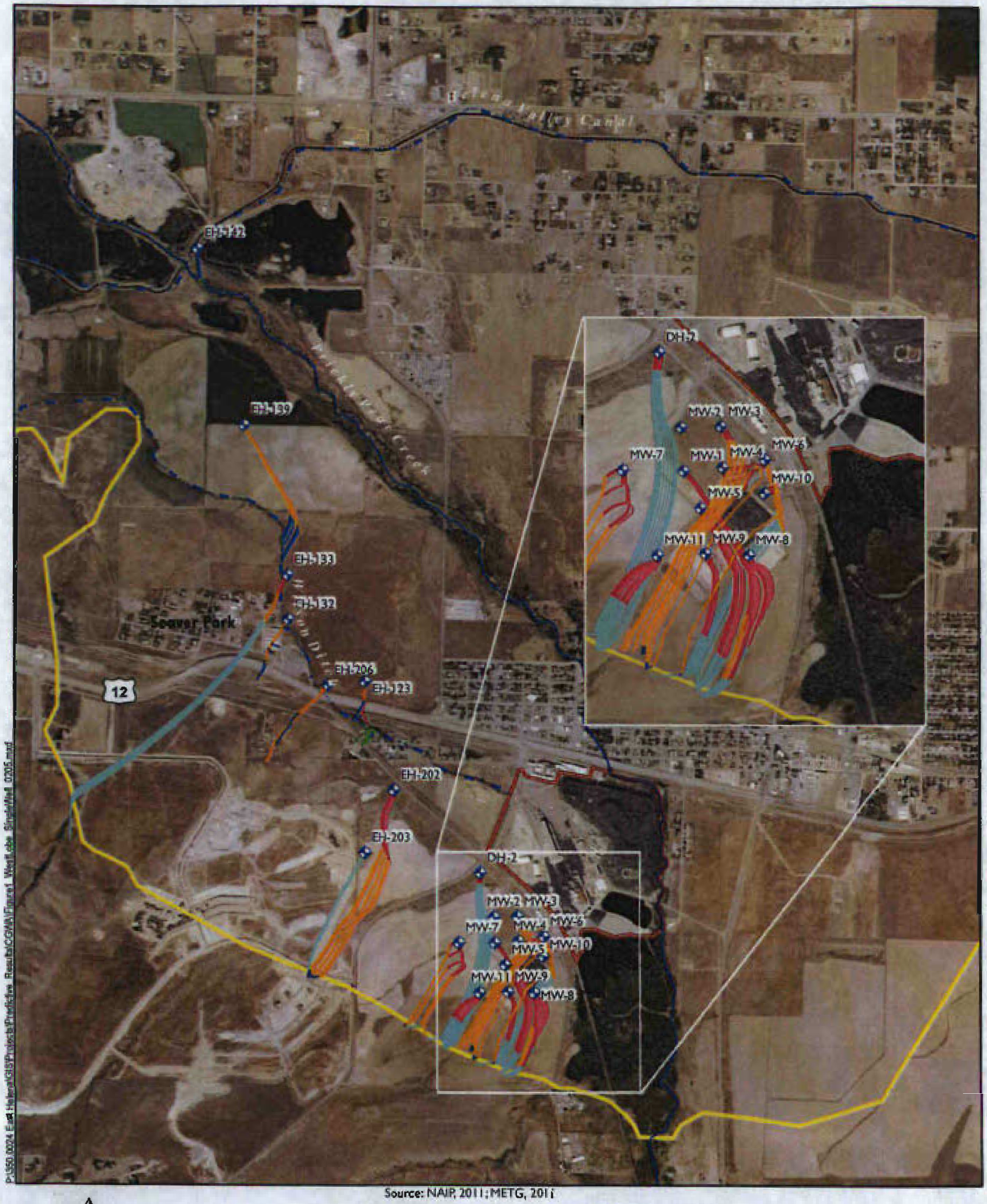
NewFields, 2014. Groundwater Flow Model Calibration Refinement, Transient Verification, and Interim Measures Support, East Helena Site. Technical Memorandum to METG. February 3. .

Pollock, D.W., 1994. User's guide for MODPATH/MODPATH-PLOT, Version 3: A particle tracking post processing package for MODFLOW, the U.S. Geological Survey finite difference groundwater flow model. U.S. Geological Survey, Reston, Virginia.

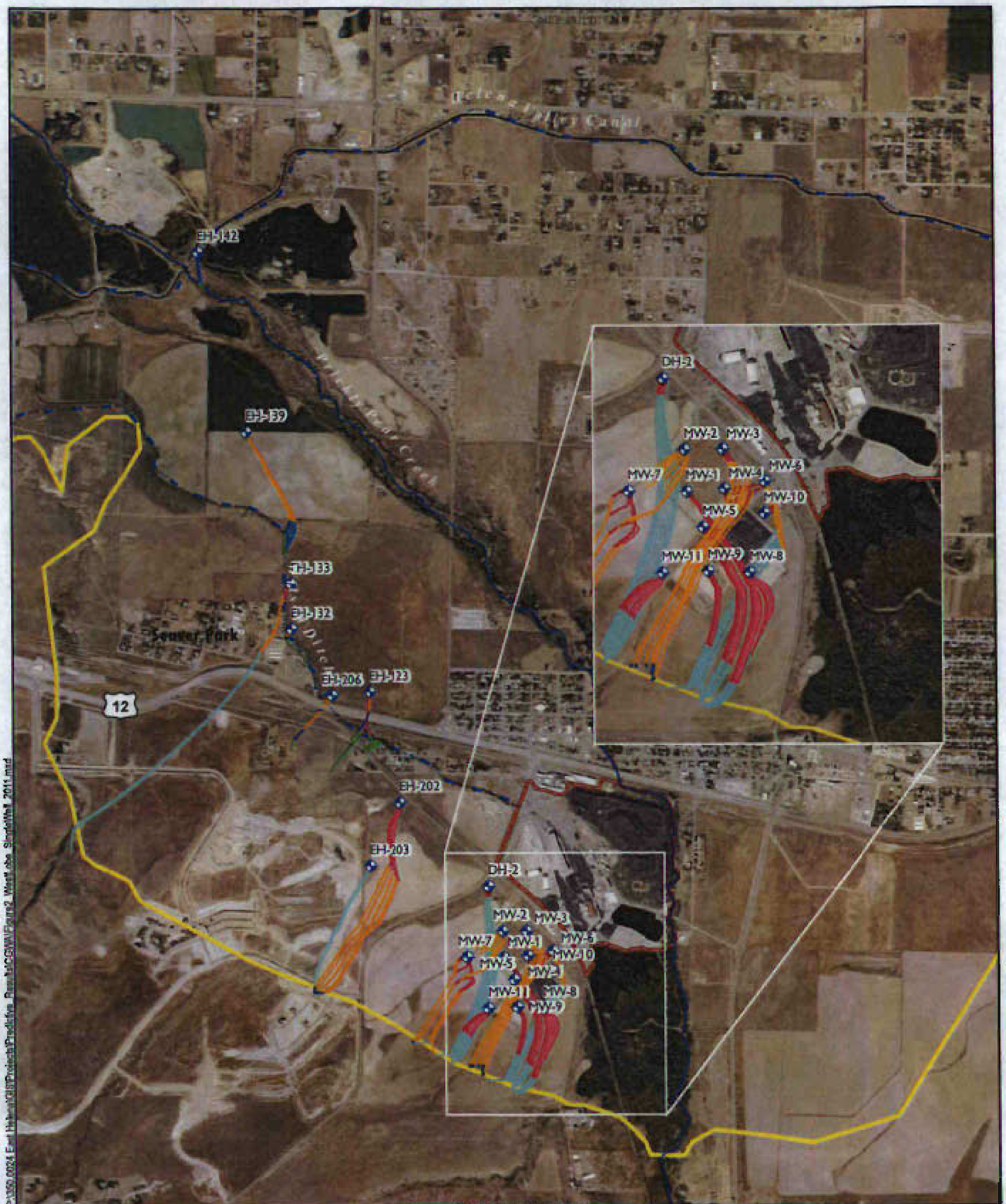
ATTACHMENT

FIGURES



NewFields

Pre-Slurry Wall Reverse Particle Tracks
Former ASARCO East Helena Facility
East Helena, Montana
FIGURE 1



NewFields

2011 Reverse Particle Tracks
Former ASARCO East Helena Facility
East Helena, Montana
FIGURE 2

NewFields

2013 Reverse Particle Tracks
Former ASARCO East Helena Facility
East Helena, Montana
FIGURE 3

Source: NAIP, 2011; METG, 2011

0 Feet 2,200

NewFields

Ditch

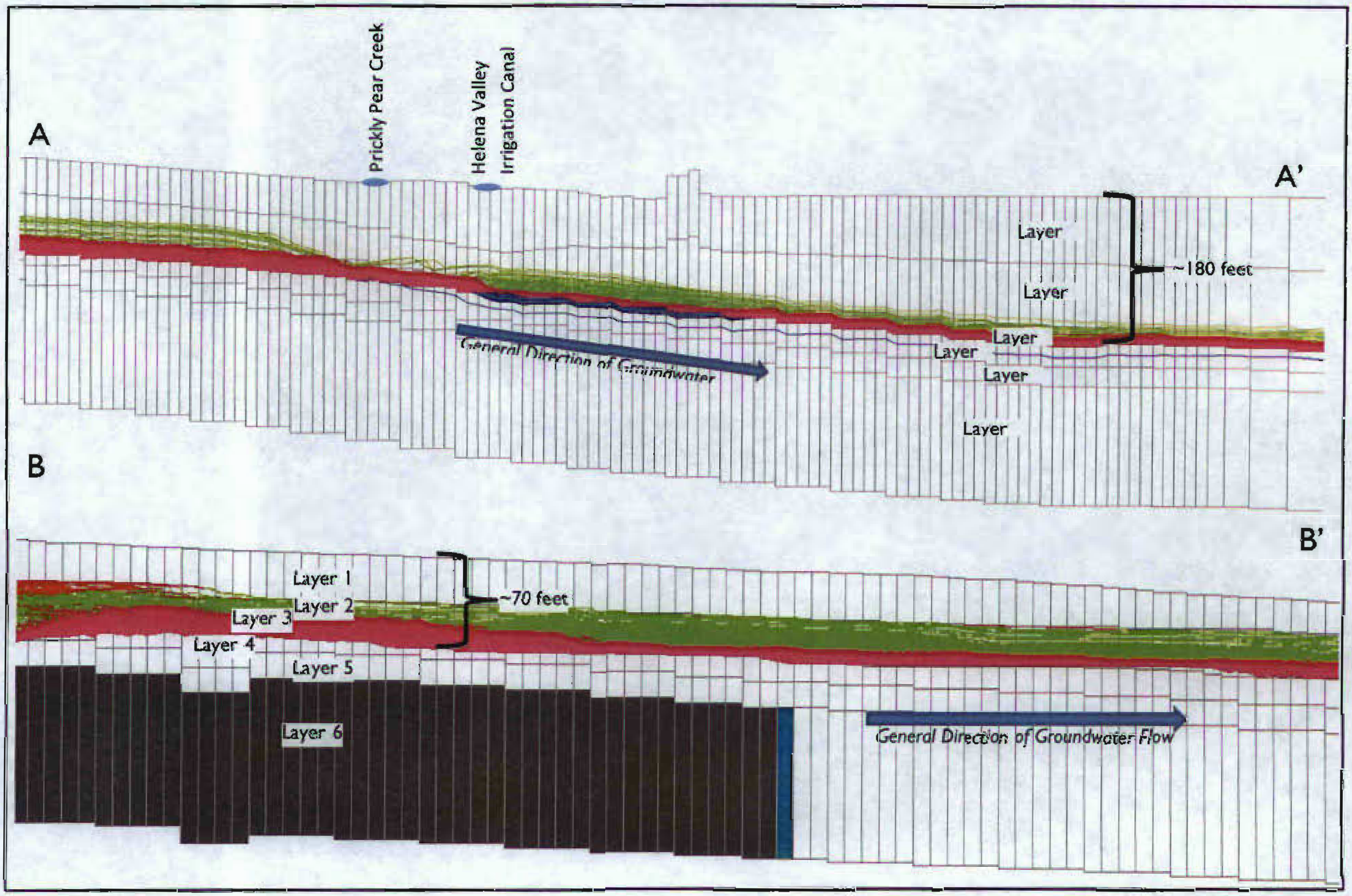
Selenium > 0.01 mg/L (2010)

Facility Boundary

Model Domain

Note: Cross sections are shown on Figures 5 and 6.

Cross Section Locations
Former ASARCO East Helena Facility
East Helena, Montana
FIGURE 4



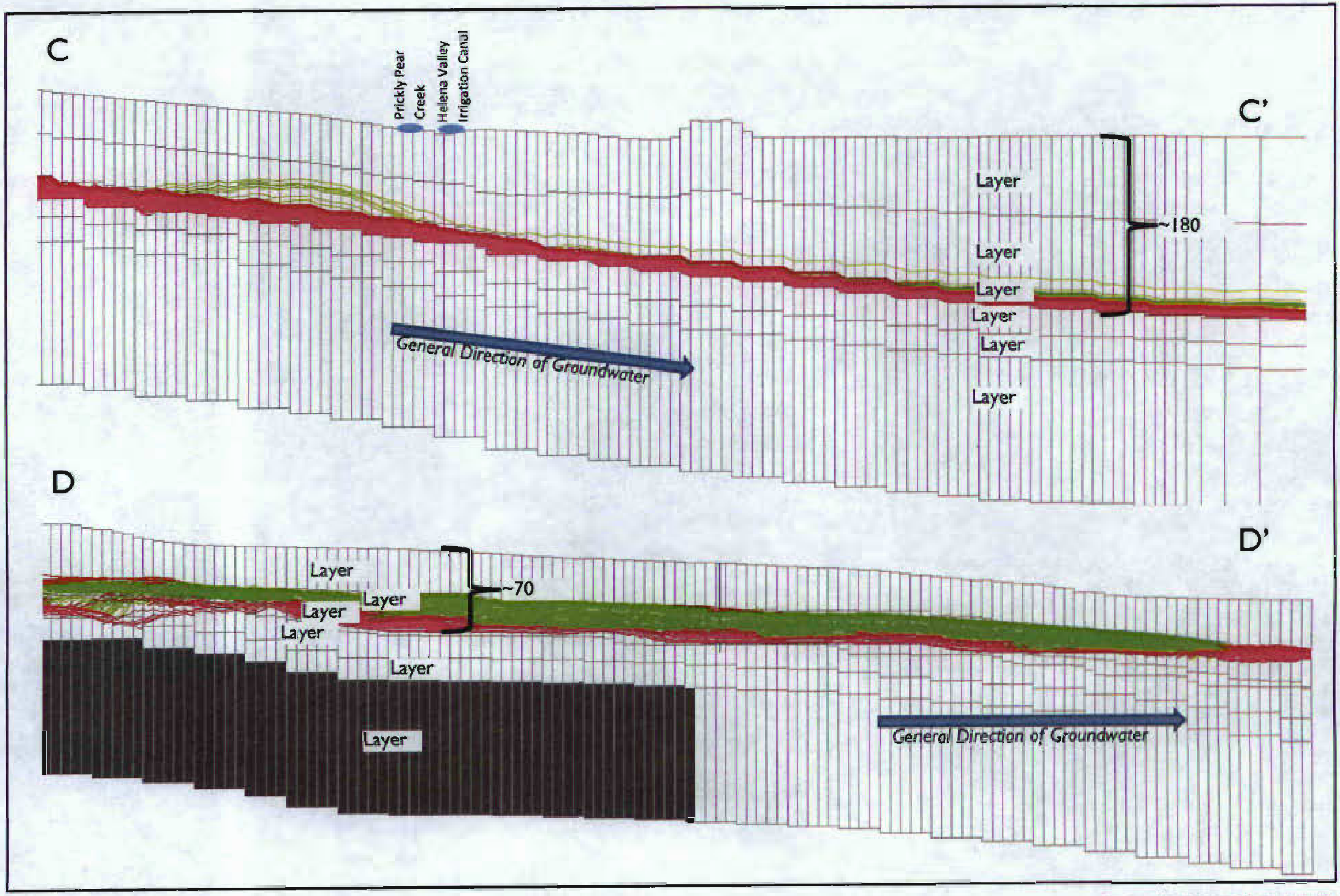
NewFields

Particle Tracks

- Layer 1
- Layer 2
- Layer 3
- Layer 4

Note: Location of cross-section shown on Figure 4.

Cross Section A-A' and B-B'
Former ASARCO East Helena Facility
East Helena, Montana
FIGURE 5

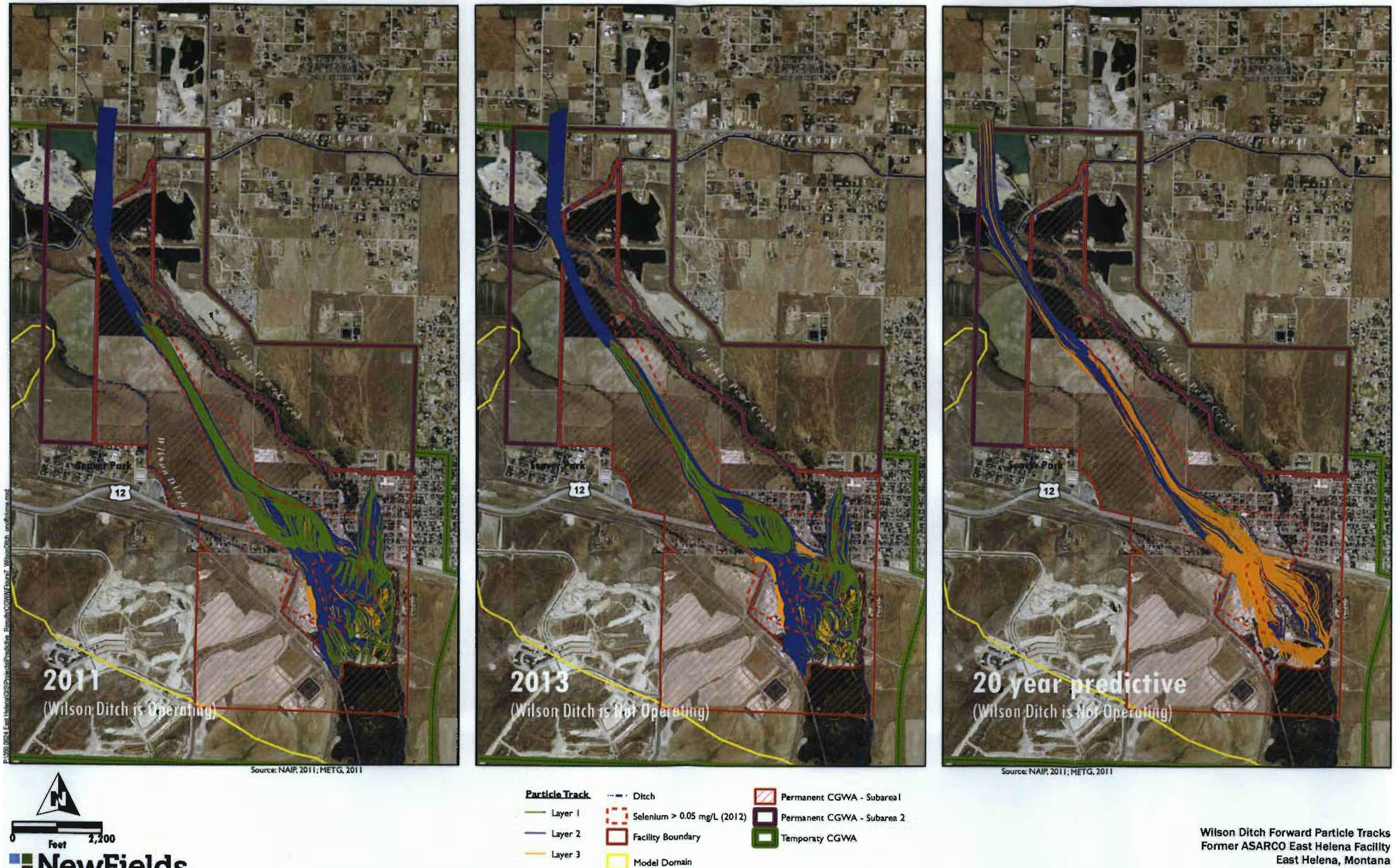


NewFields

Particle Tracks
- Layer 1
- Layer 2
- Layer 3
- Layer 4

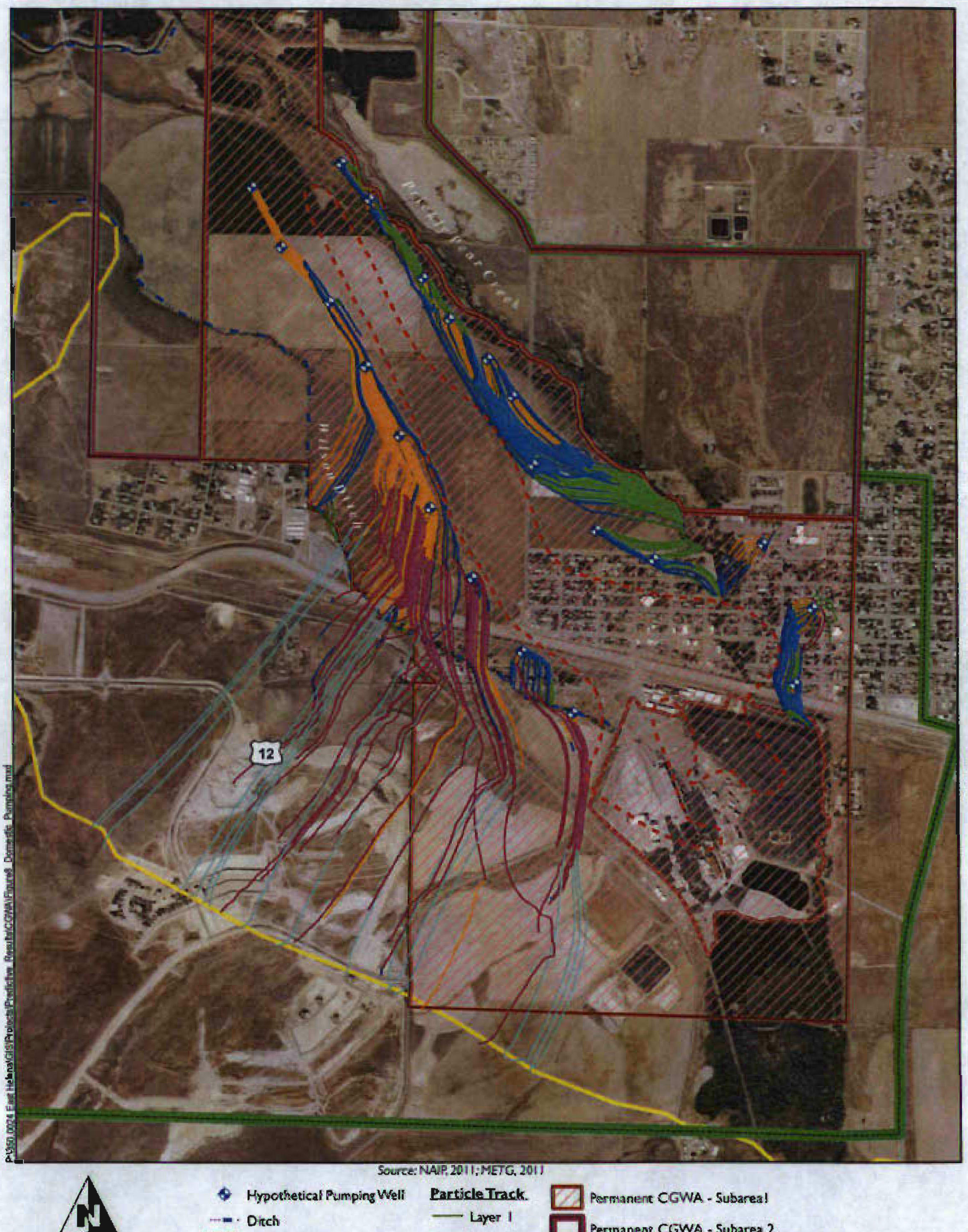
Note: Location of cross-section shown on Figure 4.

Cross Section C-C' and D-D'
Former ASARCO East Helena Facility
East Helena, Montana
FIGURE 6



NewFields

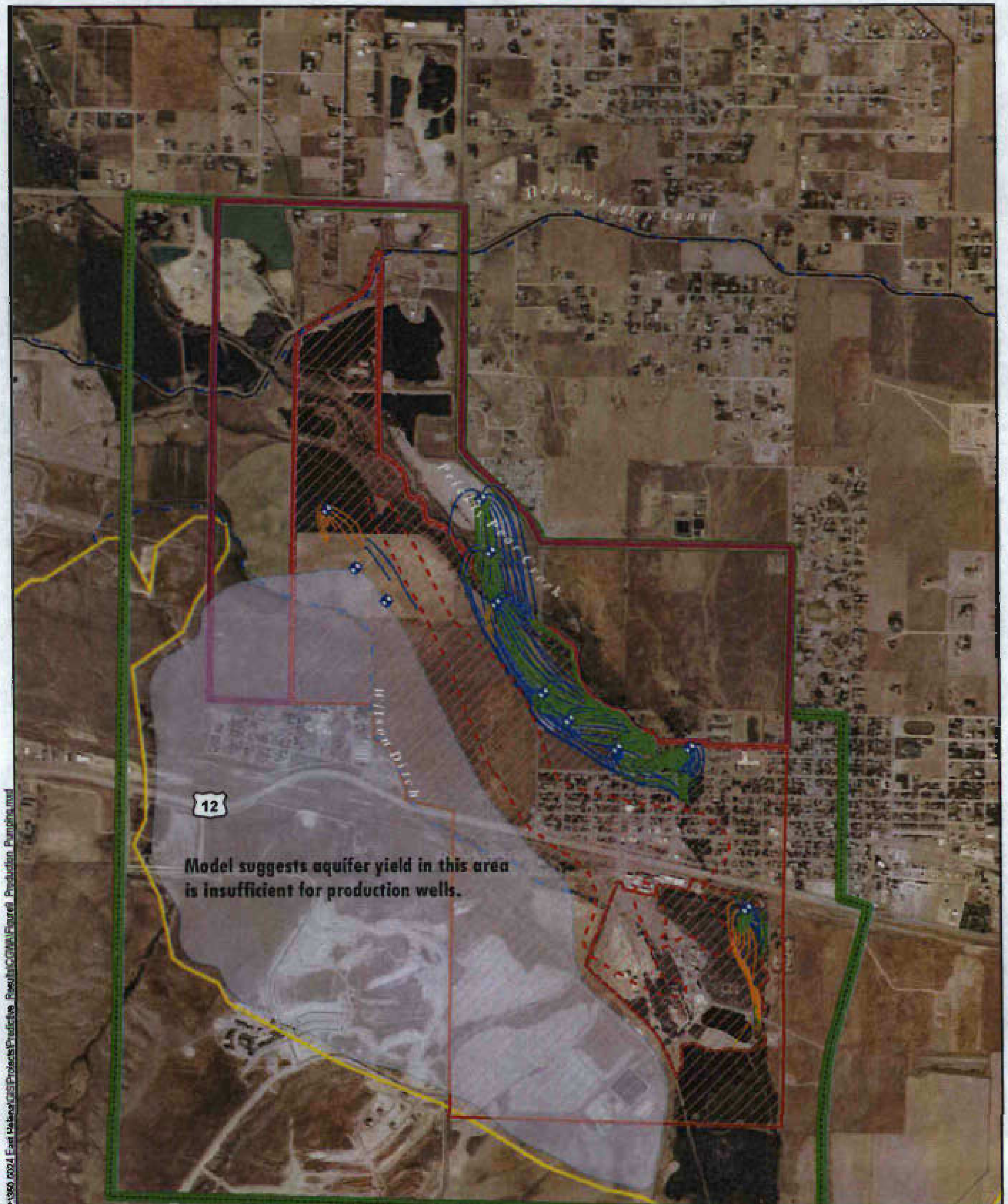
Wilson Ditch Forward Particle Tracks
Former ASARCO East Helena Facility
East Helena, Montana
FIGURE 7



Source: NAIP, 2011; METG, 2011

NewFields

Domestic Well Particle Tracks
Former ASARCO East Helena Facility
East Helena, Montana
FIGURE 8



Source: NAIP, 2011; METG, 2011

- Hypothetical Pumping Well
- Ditch
- Selenium > 0.05 mg/L (2012)
- Model Domain

Particle Track

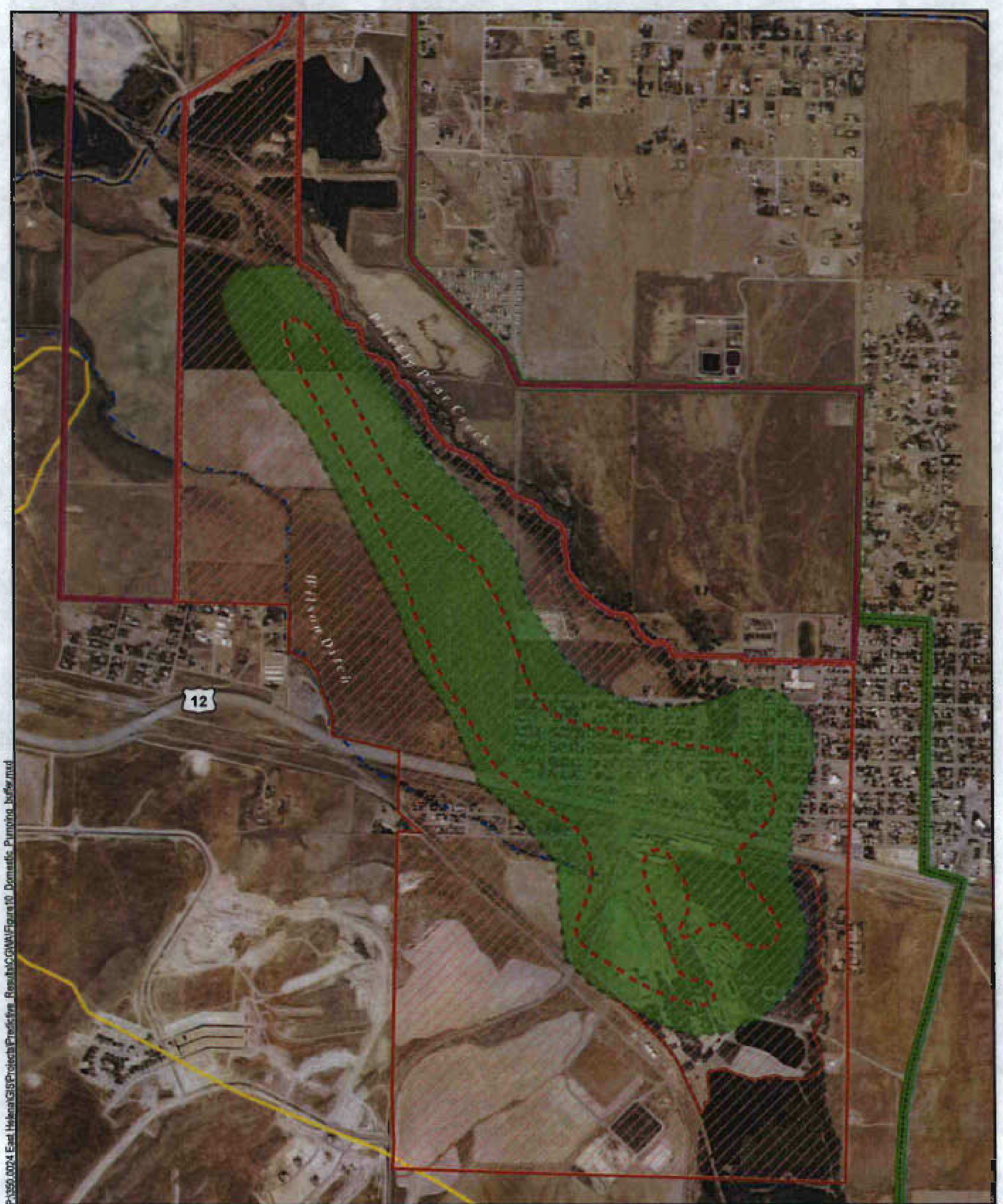
- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5
- Facility Boundary

- Permanent CGWA - Subarea 1
- Permanent CGWA - Subarea 2
- Temporary CGWA

0 Feet 2,200

NewFields

Production Well Particle Tracks
Former ASARCO East Helena Facility
East Helena, Montana
FIGURE 9



Source: NAIP, 2011; METG, 2011

0 Feet 1,600

NewFields

Buffer Zone

Ditch

Selenium > 0.05 mg/L (2012)

Facility Boundary

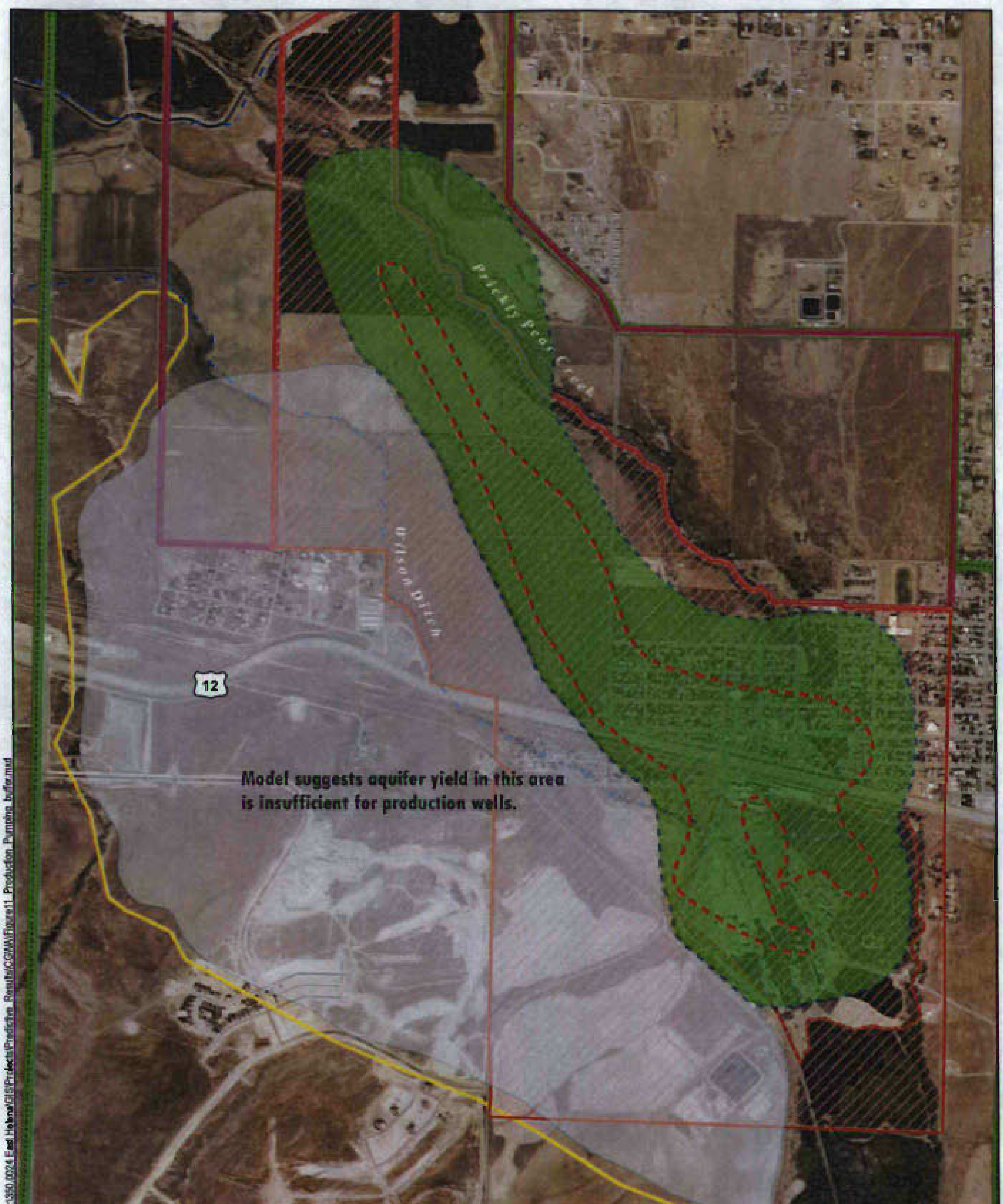
Model Domain

Permanent CGWA - Subarea1

Permanent CGWA - Subarea 2

Temporaty CGWA

Domestic Well Buffer Zone
Former ASARCO East Helena Facility
East Helena, Montana
FIGURE 10



Source: NAIP, 2011; METG, 2011

Buffer Zone
Ditch
Selenium > 0.05 mg/L (2012)
Facility Boundary
Model Domain
Permanent CGWA - Subarea1
Permanent CGWA - Subarea 2
Temporary CGWA

0 Feet 1,600

NewFields

Production Well Buffer Zone
Former ASARCO East Helena Facility
East Helena, Montana
FIGURE 11

APPENDIX D

EAST HELENA FACILITY PROJECT
WATER QUALITY DATABASE
(LOCATED ON CD)

APPENDIX E

PROPERTY OWNERSHIP WITHIN THE EAST VALLEY CGWA BOUNDARIES

Appendix E. Property Ownership Within East Valley CGWA

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
1	5188836201010000	Yes	No
2	5188836201030000	Yes	No
3	5188836105010000	Yes	No
4	No Information	Yes	Unknown
5	5188836101400000	Yes	No
6	No Information	Yes	Unknown
7	5188836101300000	Yes	Yes
8	5188836101200000	Yes	Yes
9	5188825310010000	Yes	No
10	5188825310030000	Yes	No
11	5188825310050000	Yes	No
12	5188825311030000	Yes	No
13	5188825311010000	Yes	No
14	5188825309010000	Yes	No
15	5188825312010000	Yes	No
16	5188825312030000	Yes	No
17	5188825312060000	Yes	No
18	5188825312150000	Yes	No
19	5188825313010000	Yes	No
20	5188825302170000	Yes	No
21	5188825302150000	Yes	No
22	5188825302130000	Yes	No
23	5188825302110000	Yes	No
24	5188825302090000	Yes	No
25	5188825303200000	Yes	No
26	5188825303180000	Yes	No
27	5188825303150000	Yes	No
28	5188825303120000	Yes	No
29	5188825302010000	Yes	No
30	5188825302030000	Yes	No
31	5188825302050000	Yes	No
32	5188825302070000	Yes	No
33	5188825303010000	Yes	No
34	5188825303030000	Yes	No
35	5188825303050000	Yes	No
36	5188825303060000	Yes	No
37	5188825305010000	Yes	No
38	5188825305020000	Yes	No
39	5188825305030000	Yes	No
40	5188825305050000	Yes	No
41	5188825305070000	Yes	No
42	5188825306010000	Yes	No
43	5188825306030000	Yes	No
44	5188825306050000	Yes	No
45	5188825307010000	Yes	No

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
46	5188825308010000	Yes	No
47	5188825404010000	Yes	No
48	5188825405010000	Yes	No
49	5188825405030000	Yes	No
50	5188825405050000	Yes	No
51	5188825405110000	Yes	No
52	5188825405130000	Yes	No
53	5188825405150000	Yes	No
54	5188825405170000	Yes	No
55	5188825405190000	Yes	No
56	5188825405210000	Yes	No
57	5188825405230000	Yes	No
58	5188825405250000	Yes	No
59	5188825406010000	Yes	No
60	5188825406090000	Yes	No
61	5188825406110000	Yes	No
62	5188825406030000	Yes	No
63	5188825406050000	Yes	No
64	5188825406070000	Yes	No
65	5188825406150000	Yes	No
66	5188825314010000	Yes	No
67	5188825314030000	Yes	No
68	5188825314050000	Yes	No
69	5188825314070000	Yes	No
70	5188825314090000	Yes	No
71	5188825315010000	Yes	No
72	5188825315030000	Yes	No
73	5188825315050000	Yes	No
74	5188825315070000	Yes	No
75	5188825315090000	Yes	No
76	5188825315110000	Yes	No
77	5188825315130000	Yes	No
78	5188825401010000	Yes	No
79	5188825401050000	Yes	No
80	5188825401030000	Yes	No
81	5188825401070000	Yes	No
82	5188825401110000	Yes	No
83	5188825401090000	Yes	No
84	5188825401130000	Yes	No
85	5188825402310000	Yes	No
86	5188825402270000	Yes	No
87	5188825402220000	Yes	No
88	5188825402210000	Yes	No
89	5188825402190000	Yes	No
90	5188825402170000	Yes	No

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
91	5188825402150000	Yes	No
92	5188825402130000	Yes	No
93	5188825402110000	Yes	No
94	5188825402010000	Yes	No
95	5188825402030000	Yes	No
96	5188825402050000	Yes	No
97	5188825402070000	Yes	No
98	5188825402080000	Yes	No
99	5188825402090000	Yes	No
100	5188825410010000	Yes	No
101	5188825410030000	Yes	No
102	5188825410050000	Yes	No
103	5188825410070000	Yes	No
104	5188825403010000	Yes	No
105	5188825403030000	Yes	No
106	5188825403070000	Yes	No
107	5188825403090000	Yes	No
108	5188825403110000	Yes	No
109	5188825403150000	Yes	No
110	5188825403130000	Yes	No
111	5188825411170000	Yes	No
112	5188825411190000	Yes	No
113	5188825411130000	Yes	No
114	5188825411110000	Yes	No
115	5188825411090000	Yes	No
116	5188825411010000	Yes	No
117	5188825411050000	Yes	No
118	5188825411070000	Yes	No
119	5188825407010000	Yes	No
120	5188825407030000	Yes	No
121	5188825407050000	Yes	No
122	5188825407070000	Yes	No
123	5188825407090000	Yes	No
124	5188825407130000	Yes	No
125	5188825407170000	Yes	No
126	5188825407150000	Yes	No
127	5188825412270000	Yes	No
128	5188825412250000	Yes	No
129	5188825412230000	Yes	No
130	5188825412210000	Yes	No
131	5188825412190000	Yes	No
132	5188825412170000	Yes	No
133	5188825412150000	Yes	No
134	5188825412130000	Yes	No
135	5188825412010000	Yes	No

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
136	5188825412030000	Yes	No
137	5188825412050000	Yes	No
138	5188825412070000	Yes	No
139	5188825412090000	Yes	No
140	5188825412110000	Yes	No
141	5188825408010000	Yes	No
142	5188825408020000	Yes	No
143	5188825408030000	Yes	Yes
144	5188825408050000	Yes	No
145	5188825408070000	Yes	No
146	5188825408090000	Yes	Yes
147	No Information	Yes	Unknown
148	5188825413170000	Yes	No
149	5188825413150000	Yes	No
150	5188825413130000	Yes	No
151	5188825413020000	Yes	No
152	5188825413010000	Yes	No
153	5188825413030000	Yes	No
154	5188825413050000	Yes	No
155	5188825413070000	Yes	No
156	5188825413090000	Yes	No
157	5188825413110000	Yes	No
158	5188825409010000	Yes	No
159	5188825409030000	Yes	No
160	5188825409040000	Yes	No
161	5188825409050000	Yes	No
162	5188825409070000	Yes	No
163	5188825409090000	Yes	No
164	5188825409110000	Yes	No
165	5188825316030000	Yes	No
166	5188825316210000	Yes	No
167	5188825316190000	Yes	No
168	5188825316170000	Yes	No
169	5188825316150000	Yes	No
170	5188825316110000	Yes	No
171	5188825316130000	Yes	No
172	5188825316090000	Yes	No
173	5188825317230000	Yes	No
174	5188825317210000	Yes	No
175	5188825317190000	Yes	No
176	5188825317170000	Yes	No
177	5188825317150000	Yes	No
178	5188825317130000	Yes	No
179	5188825317110000	Yes	No
180	5188825317010000	Yes	No

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MapKey	PARCEL ID	Within COEH Limits?	Well Present?
181	5188825317030000	Yes	No
182	5188825317050000	Yes	No
183	5188825317070000	Yes	No
184	5188825317090000	Yes	No
185	5188825318230000	Yes	No
186	5188825318210000	Yes	No
187	5188825318190000	Yes	No
188	5188825318170000	Yes	No
189	5188825318150000	Yes	No
190	5188825318130000	Yes	No
191	5188825318010000	Yes	No
192	5188825318030000	Yes	No
193	5188825318050000	Yes	No
194	5188825318070000	Yes	No
195	5188825318090000	Yes	No
196	5188825318110000	Yes	Yes
197	5188825414290000	Yes	No
198	5188825414270000	Yes	No
199	5188825414250000	Yes	No
200	5188825414230000	Yes	No
201	5188825414220000	Yes	No
202	5188825414210000	Yes	No
203	5188825414190000	Yes	No
204	5188825414170000	Yes	No
205	5188825414150000	Yes	No
206	5188825414180000	Yes	No
207	5188825414010000	Yes	No
208	5188825414030000	Yes	No
209	5188825414050000	Yes	No
210	5188825414070000	Yes	No
211	5188825414090000	Yes	No
212	5188825414110000	Yes	No
213	5188825414130000	Yes	No
214	5188825415350000	Yes	No
215	5188825415330000	Yes	No
216	5188825415310000	Yes	No
217	5188825415290000	Yes	No
218	5188825415270000	Yes	No
219	5188825415250000	Yes	No
220	5188825415230000	Yes	No
221	5188825415210000	Yes	No
222	5188825415010000	Yes	No
223	5188825415030000	Yes	No
224	5188825415050000	Yes	No
225	5188825415090000	Yes	No

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
226	5188825415110000	Yes	No
227	5188825415130000	Yes	No
228	5188825415150000	Yes	No
229	5188825415170000	Yes	No
230	5188825415190000	Yes	No
231	5188825416170000	Yes	No
232	5188825416150000	Yes	No
233	5188825416130000	Yes	No
234	5188825416110000	Yes	No
235	5188825416090000	Yes	No
236	5188825416070000	Yes	No
237	5188825416010000	Yes	No
238	5188825416030000	Yes	No
239	5188825416050000	Yes	No
240	5188825416040000	Yes	No
241	5188825416060000	Yes	No
242	5188825417270000	Yes	No
243	5188825417250000	Yes	No
244	5188825417230000	Yes	No
245	5188825417220000	Yes	No
246	5188825417210000	Yes	No
247	5188825417190000	Yes	No
248	5188825417170000	Yes	No
249	5188825417010000	Yes	No
250	5188825417030000	Yes	No
251	5188825417050000	Yes	No
252	5188825417070000	Yes	No
253	5188825417090000	Yes	No
254	5188825417110000	Yes	No
255	5188825417130000	Yes	No
256	5188825417150000	Yes	No
257	5188825418210000	Yes	No
258	5188825418190000	Yes	No
259	5188825418170000	Yes	No
260	5188825418150000	Yes	No
261	5188825418010000	Yes	No
262	5188825418030000	Yes	No
263	5188825418050000	Yes	No
264	5188825418070000	Yes	No
265	5188825418090000	Yes	No
266	5188825418110000	Yes	No
267	5188825418130000	Yes	No
268	5188825419070000	Yes	No
269	5188825419100000	Yes	No
270	5188825419010000	Yes	No

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
271	5188825419050000	Yes	No
272	5188825419030000	Yes	No
273	5188825319190000	Yes	No
274	5188825319170000	Yes	No
275	5188825319150000	Yes	No
276	5188825319130000	Yes	No
277	5188825319110000	Yes	No
278	5188825319010000	Yes	No
279	5188825319050000	Yes	No
280	5188825319090000	Yes	No
281	5188825319070000	Yes	No
282	5188825320250000	Yes	No
283	5188825320210000	Yes	No
284	5188825320190000	Yes	No
285	5188825320170000	Yes	No
286	5188825320150000	Yes	No
287	5188825320130000	Yes	No
288	5188825320010000	Yes	No
289	5188825320030000	Yes	No
290	5188825320050000	Yes	No
291	5188825320070000	Yes	No
292	5188825320090000	Yes	No
293	5188825320110000	Yes	No
294	5188825321190000	Yes	No
295	5188825321170000	Yes	No
296	5188825321150000	Yes	No
297	5188825321130000	Yes	No
298	5188825321110000	Yes	No
299	5188825321090000	Yes	No
300	5188825321010000	Yes	No
301	5188825321030000	Yes	No
302	5188825321050000	Yes	No
303	5188825321070000	Yes	No
304	5188825420170000	Yes	No
305	5188825420150000	Yes	No
306	5188825420130000	Yes	No
307	5188825420090000	Yes	No
308	5188825420070000	Yes	No
309	5188825420010000	Yes	No
310	5188825420030000	Yes	No
311	5188825421210000	Yes	No
312	5188825421190000	Yes	No
313	5188825421170000	Yes	No
314	5188825421150000	Yes	No
315	5188825421130000	Yes	No

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
316	5188825421110000	Yes	No
317	5188825421010000	Yes	No
318	5188825421050000	Yes	No
319	5188825421070000	Yes	No
320	5188825421090000	Yes	No
321	5188825421100000	Yes	No
322	5188825422210000	Yes	No
323	5188825422190000	Yes	No
324	5188825422170000	Yes	No
325	5188825422150000	Yes	No
326	5188825422130000	Yes	No
327	5188825422110000	Yes	No
328	5188825422010000	Yes	No
329	5188825422030000	Yes	No
330	5188825422050000	Yes	No
331	5188825422070000	Yes	No
332	5188825422090000	Yes	No
333	5188825423210000	Yes	No
334	5188825423190000	Yes	No
335	5188825423170000	Yes	Yes
336	5188825423150000	Yes	Yes
337	5188825423130000	Yes	No
338	5188825423010000	Yes	No
339	5188825423030000	Yes	No
340	5188825423050000	Yes	No
341	5188825423070000	Yes	No
342	5188825423090000	Yes	No
343	5188825423110000	Yes	No
344	5188825424230000	Yes	No
345	5188825424210000	Yes	No
346	5188825424190000	Yes	No
347	5188825424170000	Yes	No
348	5188825424150000	Yes	No
349	5188825424130000	Yes	No
350	5188825424010000	Yes	No
351	5188825424030000	Yes	No
352	5188825424050000	Yes	No
353	5188825424070000	Yes	No
354	5188825424090000	Yes	No
355	5188825424110000	Yes	No
356	5188825425090000	Yes	No
357	5188825425070000	Yes	No
358	5188825425050000	Yes	No
359	5188825425030000	Yes	No
360	5188825425010000	Yes	No

Appendix E. Property Ownership Within East Valley CGWA

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
361	5188825425110000	Yes	No
362	5188825425130000	Yes	No
363	5188825425150000	Yes	No
364	5188825425170000	Yes	No
365	5188825327010000	Yes	Yes
366	5188825327030000	Yes	Yes
367	5188825327050000	Yes	Yes
368	5188825322010000	Yes	No
369	5188825322030000	Yes	No
370	5188825322050000	Yes	No
371	5188825322070000	Yes	No
372	5188825328010000	Yes	No
373	5188825328030000	Yes	Yes
374	5188825328050000	Yes	Yes
375	5188825328070000	Yes	No
376	5188825323010000	Yes	No
377	5188825323030000	Yes	No
378	5188825323050000	Yes	No
379	5188825323070000	Yes	No
380	5188825323090000	Yes	No
381	5188825329010000	Yes	No
382	5188825329030000	Yes	No
383	5188825329050000	Yes	No
384	5188825329070000	Yes	Yes
385	5188825329090000	Yes	Yes
386	5188825324010000	Yes	No
387	5188825324030000	Yes	No
388	5188825324050000	Yes	No
389	5188825324070000	Yes	No
390	5188825324090000	Yes	No
391	5188825330010000	Yes	Yes
392	5188825330030000	Yes	No
393	5188825330050000	Yes	Yes
394	5188825330070000	Yes	No
395	5188825330090000	Yes	No
396	5188825325010000	Yes	No
397	5188825325030000	Yes	No
398	5188825325050000	Yes	No
399	5188825325070000	Yes	No
400	5188825325110000	Yes	No
401	5188825331010000	Yes	Yes
402	5188825331030000	Yes	Yes
403	5188825331070000	Yes	Yes
404	5188825331090000	Yes	Yes
405	5188825326010000	Yes	Yes

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
406	5188825326030000	Yes	No
407	5188825326050000	Yes	No
408	5188825326070000	Yes	No
409	5188825326090000	Yes	No
410	5188825326110000	Yes	No
411	5188825438050000	Yes	No
412	5188825438010000	Yes	No
413	5188825438090000	Yes	No
414	5188825426170000	Yes	No
415	5188825426150000	Yes	No
416	5188825426120000	Yes	No
417	5188825426110000	Yes	No
418	5188825426100000	Yes	No
419	5188825426010000	Yes	No
420	5188825426030000	Yes	No
421	5188825426050000	Yes	No
422	5188825426070000	Yes	No
423	5188825427190000	Yes	Yes
424	5188825427170000	Yes	No
425	5188825427250000	Yes	No
426	5188825427150000	Yes	No
427	5188825427130000	Yes	No
428	5188825427110000	Yes	No
429	5188825427010000	Yes	No
430	5188825427030000	Yes	Yes
431	5188825427050000	Yes	No
432	5188825427070000	Yes	No
433	5188825427080000	Yes	No
434	5188825427090000	Yes	No
435	5188825428190000	Yes	No
436	5188825428170000	Yes	No
437	5188825428150000	Yes	No
438	5188825428130000	Yes	No
439	5188825428110000	Yes	No
440	5188825428010000	Yes	No
441	5188825428020000	Yes	No
442	5188825428030000	Yes	No
443	5188825428050000	Yes	No
444	5188825428070000	Yes	No
445	5188825428090000	Yes	No
446	5188825429190000	Yes	No
447	5188825429170000	Yes	No
448	5188825429140000	Yes	No
449	5188825429130000	Yes	No
450	5188825429110000	Yes	No

Appendix E. Property Ownership Within East Valley CGWA

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
451	5188825429097000	Yes	No
452	5188825429017000	Yes	No
453	5188825429027000	Yes	No
454	5188825429037000	Yes	No
455	5188825429070000	Yes	No
456	5188825429050000	Yes	Yes
457	5188825429150000	Yes	No
458	5188825430010000	Yes	No
459	5188825431170000	Yes	No
460	5188825431150000	Yes	No
461	5188825431130000	Yes	No
462	5188825431110000	Yes	No
463	5188825431090000	Yes	No
464	5188825431010000	Yes	No
465	5188825431030000	Yes	No
466	5188825431050000	Yes	No
467	5188825431070000	Yes	Yes
468	5188825432190000	Yes	No
469	5188825432170000	Yes	No
470	5188825432150000	Yes	No
471	5188825432130000	Yes	No
472	5188825432110000	Yes	No
473	5188825432090000	Yes	No
474	5188825432010000	Yes	No
475	5188825432020000	Yes	No
476	5188825432030000	Yes	No
477	5188825432047000	Yes	No
478	5188825432050000	Yes	No
479	5188825432060000	Yes	No
480	5188825433010000	Yes	No
481	5188825434150000	Yes	No
482	5188825434130000	Yes	No
483	5188825434110000	Yes	No
484	5188825434010000	Yes	No
485	5188825434030000	Yes	No
486	5188825434050000	Yes	No
487	5188825434070000	Yes	No
488	5188825434090000	Yes	No
489	5188825435230000	Yes	No
490	5188825435217000	Yes	No
491	5188825435190000	Yes	No
492	5188825435170000	Yes	No
493	5188825435150000	Yes	No
494	5188825435130000	Yes	No
495	5188825435010000	Yes	No

Appendix E. Property Ownership Within East Valley CGWA

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
496	5188825435030000	Yes	No
497	5188825435050000	Yes	No
498	5188825435070000	Yes	No
499	5188825435090000	Yes	No
500	5188825435110000	Yes	No
501	5188825436010000	Yes	No
502	5188825437010000	Yes	No
503	5188825332150000	No	No
504	5188825332170000	No	Yes
505	5188825332090000	No	No
506	5188825332010000	No	Yes
507	5188825440010000	Yes	No
508	5188826102010000	Yes	No
509	5188825332200000	Yes	No
510	5188825316280000	Yes	No
511	5188825332250000	No	No
512	0518882610120AG00	No	No
513	5188825201090000	No	Yes
514	0518882520115AG00	No	No
515	5188823301201000	No	No
516	5188823301150000	No	No
517	5188823401200000	No	No
518	5188823101150000	No	No
519	5188823201090000	No	No
520	0518882320125AG00	No	Yes
521	5188823201070000	No	Yes
522	5188823101020000	No	No
523	5188823101010000	No	Yes
524	5188823101200000	No	Yes
525	5188823101030000	No	Yes

Appendix E. Property Ownership Within East Valley CGWA

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
P1	5188823201030000	No	Yes
P2	5188823201050000	No	Yes
P3	5188823201010000	No	Yes
P4	5188823101130000	Yes	Yes
P5	5188823102200000	No	Unknown
P6	5188823102010000	Yes	Unknown
P7	5188823102150000	No	Unknown
P8	5188823102050000	No	Yes
P9	5188823102100000	No	Unknown
P10	5188823101070000	No	Yes
P11	5188823101090000	No	Yes
P12	5188823101050000	No	Unknown
P13	5188823401010000	No	Yes
P14	0518882430101AG00	No	Unknown
P15	5188823301050000	No	Unknown
P16	5188821301010000	No	Unknown
P17	0518882620101AG00	No	Yes
P18	5188826201200000	No	Yes
P19	5188825101010000	Yes	Yes
P20	5188825101500000	No	Yes
P21	5188826301070000	No	Unknown
P22	5188826301090000	No	Yes
P23	5188826301100000	No	Unknown
P24	5188826301010000	No	Yes
P25	5188835101010000	No	Unknown
P26	5188826401300000	No	Yes
P27	5188826401200000	No	Yes
P28	5188826401030000	No	Yes
P29	5188825301010000	No	Yes
P30	5188835202200000	No	Unknown
P31	5188835202150000	No	Unknown
P32	5188835202050000	No	Unknown
P33	5188835202100000	No	Unknown
P34	5188835201010000	No	Unknown
P35	5188835214010000	No	Unknown
P36	5188835209010000	No	Unknown
P37	5188835106100000	No	Unknown
P38	5188835106010000	No	Unknown
P39	5188835106700000	No	Unknown
P40	5188835101300000	No	Unknown
P41	5188835201400000	No	Unknown
P42	5188835313010000	No	Unknown
P43	5188835102017000	No	Unknown
P44	5188835102100000	No	Unknown
P45	5188835411400000	No	Unknown

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
P46	5188835411010000	No	Unknown
P47	5188835401010000	No	Unknown
P48	5188835404010000	No	Unknown

Appendix E. Property Ownership Within East Valley CGWA

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
SP1	5188826309120000	No	Yes
SP2	5188826309010000	No	Yes
SP3	5188826309050000	No	Yes
SP4	5188826309060000	Yes	Yes
SP5	5188826309100000	No	Yes
SP6	5188826302010000	Yes	Yes
SP7	5188826302040000	No	Yes
SP8	5188826302150000	No	Yes
SP9	5188826302130000	No	Yes
SP10	5188826302050000	No	Unknown
SP11	5188826302060000	No	Yes
SP12	5188826308370000	No	Yes
SP13	5188826308310000	No	Unknown
SP14	5188826308410000	No	Yes
SP15	5188826308330000	No	Yes
SP16	5188826308290000	No	Yes
SP17	5188826308230000	No	Yes
SP18	5188826308210000	No	Yes
SP19	5188826308010000	No	Yes
SP20	5188826308270000	No	Yes
SP21	5188826308050000	No	Yes
SP22	5188826308170000	No	Yes
SP23	5188826308100000	No	Yes
SP24	5188826308150000	No	Yes
SP25	5188826303010000	No	Yes
SP26	5188826303240000	No	Yes
SP27	5188826303100000	No	Yes
SP28	5188826303220000	No	Yes
SP29	5188826303200000	No	Yes
SP30	5188826303140000	No	Yes
SP31	5188826303180000	No	Yes
SP32	5188826307250000	No	Yes
SP33	5188826307270000	No	Yes
SP34	5188826307290000	No	Yes
SP35	5188826306150000	No	Unknown
SP36	5188826306130000	No	Yes
SP37	5188826306110000	No	Yes
SP38	5188826307230000	No	Yes
SP39	5188826307210000	No	Yes
SP40	5188826306090000	No	Yes
SP41	5188826307190000	No	Yes
SP42	5188826307010000	No	Yes
SP43	5188826307110000	No	Yes
SP44	5188826306030000	No	Yes
SP45	5188826306080000	No	Yes

Appendix E. Property Ownership Within East Valley CGWA

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
SP46	5188826306070000	No	Yes
SP47	5188826307050000	No	Yes
SP48	5188826307070000	No	Yes
SP49	5188826307090000	No	Yes
SP50	5188826310010000	No	Unknown
SP51	5188826304010000	No	Unknown
SP52	5188826305010000	No	Unknown
SP53	5188826401400000	No	Yes

Appendix E. Property Ownership Within East Valley CGWA

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
RD1	5188835205180000	No	Unknown
RD2	5188835205160000	No	Unknown
RD3	5188835205140000	No	Unknown
RD4	5188835205120000	Yes	Unknown
RD5	5188835205100000	No	Unknown
RD6	5188835205080000	Yes	Unknown
RD7	5188835205060000	No	Unknown
RD8	5188835205010000	No	Unknown
RD9	5188835205020000	No	Unknown
RD10	5188835205030000	No	Unknown
RD11	5188835205040000	No	Unknown
RD12	5188835204320000	No	Unknown
RD13	5188835204060000	No	Unknown
RD14	5188835204300000	No	Unknown
RD15	5188835204080000	No	Unknown
RD16	5188835204280000	No	Unknown
RD17	5188835204100000	No	Unknown
RD18	5188835204260000	No	Unknown
RD19	5188835204120000	No	Unknown
RD20	5188835204240000	No	Unknown
RD21	5188835204140000	No	Unknown
RD22	5188835204220000	No	Unknown
RD23	5188835204200000	No	Unknown
RD24	5188835204160000	No	Unknown
RD25	5188835204180000	No	Unknown
RD26	5188835111010000	No	Unknown
RD27	5188835111020000	No	Unknown
RD28	5188835111040000	No	Unknown
RD29	5188835111060000	No	Unknown
RD30	5188835111080000	No	Unknown
RD31	5188835111100000	No	Unknown
RD32	5188835111120000	No	Unknown
RD33	5188835111140000	No	Unknown
RD34	5188835111160000	No	Unknown
RD35	5188835111180000	No	Unknown
RD36	5188835111220000	No	Unknown
RD37	5188835111240000	No	Unknown
RD38	5188835111260000	No	Unknown
RD39	5188835111300000	No	Unknown
RD40	5188835111320000	No	Unknown
RD41	5188835111340000	No	Unknown
RD42	5188835111360000	No	Unknown
RD43	5188835111380000	No	Unknown
RD44	5188835112010000	No	Unknown
RD45	5188835325350000	No	Unknown

Appendix E. Property Ownership Within East Valley CGWA

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
RD46	5188835325370000	No	Unknown
RD47	5188835325310000	No	Unknown
RD48	5188835325290000	No	Unknown
RD49	5188835325270000	No	Unknown
RD50	5188835325250000	No	Unknown
RD51	5188835325230000	No	Unknown
RD52	5188835325210000	No	Unknown
RD53	5188835325190000	No	Unknown
RD54	5188835325170000	No	Unknown
RD55	5188835325150000	No	Unknown
RD56	5188835326450000	No	Unknown
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RD61	5188835326510000	No	Unknown
RD62	5188835326530000	No	Unknown
RD63	5188835326010000	No	Unknown
RD64	5188835326030000	No	Unknown
RD65	5188835326390000	No	Unknown
RD66	5188835326050000	No	Unknown
RD67	5188835326370000	No	Unknown
RD68	5188835326070000	No	Unknown
RD69	5188835326350000	No	Unknown
RD70	5188835326090000	No	Unknown
RD71	5188835326330000	No	Unknown
RD72	5188835326110000	No	Unknown
RD73	5188835326310000	No	Unknown
RD74	5188835326130000	No	Unknown
RD75	5188835326290000	No	Unknown
RD76	5188835326150000	No	Unknown
RD77	5188835326270000	No	Unknown
RD78	5188835326170000	No	Unknown
RD79	5188835326250000	No	Unknown
RD80	5188835326190000	No	Unknown
RD81	5188835326230000	No	Unknown
RD82	5188835326210000	No	Unknown
RD83	5188835107017000	No	Unknown
RD84	5188835107680000	No	Unknown
RD85	5188835107660000	No	Unknown
RD86	5188835107640000	No	Unknown
RD87	5188835107020000	No	Unknown
RD88	5188835107620000	No	Unknown
RD89	5188835107600000	No	Unknown
RD90	5188835107580000	No	Unknown

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
RD91	5188835107040000	No	Unknown
RD92	5188835107060000	No	Unknown
RD93	5188835107560000	No	Unknown
RD94	5188835107540000	No	Unknown
RD95	5188835107080000	No	Unknown
RD96	5188835107100000	No	Unknown
RD97	5188835107520000	No	Unknown
RD98	5188835107500000	No	Unknown
RD99	5188835107120000	No	Unknown
RD100	5188835107480000	No	Unknown
RD101	5188835107140000	No	Unknown
RD102	5188835107460000	No	Unknown
RD103	5188835107440000	No	Unknown
RD104	5188835107160000	No	Unknown
RD105	5188835107180000	No	Unknown
RD106	5188835107420000	No	Unknown
RD107	5188835107200000	No	Unknown
RD108	5188835107400000	No	Unknown
RD109	5188835107220000	No	Unknown
RD110	5188835107380000	No	Unknown
RD111	5188835107240000	No	Unknown
RD112	5188835107360000	No	Unknown
RD113	5188835107340000	No	Unknown
RD114	5188835107260000	No	Unknown
RD115	5188835107280000	No	Unknown
RD116	5188835107320000	No	Unknown
RD117	5188835107300000	No	Unknown
RD118	5188835108400000	No	Unknown
RD119	5188835108010000	No	Unknown
RD120	5188835327010000	No	Unknown
RD121	5188835327250000	No	Unknown
RD122	5188835327030000	No	Unknown
RD123	5188835327230000	No	Unknown
RD124	5188835327050000	No	Unknown
RD125	5188835327210000	No	Unknown
RD126	5188835327070000	No	Unknown
RD127	5188835327190000	No	Unknown
RD128	5188835327090000	No	Unknown
RD129	5188835327170000	No	Unknown
RD130	5188835327110000	No	Unknown
RD131	5188835327150000	No	Unknown
RD132	5188835327130000	No	Unknown
RD133	5188835328210000	No	Unknown
RD134	5188835328230000	No	Unknown
RD135	5188835328190000	No	Unknown

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
RD136	5188835328170000	No	Unknown
RD137	5188835328150000	No	Unknown
RD138	5188835328130000	No	Unknown
RD139	5188835328110000	No	Unknown
RD140	5188835328090000	No	Unknown
RD141	5188835328070000	No	Unknown
RD142	5188835328050000	No	Unknown
RD143	5188835328030000	No	Unknown
RD144	5188835328010000	No	Unknown
RD145	5188835413010000	No	Unknown
RD146	5188835413030000	No	Unknown
RD147	5188835413050000	Yes	Unknown
RD148	5188835413070000	No	Unknown
RD149	5188835413090000	No	Unknown
RD150	5188835413110000	No	Unknown
RD151	5188835414010000	No	Unknown
RD152	5188835409210000	No	Unknown
RD153	5188835410310000	No	Unknown
RD154	5188835410290000	No	Unknown
RD155	5188835410270000	No	Unknown
RD156	5188835410250000	No	Unknown
RD157	5188835410230000	No	Unknown
RD158	5188835410210000	No	Unknown
RD159	5188835410190000	No	Unknown
RD160	5188835410170000	No	Unknown
RD161	5188835403570000	No	Unknown
RD162	5188835409190000	No	Unknown
RD163	5188835410010000	No	Unknown
RD164	5188835410030000	No	Unknown
RD165	5188835410050000	No	Unknown
RD166	5188835410070000	No	Unknown
RD167	5188835410090000	No	Unknown
RD168	5188835410110000	No	Unknown
RD169	5188835410130000	No	Unknown
RD170	5188835410150000	No	Unknown
RD171	5188835403550000	No	Unknown
RD172	5188835403530000	No	Unknown
RD173	5188835407230000	No	Unknown
RD174	5188835408430000	No	Unknown
RD175	5188835408410000	No	Unknown
RD176	5188835408390000	No	Unknown
RD177	5188835408370000	No	Unknown
RD178	5188835408350000	No	Unknown
RD179	5188835408330000	No	Unknown
RD180	5188835408310000	No	Unknown

Appendix E. Property Ownership Within East Valley CGWA

MapKey	PARCEL ID	Within COEH Limits?	Well Present?
RD181	5188835408290000	No	Unknown
RD182	5188835408270000	No	Unknown
RD183	5188835408250000	No	Unknown
RD184	5188835408230000	No	Unknown

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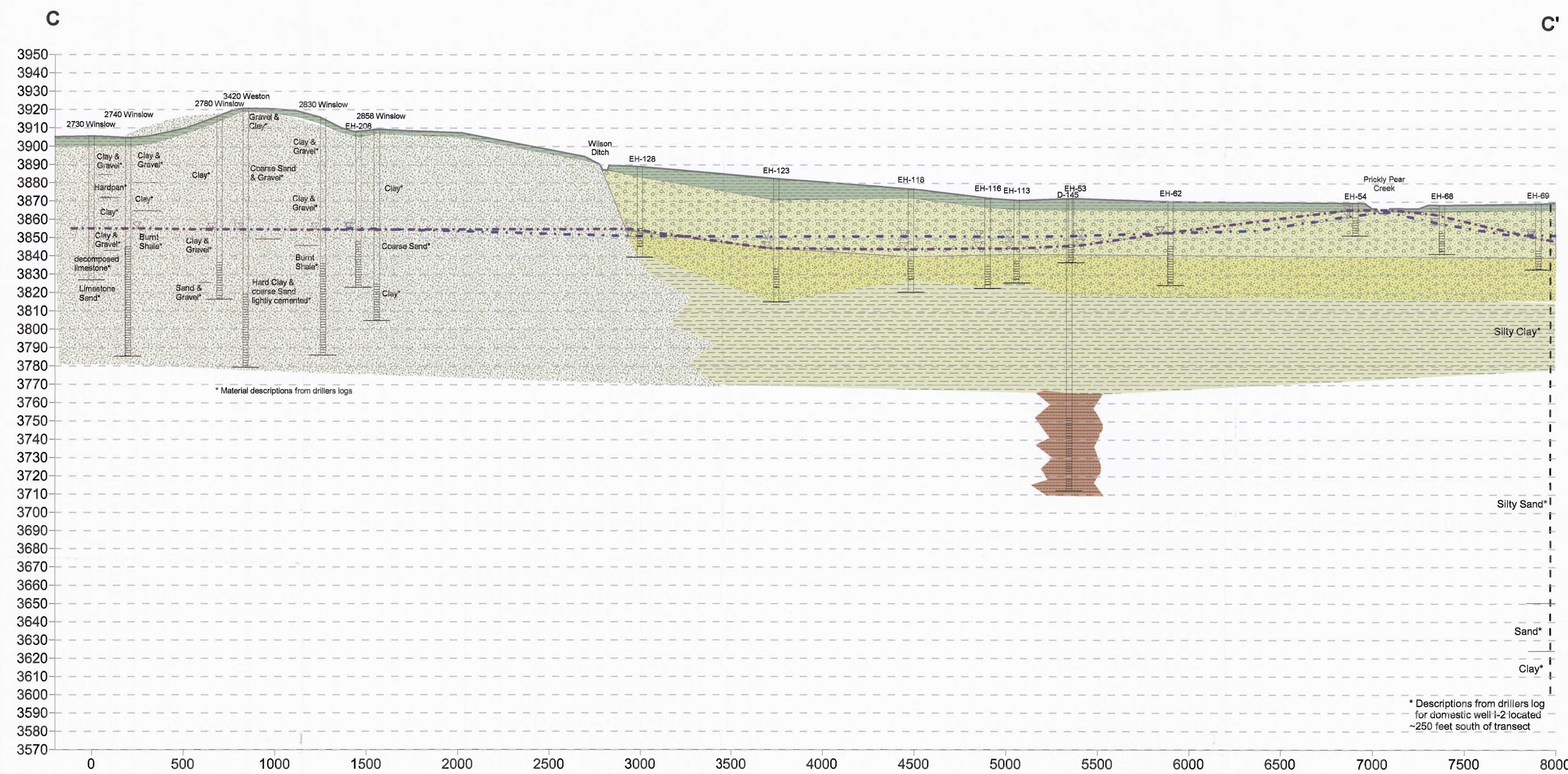
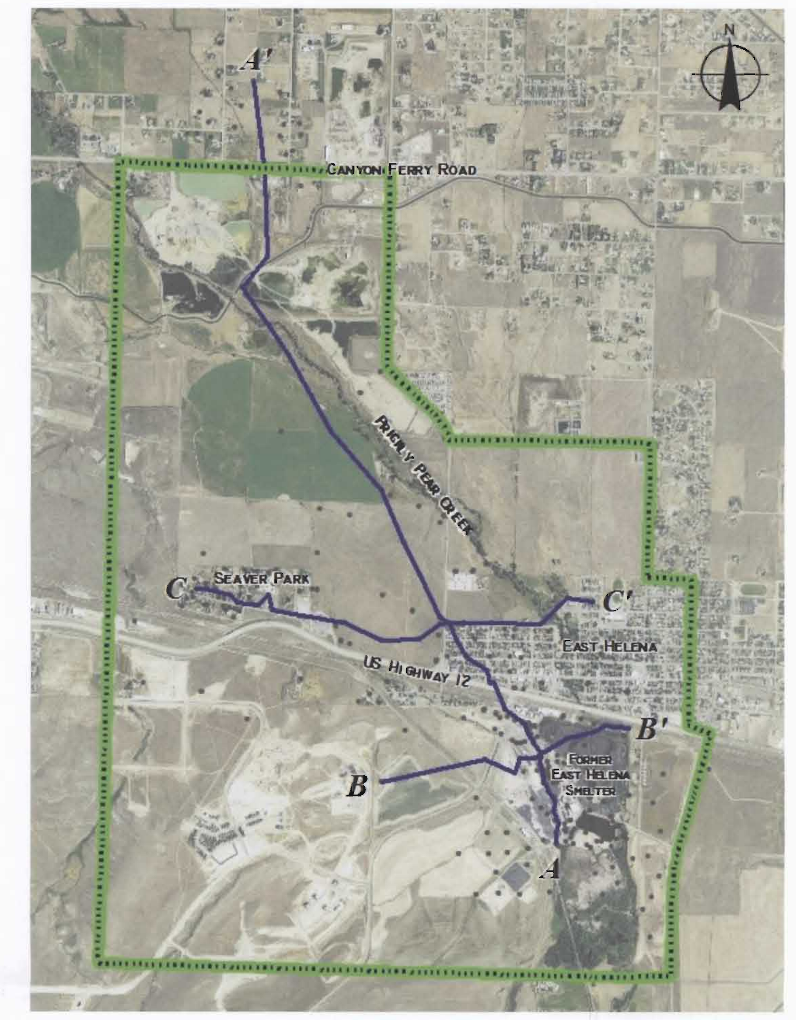
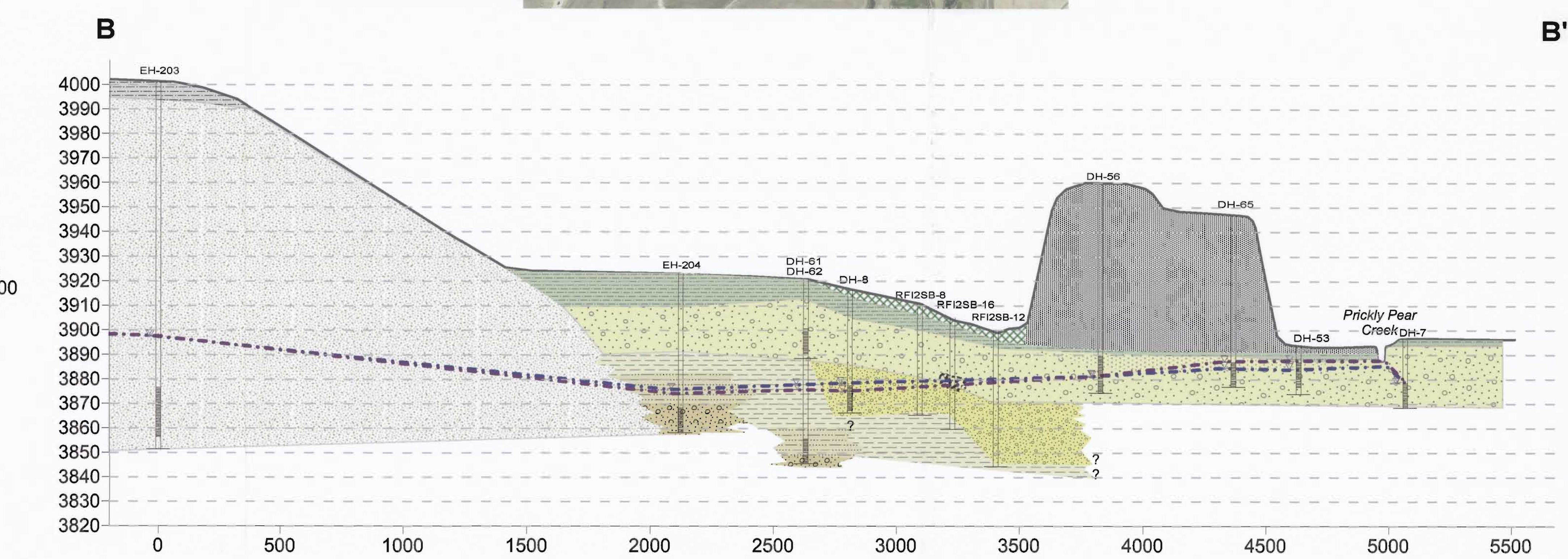
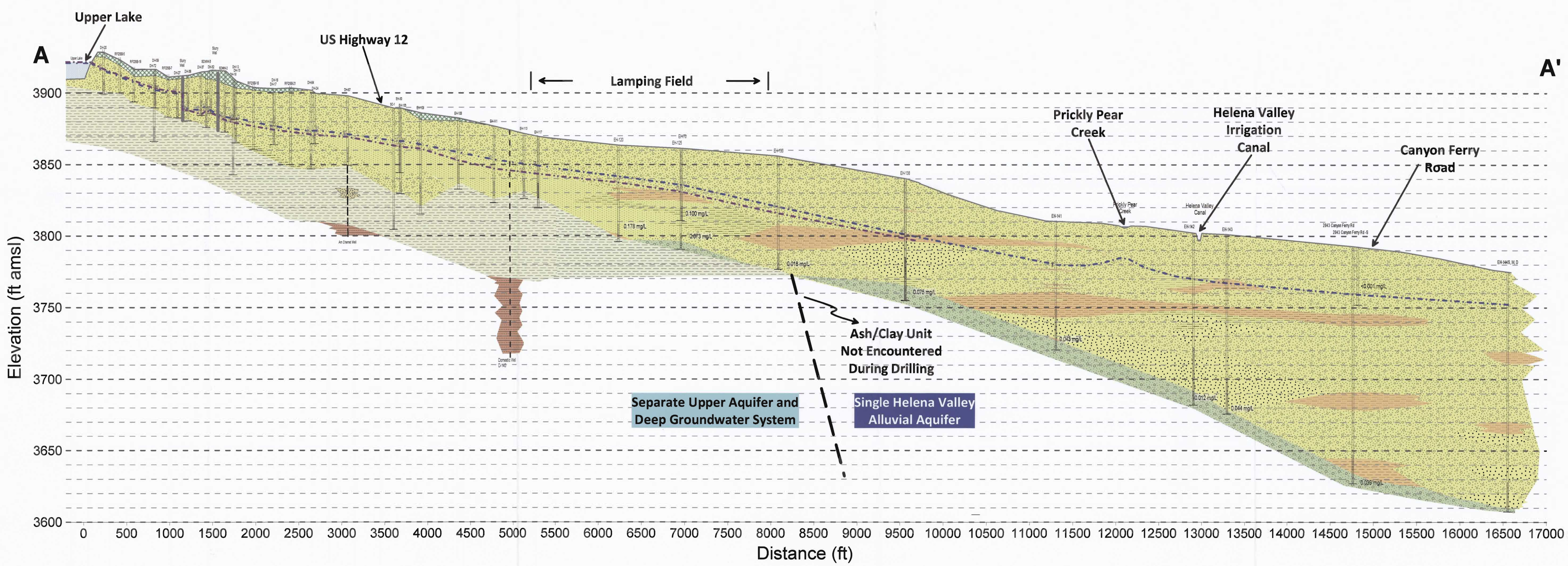
PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	EAST HELENA FACILITY MONITORING WELL LOCATIONS	EXHIBIT 1









LEGEND

- Slag
- Fill
- Holocene Silt
- Quaternary Sand & Gravel
- Quaternary/Tertiary Silty Sandy Clay
- Quaternary/Tertiary Sand
- Quaternary/Tertiary Silty Sand & Gravel
- Undifferentiated Tertiary Silt Sand & Gravel
- Tertiary Volcaniclastic Silt/Clay Unit (weathered ash)
- Tertiary interlayered F.Sand & Volcaniclastic Silt/Clay
- Tertiary Sand & Gravel
- "Burnt Shale" (material description in well log typically used to refer to a consolidated clay)
- Hardrocarbon stained soils
- Spring static water level
- Fall static water level

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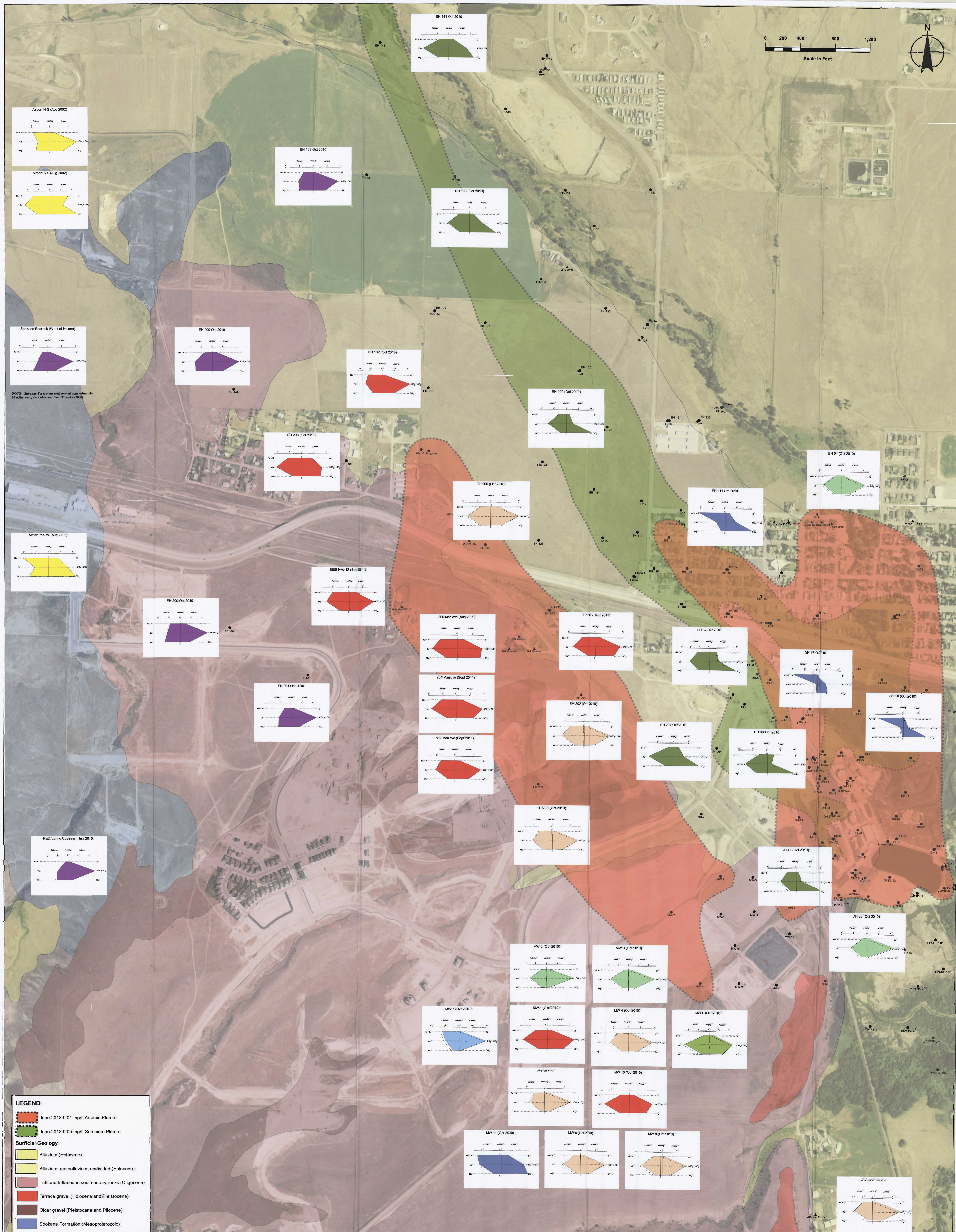
PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	GEOLOGIC CROSS SECTIONS	EXHIBIT 2



Document Path: V:\10022\GIS\CGWA\Exhibits\Exhibit 3_Geochem.mxd

Hydrometrics, Inc. Consulting Scientists and Engineers	PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	LOCAL GROUNDWATER GEOCHEMISTRY EAST HELENA FACILITY	EXHIBIT 3

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PETITION FOR EAST VALLEY CONTROLLED GROUNDWATER AREA	PROPERTY OWNERSHIP WITHIN EAST VALLEY CONTROLLED GROUNDWATER AREA	EXHIBIT 4