Appendix F
EPA Environmental Response Team (ERT) Data Gap Remedial Investigation Report

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Contents

This appendix contains the *Final Report Iron King Mine Site, Dewey-Humboldt, Arizona* developed by Lockheed Martin Scientific, Engineering, Response, and Analytical Services (Lockheed Martin SERAS) in February 2015. The report documents Phase 4 of the remedial investigation (RI), which consisted of additional investigations performed in 2013 through 2015 by EPA's Environmental Response Team (ERT) to satisfy data gaps. The Phase 4 investigation scope is discussed in detail in Section 4.5 of the RI Report.

The ERT/Lockheed Martin SERAS report contains the following sections:

- Section 1 - Subsurface Investigation: Humboldt Smelter and Chaparral Gulch
- Section 2 - Surface Geophysical Investigation: Smelter Tailings Swale and Adjoining Floodplain
- Section 3 - Dross, Plateau Soils, and Slag Investigations
- Section 4 - Main Tailings Pile and Waste Rock Investigations
- Section 5 - Installation of New Site-Wide Monitoring Wells
- Section 6 - Geologic Model
- Section 7 - Groundwater Sampling
- Section 8 - Surface Water Sampling & Monitoring
- Section 9 - Biological Survey and Bioassessment Sampling
- Section 10 - Soil Ecological Testing
- Section 11 - Soil Sampling: Residential Properties
- Section 12 - Surface Soil Sampling: Non-Residential Areas
- Section 13 - Analysis, Validation, and Data Management
- Section 14 - Survey Report

The PDF that follows contains the text, tables, and figures for each section. Because of the number of files and file size, the PDF does not include the following items. These files are provided separately.

- Appendixes associated with the individual sections listed above
- Report appendixes, which include the following
  - Appendix A: Scribe File
  - Appendix B: Final Laboratory Reports
  - Appendix C: Standard Operating Procedures (SOPs)
  - Appendix D: Geographic Information System (GIS) Files
- Support Information, which includes the following:
  - Chaparral Gulch flood hazard survey prepared by Cardno, Inc., for Yavapai County
  - Construction materials survey performed by Lockheed Martin SERAS to identify local offsite sources of natural materials that could be used in future Site remediation
  - Geotechnical laboratory data
  - Humboldt Smelter stack structural condition assessment performed by Core Structure Group, LLC (subcontractor to Lockheed Martin SERAS)

FINAL REPORT
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

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EXECUTIVE SUMMARY

The Iron King Mine-Humboldt Smelter Superfund Site (Site) is located in the Town of Dewey-Humboldt (Yavapai County), Arizona. The Site is a combination of sources and releases from two primary areas: the Iron King Mine (IKM) and the Humboldt Smelter (HS). A portion of the Town of Dewey-Humboldt is situated between the IKM and the Smelter.

The primary contaminants of concern at the Site are lead (Pb) and arsenic (As). For "source" delineation (i.e., excluding residential properties), EPA Region 9 had defined cut-off concentrations of 400 and 200 milligrams per kilogram (mg/kg) for Pb and As, respectively.

Three waterways (Chaparral Gulch, Galena Gulch and Agua Fria River) also transect the Site or Site boundaries. Most portions of Chaparral Gulch and all of Galena Gulch are classified as ephemeral as they only support water for short periods of time following major rainfall events. The section of the Agua Fria adjacent to the Site and a lower section of Chaparral Gulch, downstream of the Chaparral Gulch Dam, support at least some water most if not all times during any given year.

The IKM occupies approximately 153 acres and is bordered by Chaparral Gulch to the north, Galena Gulch to the south, Highway 69 to the east, and undeveloped land to the west. The IKM is comprised of the Iron King Mine proper area, an operations area, and a former fertilizer plant. The mine was periodically operated from 1906 to 1969 for extraction of gold, silver, copper, lead, and zinc. The Main Tailings Pile (MTP) on the property covers over 55 acres, is over 100 feet high, and contains over 6,000,000 cubic yards of tailings.

The HS Area, located east of Highway 69, occupies approximately 182 acres along the north side Chaparral Gulch, including property at the east end of Main Street around the old smelter stack. This area includes approximately 17.5 acres of yellow-orange tailings, 15 acres of grey smelter ash (called *dross*), and 10.5 acres of slag material. These mine-related and smelter wastes are sources of Pb and As contamination to neighboring residential soils through air transport, surface deposition, and in some cases, use as yard fill material. In addition to nearby residential areas, areas of concern around the Smelter area also include sections of Chaparral Gulch, the Agua Fria River, and adjoining drainage channels and outfalls.

In July 2013, the Environmental Protection Agency (EPA) Region 9 (the Region) requested assistance from the EPA/Environmental Response Team (ERT) for conducting a data gap assessment at the Site. The objective of this assessment was to collect additional site-specific data that will be used to assist in developing and evaluating remedial alternatives and completing a feasibility study (FS) for the Site. Lockheed Martin personnel from the Scientific, Engineering, Response and Analytical Services (SERAS) contract assisted the EPA/ERT in completing this work.

Objectives, approaches, and methods that were used to address identified field tasks were developed from the following:

- Information presented in a draft Data Gap Analysis Report (CH2M Hill, 2013);
- Conference calls between the Region, ERT, SERAS, CH2M Hill (the Region 9 contractor); and
- Site reconnaissance.

Site-specific data were acquired for each area of concern, including source areas and other potentially impacted areas, as well as site-wide groundwater and surface water. The source areas include the IKM property and MTP, the HS Area (smelter dross, smelter slag, and smelter tailings), Lower Chaparral Gulch, Chaparral Gulch Dam, and the Agua Fria River. Potentially impacted areas include peripheral or undeveloped areas around the IKM property, Galena Gulch, upper and middle sections of Chaparral Gulch, and in-town residential parcels.

During August 2013, ERT and SERAS personnel mobilized to the site to assess a cluster of ten residential properties that were presumed to contain elevated concentrations of lead and arsenic in surface soils. Subsequent to this event, all other field activities at the Site were conducted between late January and late October 2014. Only minor survey work on the slag pile remains (i.e., crack monitoring) and is expected to be completed by May 2015.

This Final Report is comprised of 14 Sections that include tables, figures, and Section-supporting appendices (e.g., borehole logs, photo documentation). Four (4) additional appendices are also included that apply to most Sections: Appendix A contains the Scribe database (Microsoft® Access database); Appendix B contains all of the Final Analytical Reports associated with this project; Appendix C contains pertinent SERAS *Standard Operating Procedures* (SOPs) that were used to complete specific tasks; and Appendix D contains the geographic information system (GIS) files that were created to produce all the figures in the document. Most Sections of this report pertain to specific field activities that were conducted either throughout the Site or within specific areas of concern. In most instances, the work associated with each Section (presented below) has been summarized in bulleted fashion.

Section 1 - Subsurface Investigation: Humboldt Smelter and Chaparral Gulch

- Between Third Street and the Chaparral Gulch Dam, a track-mounted sonic drilling rig was used to advance 99 shallow borings in Chaparral Gulch to define the horizontal and vertical extents of tailings. An additional 16 borings were drilled at selected locations within the Smelter Tailings Swale to define the vertical extent of the tailings. Borehole depths ranged from approximately 1.5 to 38 feet with most ending at the top of bedrock (i.e., competent, weathered, or unlithified).
- Over 500 samples of unconsolidated material were collected and analyzed with a field portable x-ray fluorescence (XRF) analyzer for Pb, As and other metals of interest.
- A number of samples were also collected for laboratory analysis or testing, which included Target Analyte List (TAL) metals, synthetic precipitation leaching procedure (SPLP) followed by metals analysis, acid-base accounting (ABA), and physical properties characterization (i.e., grain size, plasticity, and moisture content).

- Five 2-inch diameter Schedule 40 polyvinyl chloride (PVC) piezometers were installed at four borehole locations within the Chaparral Gulch floodplain and adjoining Smelter Tailings Swale to monitor groundwater fluctuations during the course of the field investigation.
- A preliminary conceptual model of the Chaparral Gulch study area is also presented in this section, which is based on available geologic reports for the region and local area.

Section 2 - Surface Geophysical Investigation: Smelter Tailings Swale and Adjoining Floodplain

A surface geophysical investigation of the Smelter Tailings Swale and the adjoining floodplain was conducted to determine the subsurface geometry (i.e., variable thickness) and volume of the tailings. Geophysical methods included multi-electrode resistivity and frequency domain electromagnetics (terrain conductivity). Activities included:

- An initial site visit and examination of the variable local topography to establish the appropriate geophysical methods to employ;
- Acquisition and modeling of Schlumberger array (multi-electrode resistivity) data to assist in mapping the thickness of transported and re-deposited mine tailings;
- Analysis of terrain conductivity response measurements;
- Delineation and mapping of tailings deposits based on the collected data; and
- Volume estimation of tailings.

Section 3 - Dross, Plateau Soils, and Slag Investigations

<u>Dross Investigation</u>

- Approximately 300 unconsolidated samples were collected from 140 hand auger and seven sonic-drilled borehole locations to determine the spatial extent and volume of the dross material. Investigation depths were variable, usually averaging around 2 to 3 feet below grade. In one area (a sonic-drilled borehole), the maximum drilling depth was approximately 11 feet below grade. Collected samples were also used to determine the spatial extent and volume of contaminated soils (or natural deposits) beyond and beneath the dross.

- All samples were analyzed for Pb, As, and other metals of interest using a field portable XRF analyzer. A limited number of samples were also collected for laboratory analysis or testing, which included TAL metals, SPLP metals, ABA, dioxins/furans (two samples), and physical properties characterization (i.e., grain size, plasticity, and moisture content).

<u>Plateau Soil Characterization</u>

- The primary objective of this investigation was to provide analytical and test results that could be used to develop a conceptual design for a possible containment cell to store the dross material.

- Boreholes were advanced up to approximately 7.5 feet in depth at five locations using a track-mounted sonic drilling rig. Continuous samples (from grade to final depth) were collected at each location and logged for lithology and moisture conditions.

- A total of 11 samples were collected from five borehole locations and analyzed for Pb, As, and other metals of interest using a field portable XRF analyzer. A limited number of samples were also collected for TAL metals analysis and physical properties characterization (i.e., grain size, plasticity, and moisture content).

<u>Slag Pile Characterization</u>

- Two slag piles exist on the HS property. The main slag pile is located directly north-northeast of the smelter stack and a smaller satellite slag pile is located approximately 1,400 feet southeast of the smelter stack.

- Three surface samples of slag material were collected: one from the main slag pile and two from the satellite slag pile. All samples were analyzed for TAL metals, SPLP metals, ABA, and specific gravity.

Section 4 - Main Tailings Pile and Waste Rock Investigations

<u>Shallow Boreholes</u>

- A track-mounted sonic drilling rig was used to advance 11 boreholes (up to 24 feet in depth) in areas beyond the MTP to determine the extent of mine-related contamination: Five boreholes were drilled in an area west of MTP; and six boreholes were drilled in an area southwest of main retention ponds (below the 1964 "blowout" area). Continuous samples were logged for lithology, moisture conditions, presence of perched water, and occurrence and depth of the tailings.

- Approximately 50 samples were collected from the 11 boreholes and analyzed for Pb, As, and other metals of interest using a field portable XRF analyzer.

<u>MTP Investigation</u>

- A truck-mounted sonic drilling rig was used to advance three deep boreholes through the MTP and into underlying native material (i.e., the Hickey Formation). Continuous sonic core samples were collected from grade to final depth in each borehole to assess the physical characteristics of both the tailings and underlying Hickey Formation (weathered or unlithified bedrock). Total borehole depths ranged from approximately 77 to 134 feet below grade, which extended 28 to 30 feet beyond the base of the tailings, into the underlying Hickey Formation.

- Three to four unconsolidated samples were collected from each borehole for analysis of TAL metals, SPLP metals, and ABA. Samples were collected near the ground surface, in wet intermediate zones within the tailings, near the base of the tailings (two boreholes), and in the underlying Hickey Formation.

- Standard Penetration Tests (SPTs) were conducted at regular intervals in each borehole and a total of 48 samples (retrieved with either Shelby tubes or thick wall ring-lined samplers) were obtained for a number of laboratory geotechnical tests (with a combined total of 101).

- Upon drilling termination at each location, the borehole was backfilled to the base of the tailings and completed as a well to monitor for perched or transient groundwater within in the MTP. The wells were constructed with 4-inch diameter, Schedule 80 PVC riser pipe and 20 feet of 10 slot Schedule 80 PVC screen, with the bottom of the screens positioned near the base of the tailings. Four intermediate depth wells (CHF-MW01, CHF-MW02, CHF-MW03 and STS-MW04I) and one shallow depth well (STS-MW04S) were installed.

<u>Waste-Rock Investigation</u>

- A visual survey of waste-rock piles on the IKM site was performed to assess their suitability as construction material for possible use during future site restoration. Waste-rock was stockpiled in an area west of the former IKM operations area and along the east side of Galena Gulch. Three samples of waste-rock material were collected from the area west of the former operations area and analyzed for TAL metals, SPLP metals, and ABA.

Section 5 - Installation of New Site-Wide Monitoring Wells

- A combination of track-mounted and truck-mounted sonic drilling rigs were used to install six new monitor wells at four locations (east of Highway 69). Two wells (both shallow and deep) were installed at two new monitoring locations (MW-10S/10D and MW-12S/12D); one deep well (MW-02D) was installed adjacent to an existing shallow well (MW-02S); and one shallow well (MW-11S) was installed at a new monitoring location.

- Sonic drilling was primarily used for borehole advancement. However, for the three deep wells (MW-02D, MW-10D and MW-12D), downhole air hammer drilling was required at some point during borehole advancement to reach targeted depths. For all sonic drilling, the boreholes were continuously cored, sampled, and logged from ground surface to final depths. During borehole advancement with the hammer bit, washed drill cuttings were periodically collected for lithologic description.

- The monitor wells were constructed with 4-inch diameter Schedule 80 PVC riser pipe and varying lengths of 10 slot (0.010 inches) Schedule 80 PVC screen. Final depths for shallow wells (MW-10S, MW-11S, and MW-12S) ranged from 45 feet (MW-12S) to 77 feet (MW-11S) with all having screen intervals of 15 feet. Final depths for the deep wells ranged from 175 feet (MW-12D) to 356 feet (MW-02D) with screen intervals ranging from 30 to 50 feet.

- Subsequent to installation, the completed monitor wells were developed using a combination of air lifting, surging, and pumping.

- This section also provides a review of the regional geology and hydrogeology, a presentation of two geologic cross sections that were developed for the Site, a review of groundwater fluctuations in the Chaparral Gulch floodplain piezometers, and an assessment of vertical groundwater gradients using selected well couplets (i.e., paired shallow and deep wells).

Section 6 - Geologic Model

Based on data collected during the 2014 field investigations, along with acquired data from previous investigations, a geologic model (with focus on Chaparral Gulch) was developed for the Site using both 3-dimensional (3D) and 2-dimensional (2D) visualization software. Components of the model included:

- A hydrostratigraphic schematic section, extending along the axis of Chaparral Gulch, from the IKM Site to the Chaparral Gulch Dam;
- A number of stratigraphic profiles across Chaparral Gulch, between Third Street and the Dam;
- An isopach map of tailings within the Gulch showing their thickness and horizontal extents;
- Depth to groundwater contours and schematic flow directions within the Gulch area;
- Visual illustrations showing the distribution of elevated lead-arsenic concentrations in unconsolidated deposits along the Gulch (at 5-foot depth intervals); and
- Tabulated concentrations of arsenic, lead, and copper from over 500 borehole samples.

Section 7 - Groundwater Sampling

- Groundwater samples were collected on two occasions (late July and late October 2014) from both existing and new monitor wells to 1) further evaluate contaminant distributions in groundwater throughout the study area, and 2) develop a detailed knowledge of the groundwater chemistry for assessing the chemical signatures of the groundwater and understanding the chemical reactions that are occurring along the groundwater flow paths.

- The following sets of monitor wells (or piezometers) were sampled: 10 existing monitor wells, the six new 4-inch PVC wells, and four of the five new 2-inch PVC piezometers (within the Chaparral Gulch floodplain area). A number of wells, including the three new wells on the MTP, were found to be dry during both sampling events.

- Laboratory analysis of samples included the following: total TAL metals (unfiltered samples), dissolved TAL metals (filtered samples) and water quality parameters (alkalinity-carbonate-bicarbonate, chloride, fluoride, nitrate + nitrite, sulfate, phosphorus, total silica, dissolved organic carbon, and total dissolved solids). A number of field indicator parameters (e.g., pH) were also recorded during both sampling events.

- Water levels were additionally recorded in the existing monitor wells on three separate occasions (June, July and October 2014) and in the new wells on two occasions (July and October 2014).

Section 8 - Surface Water Sampling & Monitoring

- A number of surface water samples were collected to assess the impact of site sources on surface water quality in the Chaparral Gulch (downstream of the dam) and the adjoining Agua Fria River during the summer 2014 monsoon season (i.e., when rainfall, surface water flow, and sediment transport are typically at their highest). Six baseline samples were collected in early May 2014. Dedicated sampling devices were subsequently installed at nine locations to collect storm water samples in the absence of field personnel. Attempts were made to collect samples from these devices on three occasions. Total TAL metals were analyzed for all locations (i.e., when sample volumes were sufficient). For some locations, additional analyses included dissolved TAL metals, water quality parameters, and field indicator parameters.

- Sediment samples were collected at eight locations in Chaparral Gulch, from the base of the dam to the confluence of the Agua Fria River, to determine sediment thickness above underlying bedrock and TAL metal concentrations within the sediments.

- Channel survey measurements were acquired at two locations in Lower Chaparral Gulch (downstream of the dam) where pressure transducers had been installed by SERAS to monitor changes in flow height (or water surface elevation) from early July through late October 2014. Knowing the flow height, channel geometry, and other channel conditions, standard methods for open channel flow were used to determine peak discharges and associated channel velocities during the monitored period.

Section 9 - Biological Survey & Bioassessment Sampling

<u>Biological Survey</u>

- The objective of the biological survey was to assess riparian corridors and upland areas within the Site boundaries that would provide suitable habitat for wildlife. As much of the habitat in and around the Site has previously been defined, the majority of the survey effort focused on the habitat in and surrounding the riparian corridor of the Agua Fria River.

- Benthic community and fish observations were documented at selected locations along the Agua Fria River and wildlife observations were recorded while traveling from one area to another throughout the Site. Benthic macroinvertebrate samples were also collected at seven locations along the Agua Fria for archiving; and if required at some point in the future, more rigorous identification.

- Based on the survey work, a general habitat map was developed for the Site along with a tabulated summary of observed species and associated habitats.

Bioassessment Sampling

- The objective of the bioassessment sampling was to provide estimates of bioaccumulation for a future Site ecological risk assessment. Sampling activities included:

  - Collection of 41 sediment samples and 18 surface water samples along Chaparral Gulch and the Agua Fria for analysis of TAL metals; nine water samples were also analyzed for a suite of water quality parameters;
  - Collection of ten co-located plant material and surface soil (tailings) samples from the MTP for analysis of TAL metals; and
  - Collection of 16 samples from the MTP and Galena Gulch for *in vitro* bioaccessibility (IVBA) analysis for lead and arsenic.

Section 10 - Soil Ecological Testing

- A bench-scale plant growth study and agronomic analysis were conducted on a limited number of surface and near-surface samples collected from the Chaparral Gulch floodplain, the MTP, and Dross area to asses why non-vegetated areas exist adjacent to well-vegetated areas.

- Samples were characterized and tested in a controlled laboratory setting for their ability to support plant growth. Agronomic analyses included plant nutrients, pH, electrical conductivity, organic matter content, acid sulfate scoring, acid producing capability, bioaccessibility, percentage of sand/silt/clay, and soil textural class.

Section 11 - Surface Soil Sampling: Residential Properties

- Surface soil sampling was conducted on residential properties located in the vicinity of the IKM and HS sites. The field effort, as specified by EPA Region 9, focused on properties that may have been (or were believed to be) impacted by site-related contamination. The acquired data will be used in conjunction with previously collected data for EPA Region 9 to assess human health risk to residents on properties within the Area of Potential Site Impacts (APSI).

- Preliminary activities for this field effort included obtaining property access (with the assistance of EPA/ERT) and defining residential property boundaries (using a GIS database obtained from Yavapai County).

- Two primary categories of residential yards that were designated for sampling within the APSI included:

  - Yards requiring yard-specific risk characterization; and
  - Yards located within an area designated for an area-based risk screening. Based on the results of the area-based screening, some of these properties were elevated to yard-specific risk characterization.

- Clean stainless steel spoons, stainless steel trowels, and hand augers were used to collect samples. Most sampling intervals were 0- to 2-inches and 10- to 14-inches below grade.

- In total, 4,400 samples were collected from 373 properties: Area-based risk screening included 88 properties and 257 samples; Yard-specific risk characterization included 285 properties and 4,143 samples.

- All soil samples were analyzed for lead, arsenic, and other metals of interest using a field portable XRF analyzer. Ten percent (%) of the samples were submitted for laboratory confirmation analysis of TAL metals.

- A total of 40 soil samples were additionally collected on residential properties for IVBA analysis for Pb and As (21 during this investigation and 19 by EPA Region 9 in April/May 2013).

Section 12 - Surface Soil Sampling: Non-Residential Areas

- Non-residential surface soil sampling was intended to evaluate metal contaminants, particularly lead and arsenic, in areas surrounding the IKM. A total of 341 surface and near-surface samples were collected with clean trowels and hand augers to depths up to three feet below grade. Approximately 43% of the samples were collected from 0- to 2-inches below grade and another 41% were collected from 10- to 14-inches below grade.

- All samples were analyzed for Pb, As, and other metals of interest using a field portable XRF analyzer. Additionally, 18 confirmation samples were collected for laboratory analysis of TAL metals.

Section 13 - Analysis, Validation, and Data Management

A summary of analyses (both field and laboratory), data validation, and data management that were used for the Site assessment are presented in Section 13. The information contained in this section is applicable to the data presented in most of the other sections. Ten laboratories, including an on-site ERT/SERAS XRF Laboratory, a Contract Laboratory Program (CLP) laboratory, the EPA Region 9 Laboratory, ERT/SERAS Inorganic Laboratory, and SERAS subcontracted laboratories were utilized to meet the analytical objectives for this project. Levels of data validation varied and are specified in Section 13.5.

All field measurements (e.g., geospatial data and XRF data) and analytical results were imported to the Scribe database (Appendix A). Data in the Scribe database may be utilized directly through Scribe or through database management software such as Microsoft Access. Key fields and naming conventions for sampling events, sample areas, and sample names used within the database are also discussed in Section 13.

Section 14 - Survey Report

Lockheed Martin SERAS subcontracted an engineering firm (Granite Basin Engineering, Inc., Prescott, Arizona) to perform ground survey work in and around the IKM and HS. Work included:

- Horizontal and vertical survey measurements of new monitor wells that had been installed throughout the study area by SERAS;
- Survey measurements on the slag pile for monitoring potential movements along existing cracks;
- Gathering and mapping both topographic and subsurface data around the Chaparral Gulch Dam (to assist with a subsequent structural stability assessment);
- Acquiring topographic data throughout the Smelter Tailings Swale to estimate the volume of tailings within this area; and
- Surveying channel cross sections and a longitudinal profile in an area downstream of the Chaparral Gulch Dam to assist with a hydraulic analysis of the Lower Chaparral Gulch.

Granite Basin's *Iron King Mine Survey Report* and supporting data, figures, and tables can be found in Section 14.

SECTION 1 – Subsurface Investigation: Humboldt Smelter and Chaparral Gulch

1.1 INTRODUCTION

The Iron King Mine (IKM) Site covers 153 acres and is located directly west of the town of Dewey-Humboldt along the flank of Spud Mountain (Figure 1-1). The IKM is located in the headwaters of the Chaparral Gulch Arroyo that drains into the Agua Fria River. The Humboldt Smelter (HS) site is approximately three miles east of the IKM, and directly north of Chaparral Gulch on a bluff overlooking the Agua Fria River.

1.2 BACKGROUND

The IKM operated from the late 1890s to 1968, with production peaking in 1963 (ACS, 2008). The ore from IKM was composed primarily of zinc (Zn) and lead (Pb) sulfide minerals, with lesser amounts of copper (Cu), silver (Ag) and gold (Au). Total ore production from the IKM was 6,033,912 tons, which was milled and concentrated on site. The Zn-Pb concentrate was shipped offsite for smelting, and the milled waste (tailings) was stockpiled on site, filling a draw at the headwaters of Chaparral Gulch. The IKM Main Tailings Pile (MTP) is estimated to contain over 6,000,000 cubic yards of tailings (EA, 2010).

The IKM was mined along a strike length of 1,600 feet and to a depth of 3,250 feet, consisting of approximately 40 miles of underground workings (ACS, 2008). After mining operations ceased in 1968, the underground workings were allowed to flood. Based on water level measurements from three deep wells (AZDEQ Reg # 55-904580, 55-904634 and 55-904635) in Galena Gulch, directly east of three IKM shafts, the IKM underground workings could be flooded to an approximate depth of 200 feet below ground surface.

The original HS was constructed in 1899 to process Cu-ore from the Big Bug Mining District (BBMD) located near Mayer, Arizona (AZ). In 1904, the HS was destroyed by fire, rebuilt and redesigned with equipment upgrades to increase the smelters Cu production (ACS, 2008). From 1905 to 1937, Cu-rich ore was shipped from the BBMD to the HS by rail-line. By 1937, ore reserves from the BBMD were exhausted and smelting operations at the HS ceased (ACS, 2008).

The near proximities of the IKM and HS, suggests a relation exists between the two operations, but this does not appear to be true (ACS, 2008). Ore from the IKM is rich in Zn-Pb and low in Cu, while the HS processed Cu-rich ore from the BBMD. In addition, greater than 98 percent (%) of the total production from IKM occurred from 1938 to 1968, well after smelting operations ended at the HS.

1.2.1 Regional Geology

The geology for the IKM and HS vicinity is summarized in Table 1-1. Detailed descriptions of the regional geology can be found in:

- Anderson and Blacet, 1972
- Anderson and Creasey, 1958
- Creasey, 1951
- DeWitt and others, 2008
- Krieger, 1965
- Kumke and Mille, 1950

1.2.2 Lead-Copper (Pb:Cu) Metal Ratios

Ore from IKM is characterized by sphalerite (ZnS), galena (PbS), with lesser amounts of chalcopyrite ($CuFeS_2$) and tennantite ($(Cu,Fe)_{12}As_4S_{13}$). The Zn to Pb (Zn:Pb) ratio for IKM ore ranged from 6.9 to 12.7, averaging 10.4. However, more important to this study is the Pb to Cu (Pb:Cu) ratio, which ranged from 2.1 to 3.8, averaging 3.0 (Anderson and Creasey, 1958). The milling process was more efficient at concentrating Zn and Cu sulfides thereby, increasing the Pb:Cu ratios in the tailings up to 28.9 (IKM-T1 to IKM-T3).

Ore from the BBMD, specifically the Blue Bell and De Soto mines was processed at the HS and characterized by chalcopyrite ($CuFeS_2$). The Pb:Cu ratio from the BBMD ranged from 0.01 to 0.06, averaging 0.03 (Lindgren, 1926). Analytical results from the HS smelter swale showed the tailings were enriched in Pb, with Pb:Cu ratios increasing up to 1.33. This suggests the HS smelting process was more efficient at extracting Cu opposed to Pb from the BBMD ore.

1.3 OBJECTIVES

ERT requested Scientific, Engineering, Response and Analytical Services (SERAS) contract personnel to assist with the following tasks:

- Complete 99 soil borings along Chaparral Gulch, from Third Street (Town of Dewey-Humboldt) to the Chaparral Gulch Dam.
- Complete 16 soil borings in the HS tailings swale.
- Develop a schematic fluvial stratigraphic profile of Chaparral Gulch and HS tailings swale from the soil boring logs.
- Use x-ray fluorescence (XRF) technology to identify fluvial sediments and/or tailings that exceed soil cleanup guidelines for either Pb or arsenic (As).
- Use XRF technology to constrain the origin and depositional history of tailings based on whether the tailings are Pb- (IKM) or Cu-rich (HS).
- Collect additional sediments for physical characterization and analyses of target analyte metals (TAL metals) and acid-base accounting (ABA) parameters.
- Conceptualize the hydraulic gradient in the Chaparral Gulch floodplain based on the initial depth to water, as observed in the 115 soil borings.

1.4 METHODOLOGY

Cascade Drilling (Phoenix, Arizona) completed 115 soil borings between February 6 and February 28, 2014. Soil borings were completed using a Prosonic/Boart Longyear 200C track-mounted Sonic rig (ASTM D6914, 2010).

The soil borings extended from north of Third Street to the Chaparral Gulch Dam over a distance of approximately 3,500 feet (Figure 1-2). The borings define the channel margins of the gulch and depth to bedrock. Due to accessibility, sampling across the upper gulch (upgradient of the HS) required transect-lines to be separated by 75 to 225 feet; while transect-lines across the floodplain (HS to the Chaparral Gulch Dam) were spaced approximately 50 feet apart. Boreholes on each transect-line were spaced from 75 to 100 feet apart, but offset by 50 feet on each successive transect-line to form a diamond pattern. The diamond pattern was used to maximize coverage and minimize contouring artifacts.

1.4.1 Soil Borings

Photographic logs for the soil borings are attached in Appendix 1-A. The lithology of each core was described with select samples targeted for XRF analysis. XRF samples for the shallow boreholes were selected based on changes in lithology and/or stratigraphic contacts. The channel deposits, tailings, Brown Clay, Principle Fluvial Gravels and bedrock were easily distinguishable. Borehole locations are shown on Figure 1-2, with survey data and coordinates recorded in the Scribe database (Appendix A). Depths of the soil borings ranged from approximately 1.5 to 38 feet with the majority ending in bedrock. Borehole coverage is summarized in Table 1-2 and boring logs attached in the designated Appendices 1-B through 1-D.

A unique alphanumeric label was assigned to each boring location, boring location followed by the soil boring number. Borings located northwest of 3rd Street locations have the prefix 'CHU-', boring locations between 3rd Street and the HS swale have the prefix 'CH', and locations in the flood plain by the prefix 'CHF'. Each prefix is followed by the soil boring number (e.g., SB04), which identifies the chronological order in which the boring was completed.

Samples collected from each boring were assigned a unique identifier consisting of the boring location label, followed by a trailing number that identified the depth of sample collection. For example, CHF-SB04-5 was collected from boring CHF-SB04 completed in the Chaparral Gulch flood plain at a depth of five feet. All sample locations are identified in Scribe by their alphanumeric label and geospatial coordinates.

Soil Sampling and Analyses

Targeted soil samples were collected to determine the concentrations of As, Pb, Cu, Zn, iron (Fe), chromium (Cr) and manganese (Mn). A total of 513 samples (Table 1-3) were analyzed in the field by XRF (Section 13.2) for comparison among fluvial, tailings and bedrock types (Figure 1-3). The analytical results are recorded in the Scribe database. XRF results for As, Pb, Cu and Zn XRF analysis are displayed on each log (Appendices 1-B through 1-D).

Soil samples were also collected and analyzed for synthetic precipitation leaching procedure (SPLP) (18 samples), TAL metals (32 samples), ABA (18 samples), hexavalent chromium (Cr^{+6}) (14 samples) and physical properties (28 samples). Analyses for physical properties included Atterberg Limits (plasticity), grain size and moisture content. Results for these analyses are recorded in the Scribe database (Appendix A) and are not discussed further in this document.

Depth to Groundwater

Upon completion of each soil boring, the borehole was left open for up to 24-hours to measure a depth to groundwater, which is recorded on the boring log. Approximately half the boreholes were dry, but the remaining borings reached the water table at depths ranging from 2 to 20 feet below ground surface. Depth to groundwater measurements in the gulch indicate the water table becomes shallower hydraulically downgradient of the HS or that a groundwater mound has developed in materials behind the Chaparral Gulch Dam.

1.4.2 Well Construction

Five monitor wells were installed at four soil boring locations and screened across the water tables. Construction records and locations for monitor well CHF-MW01 to CHF-MW03, and STS-MW04-S (shallow) and STS-MW04-I (intermediate) are attached in Appendix 1-E. Boring locations are summarized as follows:

- CHF-MW01 was constructed in soil boring CHF-SB28
- CHF-MW02 was constructed in soil boring CHF-SB35
- CHF-MW03 was constructed in soil boring CHF-SB38

- STS-MW04-S/I were constructed near soil boring STS-SB15/15B.

1.5 RESULTS AND DISCUSSON

1.5.1 XRF Analytical Results

A total of 513 soil samples from 115 soil borings were analyzed by XRF. The analytical results are recorded in the SCRIBE database (Appendix A) and summarized as follows:

- Thirty-two percent (32%) of the total number of samples and only 54% of the 'tailings' samples subset, exceeded the soil cleanup goal for either As (200 mg/kg) and/or Pb (400 mg/kg).
- A plot of Pb:Cu ratios versus distance from IKM indicates tailings from the IKM may have been transported as far as the dam (and even further), assuming the IKM tailings are characterized by a Pb:Cu ratio greater than 2.0, and HS tailings by a Pb:Cu ratio less than 0.6 (Figure 1-4).

1.5.2 Preliminary Conceptual Model of Chaparral Gulch

The stratigraphy of Chaparral Gulch is summarized in Table 1-4 and a conceptual model of the geologic development of the gulch is summarized below.

- The topography of the Site vicinity prior to Basin and Range uplift (Early Tertiary) was characterized by moderate (up to 500 feet) relief, and a very well developed regolith that mantled the Precambrian Iron King Volcanics (IKV).
- The Basin and Range event began in the Middle Tertiary with gentle uplift and warping as characterized by the deposition of the basal Hickey Conglomerate over the Precambrian IKV.
- Increased tectonism during the middle Tertiary (Miocene) resulted in emergent faulting (uplift) and volcanism as characterized by interbedded Hickey conglomerate and volcanics (mafic ash, cinder and flows).
- Development of fluvial systems during the Late Miocene was dynamic and changing, as drainage systems constantly responded to volcanic eruptions, episodic uplift and increased erosion.
- The Basin and Range event ended (Pliocene) and the Chaparral Gulch drainage system developed. The principle Fluvial gravel is deposited in a bedrock channel that down-cuts through the basal Hickey Conglomerate, across the unconformity and into the IKV in the flood plain.
- Smelting activities begin in earnest at the HS in 1904, with construction of the Chaparral Gulch Dam, and deposition of Cu-rich tailings into Chaparral Gulch. During periods of inactivity at the HS, surficial Cu-rich tailings were reworked and mixed with fluvium. Mixed fluvium is characterized by elevated Cu concentrations and mixed Precambrian and Tertiary volcanic clasts. Smelting activities contributed to the deposition of up to 20 feet of Cu-rich tailings behind the dam.
- Aggressive mining activities at IKM commenced as smelting activities ceased in 1937. Mixed fluvium, characterized by elevated Pb concentrations, prevalent iron-oxide staining, and mixed Precambrian and Tertiary volcanic clasts, are identified from Third Street to the dam, suggesting mining activities at IKM contributed further to the filling of Chaparral Gulch. IKM (Pb-rich) tailings mixed with fluvium that may have added an additional five feet of material in the lower Chaparral Gulch.
- Mining activities ceased at IKM in 1968, but the Main Tailings Pile remains a source of material that may be further weathered and transported into Chaparral Gulch.

1.6 REFERENCES

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TABLES

Table 1-1
Summary of the Regional Geology
Iron King Mine Site, Dewey-Humboldt, Arizona

Quaternary	Fluvial Deposits	• Unconsolidated **active river channel deposits**. Pebbly-sandy silt with some gravel deposits, very poorly sorted to sorted; matrix supported pebbles that are rounded to subrounded Precambrian metavolcanics and granitoids, and some (30 %) Hickey Basalt clasts. • **Fluvial deposits**. Cobbly-pebbly-sandy gravels with a clay matrix. The matrix is mottled dark green, red and dark brown clay. Gravels are pebble supported, loose to compact, and poorly to moderately sorted. Cobble and pebbles are angular to subrounded and entirely composed of Precambrian metavolcanics and granitoid clasts.	
Tertiary	Hickey Formation	• **Massive to vesicular olivine basalt** flows that may or may not be interbedded with water laid, orange to tan mafic ash and cinder. • Red to orange **mafic ash, cinders and bombs** that were deposited proximal to a cinder cone. • Unconsolidated, matrix supported **boulder to pebble conglomerate** with silt to sand matrix that is interbedded with olivine basalt flows. • Tan to light brown, **boulder to pebble conglomerate** with a **marly** (calcite-rich) matrix that is highly indurated and interbedded with both the unconsolidated conglomerate and olivine basalt flows	
Angular Unconformity (Up to 500 feet of pre-existing topographic relief with a well-developed regolith that mantles Precambrian Basement Rocks)			
Tertiary-Cretaceous	Grano-diorite	**Granodiorite**. Zoned plagioclase phenocrysts associated with biotite in a medium grain groundmass of plagioclase, quartz, and potassium-feldspar.	
Precambrian	Metavolcanics and Metasediments (Iron King and Spud Mountain Volcanics)	• **Mafic tuffaceous metasediments** with well-developed foliation and relict bedding surfaces. These rocks are dark grayish-green and contain abundant chlorite. Relict angular fragments of mafic tuff and andesite are common in the groundmass. • **Amygdaloidal andesite flow** that is interfingered with tuffaceous sediments (smt). These rocks are grayish-green and contain abundant chlorite, sericite, clinozoisite, leucoxene, and sparse quartz and calcite. • **Pelitic metasediments** that are metamorphosed to muscovite-chlorite-calcite grade and show well-developed crenulated foliation. These rocks dark green phylites.	
		• **Diorite porphyry** that intrudes the Iron King and Spud Mountain Volcanics (IKV/SMV). Saussuritized plagioclase phenocrysts in a microcrystalline groundmass of plagioclase, quartz, secondary chlorite and epidote. • **Granodiorite porphyry** that intrudes the IKV/SMV. White plagioclase phenocrysts associated with biotite and hornblende in a medium grain groundmass of plagioclase, quartz, and potassium-feldspar. • **Quartz diorite**. Plagioclase, biotite and hornblende with potassium-feldspar. Potassium-feldspar has poikilitic texture. • **Gabbro-Diorite**. Medium grain groundmass, with plagioclase (albite), clinozoisite, chlorite, and/or brown to green amphibole.	Granitoid Intrusives

Table 1-2
Summary of the Soil Borings
Iron King Mine Site, Dewey-Humboldt, Arizona

Chaparral Gulch		**Borings**	**No.**	**Appendix**
Upper Gulch (upgradient of HS Swale)	NW 3rd St	CHU-SB01 to CHU-SB15	15	B
	SE 3rd St to HS	CH-SB01 to CH-SB31	31	
Flood Plain (confluence of HS Swale to Dam	HS to Tailings Dam	CHF-SB01 to CHF-SB47	47	C
	Tailings Dam	DAM-SB01 to DAM-06	6	
HS Tailings Swale (upgradient of the confluence)	HS Swale	STS-SB01 to STS-SB15/15B	16	D

Table 1-3
Summary of Sample Analyses for the Humboldt Smelter and Chaparral Gulch Areas
Iron King Mine Site, Dewey-Humboldt, Arizona

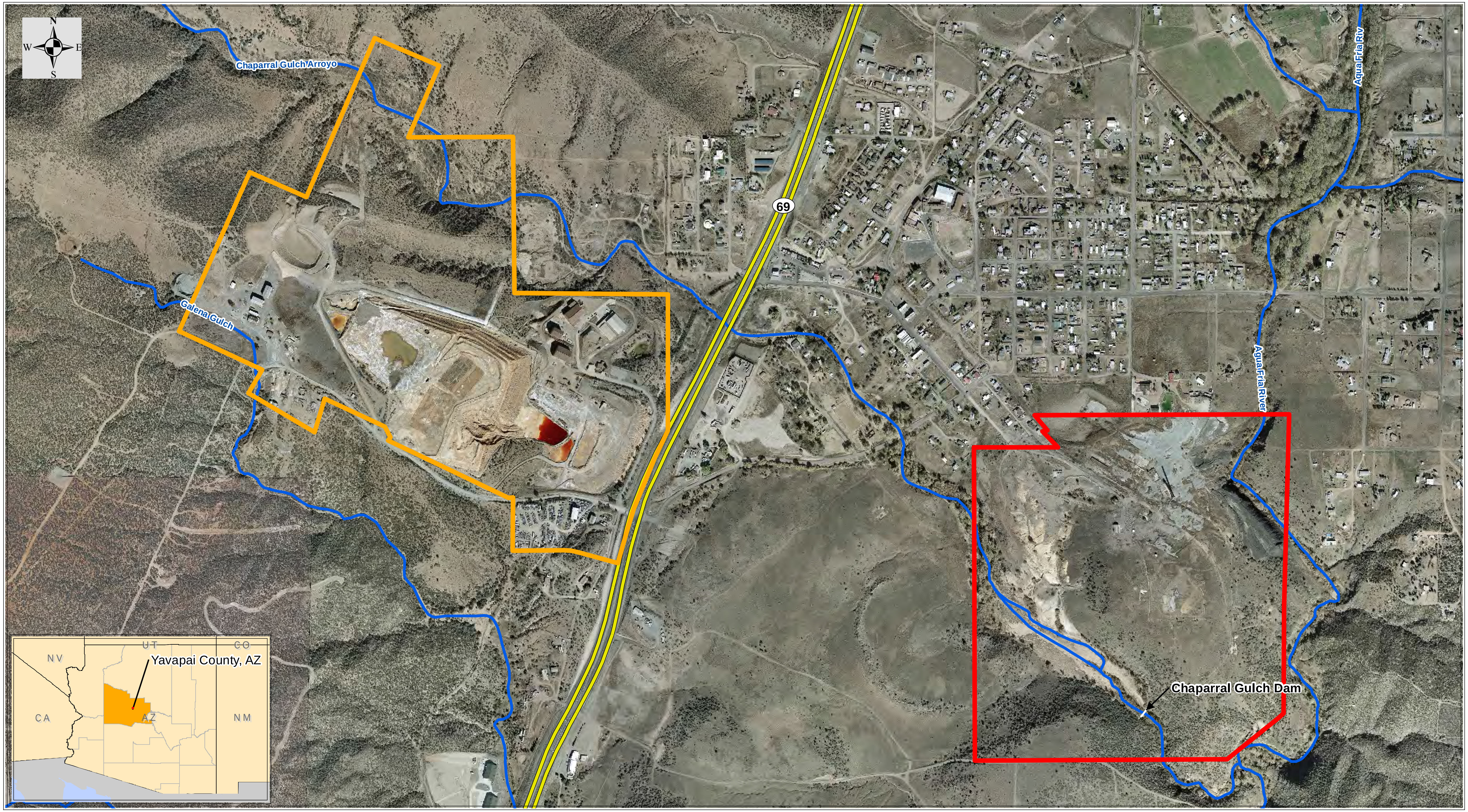
	Smelter Tailings Swale	Chaparral Gulch (upstream of floodplain)		Chaparral Gulch Floodplain	Area Behind Dam	
Laboratory Analysis/Test	STS	CH	CHU	CHF	DAM	Totals
XRF Field	63	111	65	245	29	513
TAL Metals	9	4	3	12	4	32
SPLP Metals	6	0	0	8	4	18
Acid Base Accounting	6	0	0	8	4	18
Hexavalent Chromium	6	1	0	7	0	14
Grain Size	4	7	3	8	6	28
Moisture Content	4	7	3	8	6	28
Atterberg Limits	4	7	3	8	6	28

XRF = X-ray Fluorescence
TAL = Target Analyte List
SPLP = Synthetic Precipitation Leaching Procedure

Table 1-4
Summary of Chaparral Gulch Geology
Iron King Mine Site, Dewey-Humboldt, Arizona

Modern	Channel Deposits/ Tailings	• Unconsolidated **active river channel deposits**. Pebbly-sandy silt with some gravel deposits, very poorly sorted to sorted; matrix supported pebbles that are rounded to subrounded Precambrian metavolcanics and granitoids, and some (30 %) Hickey Basalt clasts. • Reworked unconsolidated **channel deposits and tailings** that are mottled dark green, red, brown and/or ochre. Sediments are silt to very coarse sand with sparse pebbles, very loose; and well to very well sorted. These sediments are commonly interbedded with tailings • **Tailings** consisting of homogeneous silt that is either oxidized (orange, ochre and/or tan) or reduce (black and dark green), with weakly to well-developed laminae. Organic matter is commonly preserved in reduced zone.
Quaternary	Fluvial Deposits	• **Fluvial deposits**. Cobbly-pebbly-sandy gravels with a clay matrix. The matrix is mottled dark green, red and dark brown clay. Gravels are pebble supported, loose to compact, and poorly to moderately sorted. Cobble and pebbles are angular to subrounded and entirely composed of Precambrian metavolcanics and granitoids clasts. • **Lacustrine deposit**. Dark brown clay with very weakly developed laminae to massive texture and very well sorted
Tertiary	Hickey Formation	• **Massive to vesicular olivine basalt** flows that may or may not be interbedded with water laid, orange to tan mafic ash and cinder. • Red to orange **mafic ash, cinders and bombs** that were deposited proximal to a cinder cone. • Unconsolidated, matrix supported **boulder - pebble conglomerate** with silt to sand matrix that is interbedded with olivine basalt flows. • Tan to light brown, **boulder - pebble conglomerate** with a **marly** (calcite-rich) matrix that is highly indurated and interbedded with both the unconsolidated conglomerate and olivine basalt flows
Angular Unconformity (Up to 500 feet of pre-existing topographic relief with a well-developed regolith that mantles Precambrian Basement Rocks)		
Precambrian	Iron King Volcanic	**Amygdaloidal andesite flow** that is interfingered with tuffaceous sediments (smt). These rocks are grayish-green and contain abundant chlorite, sericite, clinozoisite, leucoxene, and sparse quartz and calcite.

FIGURES



Base map created using 2010 orthoimagery.

Map Creation Date: 15 Septmbert 2014

Coordinate system: Arizona State Plane Central
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Legend

Area of Interest

Iron King Mine

Humboldt Smelter

0 750 1,500
Feet

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 1-1
Site Investigation Area
Iron King Mine Site
Dewey-Humboldt, Arizona

Base map created using 2010 orthoimagery,
sample location from GPS survey in 2014.

Map Creation Date: 10 Septempert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

0 240 480
Feet

Data: g:\arcviewprojects\SERAS01\00-146
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U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 1-2
Soil Boring Location
Iron King Mine Site
Dewey-Humboldt, Arizona

Base map created using 2010 orthoimagery, sample location and XRF results from 2014.

Map Creation Date: 30 December 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\TM2014_SoilBoring\SEC1_Shallow Borings_Smelter & CH-Gulch\146_SEC1_XRF_Results_inCH_Gulch_Area_Dsize_f1-3

0 120 240 Feet

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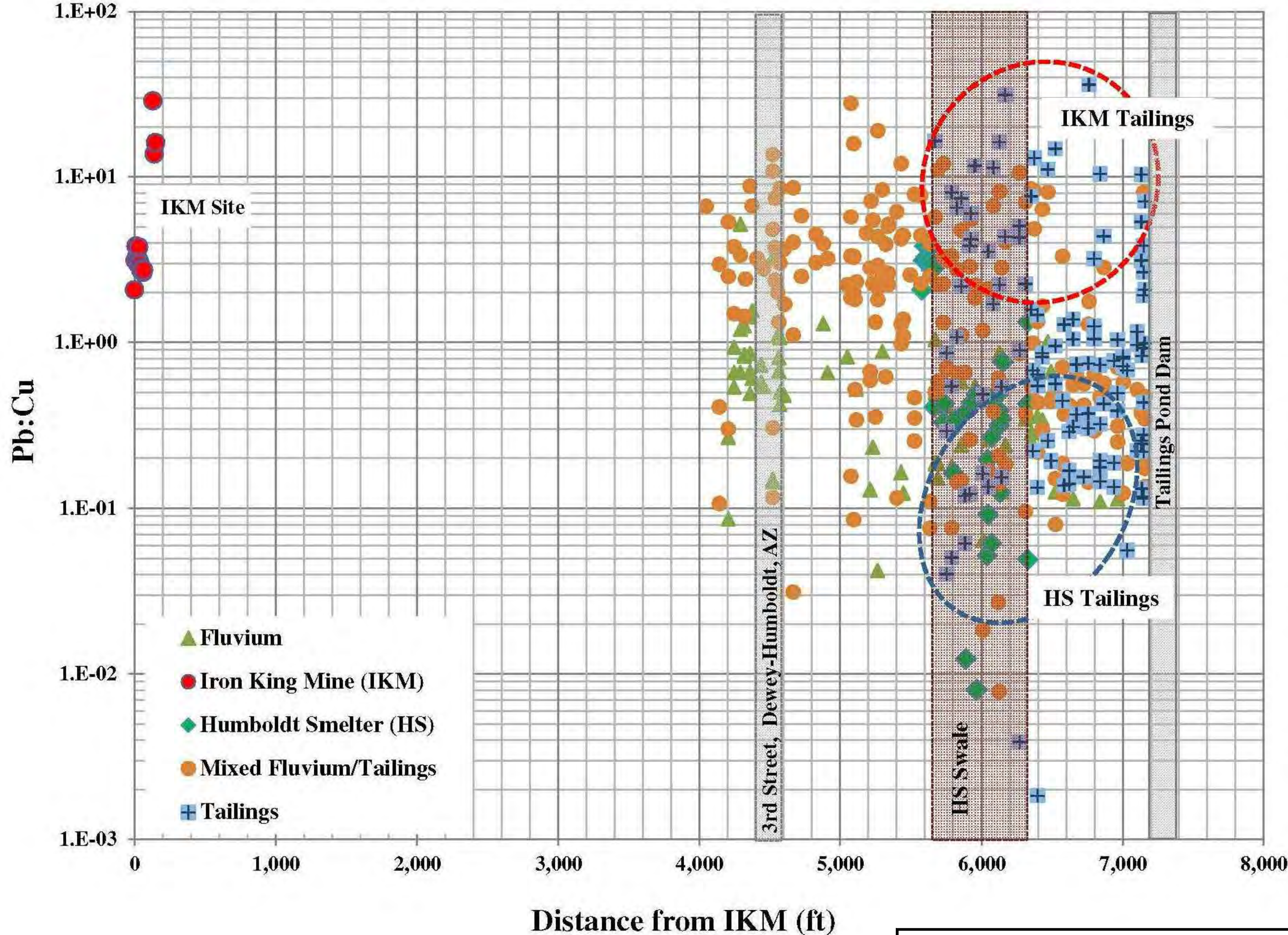
EP-W-09-031
W.A.# 0-146

Figure 1-3
XRF Results in Chaparral Gulch
Iron King Mine Site
Dewey-Humboldt, Arizona



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EP-W-09-031
W.A.# 0 - 146

Figure 1-4
Pb:Cu Ratios Chaparral Gulch
Iron King Mine Site
Dewey-Humboldt, Arizona

J:/SERAS01/ACAD_2013/00-146/TM2014_SoilBorings/146_PbCu_Ratios_f1-4.dwg 09/15/2014

APPENDIX 1-A
Photographs of Borehole Cores
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 1-B
Upper Chaparral Gulch Boring Logs
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 1-C
Chaparral Gulch Boring Logs
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 1-D

Humboldt Smelter Tailings Swale Boring Logs

Iron King Mine Site

Dewey-Humboldt, Arizona

APPENDIX 1-E
Monitor Well Construction Logs
Iron King Mine Site
Dewey-Humboldt, Arizona

SECTION 2 - Surface Geophysical Investigation: Smelter Tailings Swale and Adjoining Flood Plain

2.1 INTRODUCTION

The investigation area for the geophysical study is downgradient from the Humboldt Smelter and the tailings were a result of smelter operations. The tailings are light orange-brown medium sand with few flat pebbles. Based on layering and uniform elevation of the apparent original surface, the material was probably piped in as slurry. An earthen dam held the tailings in place until a catastrophic failure occurred in two places in the dam. Subsequent erosion, primarily along two filled-in gullies left behind a very uneven surface. The two gullies are tributaries to the Chaparral Gulch Arroyo. In the investigation area, Chaparral Gulch is filled with sediment that stopped at a dam downstream. Material eroded from behind the earthen dam overlapping the Chaparral Gulch sediment.

The proposed methods to determine the thickness and geometry of the tailings were based on a site visit to this area on November 16, 2013. During the site visit, geophysical methods dependent on the different electrical properties of the tailings relative to native materials were proposed. Subsequent fieldwork has resulted in a model somewhat different than the one which was originally proposed. The new findings have resulted in an updated approach, which was then used in conjunction with soil borings and surveyed tailings contacts, leading to estimates of the volume of tailings in the study area. Mobilization to perform the geophysical survey took place on January 3, 2014. Fieldwork occurred January 4 through9, 2014.

2.2 METHODOLOGY

2.2.1 Updated Physical Property Analysis

The transported and re-deposited mine tailings do not appear to be significantly different in grain size from underlying in-place alluvial sediments. In addition, the thickness of these re-deposited sediments increases from a feather-edge to more than 3 meters (m) across the erosion-cut channel system which formed the topographic surface prior to the infill with smelter tailings. As observed on the initial site visit, tailings appear to be distinguished from underlying sediments mainly by color. Also, there is significant local topographic variation. These observations indicated that geophysical methods relying on density (gravity, seismic) or acoustic velocity variation (seismic) are not appropriate.

The possibility that lithologic differences between the tailings and underlying sediment may be exploited using magnetic susceptibility differences (magnetics, magnetic gradiometer) was considered. Significant variation in local topography was thought to likely preclude the effectiveness of this approach. In addition, the resolution of the magnetic method is not deemed sufficient to be effective in addressing the objective.

The color differences are likely indicative that the lithology of grains and grain coatings are sufficiently different from underlying sediments that pore water and aqueous grain coatings are enhanced in ionic content. Also it was originally thought that there might be fine coatings of geochemical reaction products (e.g. clays) on the surfaces of these grains. Both of these effects would enhance the electrical conductivity of these sediments above the background level of underlying sediments. Therefore, it was originally thought that the best approach at distinguishing and mapping the thickness of the tailings would be to exploit the electrical conductivity (resistivity) contrast; the conductivity enhancement from clay alteration on grain surfaces would dominate the electromagnetic response.

In addition, due to its ease of data acquisition and interpretation, a ground-penetrating radar (GPR) system was tested. Dielectric permittivity variations between tailings and underlying sediments likely exist, but depth penetration, due to enhanced conductivity, would limit the method's depth of penetration. Tests using the GPR system proved to be ineffective.

The geophysical methods used included multi-electrode resistivity as a primary method, and frequency-domain electromagnetics (terrain conductivity) as a secondary method.

2.2.2 Multi-Electrode Resistivity Method

The multi-electrode resistivity method was the primary geophysical method to address the objective of mapping the thickness of transported and re-deposited mine tailings at the Iron King Mine site. The exact lines to be surveyed were determined by overlaying planned lines on the site map. Both dipole-dipole and Schlumberger array data were obtained; dipole-dipole array data to enhance lateral variation and Schlumberger array data to achieve increased depth penetration. These data were modeled with two-dimensional (2D) inversion software to produce resistivity versus depth sections. In addition, one-dimensional (1D) Schlumberger array data were modeled. The 1D approach produced detailed vertical resistivity variation, and provided a link between lithology determined from soil borings and the resistivity of these units.

An electrode separation of 2-m was used for many of the resistivity lines, and a separation of four meters was used on lines where depth penetration was thought to be important, due to field observations and on-site discussions. Both separations were collected on some lines. Topography was accounted for in the 2D multi-electrode resistivity modeling, since this presents considerable geometric variation in spacing and current flow lines in the subsurface. Line leveling was conducted using global positioning system (GPS) surveying of electrode positions.

2.2.3 Terrain Conductivity Method

The Geonics EM-31 terrain conductivity instrument was used as a secondary method to the multi-electrode resistivity method. The originally proposed scheme to obtain mine tailing thickness directly from the EM-31 measurements was not successful.

2.3 RESULTS

2.3.1 Geophysical Data Locations

As a base map, a Google Earth image taken January 2014 was used. Figure 2-1 shows positions of all 17 resistivity lines, overlain on the aerial photo image, and numbered as shown on that figure. This constitutes the base map used for the geophysical survey. Symbols for electrode positions on those lines vary in color and marker type, grouped by data acquisition day. For example, the electrode positions along Line 1 are shown as red dots, which are not used for other lines from the survey because only data from Line 1 were collected that first day.

EM31 data were acquired in a relatively dense pattern which will be indicated on subsequent figures. Showing these positions on the base map would create superfluous clutter on the image. Smaller portions of the survey area, shown in subsequent figures, can be correlated to the overall base map (Figure 2-1).

Figure 2-1 also shows anomalies labeled as Targets A through J, which are outlined regions of light-colored material, based upon the aerial photo image. These anomalies are interpreted to be tailings deposits, based upon their light color, which was also noted in the field.

2.3.2 Analysis of Geophysical Response – EM31 and Multi-Electrode Resistivity

Detectability of the tailings was addressed by analyzing EM31 response and multi-electrode resistivity pseudosections, 2D inverse modeling results, and 1D modeling results. These geophysical responses are then compared to geological logs obtained from the Smelter Tailings Swale (STS) soil borings (also shown in white in Figure 2-1), and the light-colored Target areas indicated in the aerial photographs used as a base map.

The initial objective of the geophysical survey was to determine if the previously proposed methodology (including the geophysical methods recommended) was able to detect and map the tailings in the survey area. Multi-electrode resistivity Lines 1, 13, 6, and 17 were analyzed, running from north to south through the geophysical survey area.

Line 1

A profile of data and modeling results along Line 1 is shown in Figure 2-2. The upper panel of data shows the EM31 terrain conductivity and inphase data along the line. The middle panel shows the 2D resistivity inverse model computed for this line. The bottom panel shows apparent resistivity pseudosection data from the multi-electrode dipole-dipole array, which was used to compute the resistivity inverse model. All these panels are aligned for comparison between them.

As can be seen in Figure 2-2, initial correlations were made between high EM31 terrain conductivity responses and low surficial resistivity, as indicated in the multi-electrode resistivity data and computed model. Low surficial resistivity zones A and B, as indicated in the figure were the result of combining field notes, looking for relatively high terrain conductivity, and low surficial resistivity (modeling results and apparent resistivity pseudosections). Figure 2-2 shows the interpreted high terrain conductivity by filling the response above a threshold of 43 milliSeimens per meter (mS/m) in orange. Labels A' and B' were placed in positions which were initially interpreted as possible detection of tailings.

In addition, Figure 2-2 also shows the locations of Targets B and G where they are crossed by Line 1, for comparison. These anomalies were drawn based on their lighter color in the aerial photo image, as discussed in an earlier section of this report. As can be seen in Figure 2-2, there appears to be some correlation between tailings, high terrain conductivity, and low surficial resistivity. However, the correlation is often unclear.

Figure 2-3 is a close-up of the base map (Figure 2-1) where the line crosses Targets B and G. Figure 2-4 shows contoured EM31 terrain conductivity, including EM31 data acquisition locations (only every 4th one, to avoid clutter on the map), for the same region as shown in Figure 2-3, for comparison. Note the general lack of correlation between contoured terrain conductivity and the interpreted Targets B and G. In fact, the topographic lows (erosional dry stream channels) at 0N (Line 1), 62-64E, and the channel at Line 5, station (sta) 128, both show very high terrain conductivity. This is an indication that the high conductivity response appears to be responding to the lithological unit below the tailings.

Schlumberger-array resistivity data for Line 1, sta 55E and 99E, are plotted in Figure 2-5(A), along with data from adjacent soundings at 59E and 103E for comparison. These locations correspond to soundings within Targets B and G, as indexed in Figures 2-3 and 2-4, respectively. Note that apparent resistivity at short electrode separations (AB/2), also delineated within the circle drawn on the plot, is higher than at wider separations. The short separation data responds to the shallow subsurface, and the wider separation data is sensing the deeper part of the section. Since these sounding positions are located in the center portion of the tailings deposits interpreted as Targets B and G along Line 1, these data indicate that the tailings may be resistive rather than conductive, with respect to the underlying lithology, as was previously thought.

One-dimensional (1D) modeling results from Schlumberger-array sounding data at 99E are shown in Figure 2-5(B). The short-separation data can be fit with a 1.4 m-thick, 120 ohm-m layer overlying a less resistive (more conductive) 28 ohm-m layer. A 1D EM31 model result is shown in Figure 2-5(C), where test data were collected with the instrument suspended from the operator's shoulder (normal operating mode), and sitting directly on the ground. These data (circles on the plot) are fit with a 2-layer model in which a 50 ohm-m layer, 1.4 m-thick, overlies a 6 ohm-m layer. Although the layer resistivity values do not coincide (likely due to anisotropy), they both show a resistive layer 1.4 m-thick, overlying a more conductive layer. This indicates that the tailings correlate to this 1.4 m-thick layer, which is more resistive than the underlying lithology. This is different from the original conceptual model in which the tailings would be a conductive layer. However, soil borings drilled after this geophysical survey field work ended describe the tailings as an oxidized unit, underlain by brown clay. In that context, the geophysical data are consistent with that description; the oxidized material (tailings) would appear resistive, and the brown clay would be conductive.

Line 13

Other than for Line 1, EM31 data were not collected along the multi-electrode resistivity lines. Therefore, for analysis, and to compare responses, selected segments of EM31 traverses which were collected along or near the resistivity lines were assembled and plotted along with the resistivity data and models.

A multi-electrode resistivity model for Line 13 is plotted in Figure 2- 6, along with EM31 data segments along, or near that line. In the figure, some of the low EM31 terrain conductivity has been colored beige in order to emphasize the response, from about 8 to 38 m along the profile. As can be seen in the figure, the low surficial resistivity in the 2D resistivity model correlates well with the low terrain conductivity response. These low response areas have been delineated as C and D, in Figure 2-6. In addition, the extent of Line 13 which passes over Target A (indexed in Figure 2-1) is shown. There appears to be no significant correlatable response to Target A in the EM31 response, and very little in the resistivity model. Other segments of the line with low terrain conductivity response are shown as E, F, and G.

Figure 2-7 shows a comparison between the 2D dipole-dipole inverse resistivity model (from Figure 2-6), and the apparent resistivity pseudosections for Line 13. The pseudosections show where the data are very noisy, primarily at greater electrode separations (lower down in the pseudosections, as indicated by "bulls-eye" –type responses), and can provide some indication of confidence in the 2D model in the upper panel. Surficial high-resistivity shown in the pseudosections is not necessarily evident in the 2D model. Some of this discrepancy is due to the color schemes used in the resistivity contouring. It should be noted that the color scale used for the apparent resistivity pseudosections is logarithmic, at 20 contours per decade.

Comparing Figures 2-6 and 2-7 reveals that the low EM31 conductivity responses correlate with high apparent resistivity in the shallow (short electrode separation) portions of the pseudosections. In fact, delineated anomalies C, D, E, F, and G mostly correlate better between the conductivity and pseudosections rather than the 2D resistivity model. In any case, by correlating with field-observed tailings, lighter colored areas from the aerial photo, and resultant Target A, it does not appear that the EM31 or multi-electrode resistivity methods provide reliable tailings delineation on Line 13.

Line 6

Figure 2-8 shows EM31 data segments along or near Line 6, and the 2D inversion-derived resistivity model for that line. High conductivity response, shown as anomalies H, and I, have some correlation to lower resistivity in the 2D model at depth (2-4 m depth, as indicated by the bluer contours). Again, using a conductivity threshold of 60 mS/m, portions of the high conductivity response are colored in orange for emphasis. STS-BH11 was drilled near Line 6, within the region of this high conductivity response (indexed in Figure 2-1). This soil boring encountered less than 1 m of fill, overlying bedrock (Hickey conglomerate). It is possible that this fill is much more conductive than the other lithologic units along this line. However, the lower resistivity at depth, as indicated in the 2D resistivity model, is not explained. Also shown in Figure 2-8 is the extent of Target F which is crossed by Line 6. As can be seen in the figure, Target F appears to have a low terrain conductivity response, and a low surficial resistivity in the 2D model.

A comparison of the 2D resistivity model for Line 6 and the pseudosections is shown in Figure 2-9. Also anomalies H and I, and Target F are also shown for comparison. As seen in the figure, anomaly H and also Target F show up as high resistivity in the shallow short-separation data in the pseudosections.

Line 17

Figures 2-10 and 2-11 show the 2D resistivity inversion-derived resistivity model for Line 17, along with segments of EM31 terrain conductivity along that line, and also the apparent resistivity pseudosection. Anomaly J, was selected based upon high surficial resistivity in the pseudosection, and a somewhat stunted EM31 terrain conductivity response. However, as can be seen in Figure 2-1, Line 17 is out of the study area, running along the ephemeral creek to the south.

2.3.3 Delineation and Analysis of Targets A – J

As described previously, interpreted tailings deposits, based upon their light color in the aerial photo image, Figure 2-1, were drawn and labeled as Targets A through J. These anomalies are analyzed in the following sections.

Target A

The portion of the base map from Figure 2-1 showing Target A, along with the contoured terrain conductivity is shown in Figure 2-12. Also shown in the figure is a portion of the information from soil boring STS-SB01, which was drilled at that position, and a plot of Schlumberger-array resistivity data centered near the borehole position, at 41 m on resistivity Line 13. As can be seen in the Figure 2-12, there is no correlation between EM31 terrain conductivity, shown in the contour map, and Target A. Based on the earlier section of this report, the EM31 terrain conductivity is likely more responsive to the underlying brown clay, and/or variations in saturation of the sediments in the survey area.

There is a thickness of tailings in the soil boring log of 0.8 m, as shown in the figure. The shallow (short electrode spacing, AB/2) portion of the Schlumberger-array sounding curve, indicated by the dashed circle, does not really show a higher resistivity at the surface corresponding to the tailings. This can be interpreted to indicate that the electrode separations were not sufficiently short to detect this relatively thin thickness of tailings.

Target B

Relevant data for Target B are shown in Figure 2-13. As can be seen in the figure, Target B was drawn based upon the light color from the aerial photo image. The contoured terrain conductivity data do not correlate with Target B, as indicated in the plot shown. Soil boring STS-SB02, shown in the figure, indicates a thickness of 0.8 m of tailings at that location. Since the terrain conductivity is most likely correlated with the brown clay below the tailings, there is no indication of a thick portion of that clay that is correlated with Target B. The very thin layer of underlying brown clay, as shown in the log, may be the reason why the terrain conductivity is not very high at the boring location (note the green-blue contours next to the soil boring).

Schlumberger resistivity sounding plots for positions 33 and 35 m along resistivity Line 10 are shown in Figure 2-13, indicating a surficial high-resistivity layer from the short electrode separations (AB/2) as indicated by the dashed circle. Also shown in Figure 2-13 is the result of 1D modeling of data from Line 10, station 35 m. This 1D model matches the 0.8 m thickness of tailings from STS-SB02, as the surficial 50 ohm-m layer, underlain by 12 ohm-m, which is likely the response of the underlying brown clay from the lithologic log of the soil boring. This result is consistent with a model that the tailings are more electrically resistive than the underlying units.

Target C

Figure 2-14 shows the delineation of Target C, based on the aerial photo image. In this case, there is a high terrain conductivity response associated with the Target C area, based on the terrain conductivity contour map shown. However, note the lack of control on the contours due to the data density, as shown by the EM31 station positions (the "+" symbols on the maps).

Data from Schlumberger soundings at 71 m and 73 m on resistivity Line 2 are plotted on Figure 2-14, and also logs from soil borings STS-SB03 and STS-SB04, located within Target C as shown in the figure. These boring logs show 1.16 m and 1.31 m thicknesses of tailings at those two positions, respectively. This much thickness of resistive tailings should be detectable in the Schlumberger-array resistivity soundings, as is confirmed by the "pull-up" in resistivity at short electrode separations (AB/2), as highlighted by the dashed circle on the plot.

Data from the Schlumberger sounding at Line 2, sta 41 m, in the central portion of Target C, is plotted with the data from the other soundings in Figure 2-15. One-dimensional (1D) modeling results of these three soundings are also shown in Figure 2-15. The models for soundings at 71 m and 73 m, near STS-SB03, are consistent with the tailing thickness from this boring, which was 1.16 m. The two models show a 1.16 m, 50 ohm-m layer, underlain by 16 ohm-m for sta 71 m, and a 1.2 m, 60 ohm-m layer, underlain by a 22 ohm-m layer for sta 73 m.

Note how the shallow resistivity (short AB/2, within the dashed circle in Figure 2-15) is lower in the sounding curve for data from sta 41 m. Modeling results show a 1.5 m, 10 ohm-m layer, underlain by 24 ohm-m. The surficial layer is conductive rather than resistive, as compared to the other soundings, but the underlying layer has about the same resistivity. This low surficial resistivity at sta 41 m may be largely due to saturation, since the underlying units are different, based on the boring logs. However, based on the consistency of the high conductivity from the terrain conductivity contour map, Figure 2-14, the result from the sounding at sta 41 m may be indicative of most of the Target C substrate.

Target D

Figure 2-16 shows the area designated as Target D based on the aerial photo color. Also shown is the contour map of EM31 terrain conductivity. There appears to be little correlation between the terrain conductivity and Target D. Soil borings STS-BH09 and STS-BH9A are located in Target D, and the boring logs are shown in Figure 2-16. Schlumberger resistivity soundings at Line 4, sta 69 m and sta 75 m are plotted in Figure 2-17, which are located near soil borings STS-BH9A and STS-BH09, respectively. Although the tailings thickness is relatively thin in these borings, 0.79 and 0.98 m, a slight "pull-up" in apparent resistivity in the Schlumberger data can be seen, which is consistent with the model.

Target E

Target E is delineated as shown in Figure 2-16, and as can also be seen in that figure, there does not appear to be any correlation with the EM31 terrain conductivity response. The delineation shown is based solely on the aerial photo coloration. There are no multi-electrode resistivity data or soil borings in Target E.

Target F

Target F is delineated in Figure 2-16, based upon aerial photo coloration. As can be seen in that figure, the terrain conductivity color contours only vaguely correlate with the area shown by Target F as a high response. Soil boring STS-BH10, Figure 2-17, located in the central region of Target F (Figure 2-16), indicates a tailings thickness of 1.28 m at that location. As before, the tailings are shown to be underlain by a brown clay, but in addition, the section below that is shown to be fluvial gravels.

Schlumberger-array resistivity sounding data at Line 6, sta 21 m and 31 m are plotted in Figure 2-17. These positions are located very near STS-BH10, as shown in Figure 2-16. A 1D model of the shallow part of sta 31 m data is shown in Figure 2-17. As before, the tailings correlate with the upper 2 m-thick, 50 ohm-m layer, which is underlain by 20 ohm-m. This thickness is somewhat greater than the 1.28 m in STS-BH10, but it is also shown in the plot that there is considerable noise in the dataset.

Target G

Figure 2-18 shows the extent of Target G, based on aerial photo coloration, and the corresponding area of the terrain conductivity color contour map. Three soil borings are located within Target G, from north to south, STS-BH06, STS-BH07, and STS-BH08. The logs for these borings are shown in Figure 2-19.

Schlumberger resistivity soundings at Line 3, sta 95 m, sta 61 m, and sta 13 m, are located near soil borings STS-BH06, STS-BH07, and STS-BH08, respectively. Sounding data from these positions are plotted in Figures 2-20 and 2-21, along with nearby soundings at sta 117 m, sta 59 m, sta 57 m, and sta 9 m, for comparison of response.

The log for soil boring STS-BH06 shows 1.43 m of tailings (Figure 2-19). Figure 2-20 shows the Schlumberger resistivity 1D model and data-fit for sta 95 m as a 1.4 m-thick, 80 ohm-m layer, overlying 15 ohm-m, in Figure 2-20. This is consistent with our resistive tailings model.

Soil boring STS-BH07 shows a 0.37 m thickness of tailings (Figure 2-19), underlain by a thin brown clay layer, a thin colluvium layer, and finally the Hickey conglomerate. Nearby Schlumberger sounding at sta 61 m shows a 1D model (Figure 2-21) with a surficial 1.3 m, 80 ohm-m layer, underlain by a 17 ohm-m layer. The modeled thickness of the surficial layer encompasses the tailings, the brown clay, and the colluvium units from STS-BH07. But, these units are also shown as “dry” in the log in Figure 2-19, which may account for the higher resistivity.

The southern portion of Target G includes STS-BH08, which has a very thick tailings layer of 2.90 m, as shown in the log in Figure 2-19. Nearby Schlumberger sounding at sta 13 m, Figure 2-21, shows a 1D model with a 1.2 m-thick, 100 ohm-m layer, underlain by 20 ohm-m. The thickness of the tailings does not match the surficial layer thickness in the 1D Schlumberger model. Note that the location of the Schlumberger sounding is very near the end of resistivity Line 3, and also near the interpreted edge of Target G. To investigate non-1D effects, the data from the nearby sounding at sta 9 m is also plotted in Figure 2-21. There is a similar response, but there may be some indication in the sta 9 m data that the thickness is greater, but there isn’t enough data to delineate that.

Also, the shallower thickness of interpreted tailings at Schlumberger sta 13 m may not be due to tailings thickness, but rather saturation within the tailings. In this case, the resistivity method is problematic, with response due to both lithology and saturation.

Target H

Target H is shown delineated in Figure 2-18, again based on aerial photo coloration. There are no soil borings in Target H, but multi-electrode resistivity Line 9 passes over it. Schlumberger array resistivity soundings centered at Line 9, sta 15 m, sta 51 m, and sta 63 m are located in Figure 2-18. As can be seen in the figure, the sounding at sta 63 m is just off Target H to the north. Schlumberger sounding data plots for these soundings are shown in Figure 2-22, along with nearby soundings at sta 17 m, sta 53 m, and sta 61 m, for comparison. As before, the "pull-up" in apparent resistivity at short electrode separations occurs for soundings centered over Target H. This does not occur for soundings at sta 61 m and sta 63 m, which are centered off Target H to the north. This is what would be expected from the developed resistivity model. Figure 2-22 also shows 1D modeling results, showing data fit, for soundings at sta 15 m and sta 51 m. These models indicate a tailings thickness of 1.3 m and 1.2 m, respectively.

Target I

Target I, as shown in Figure 2-18, includes soil boring STS-BH04, and multi-electrode resistivity Line 10 crosses over it. As before, the target was delineated by aerial photo coloration. As also seen in the figure, the EM31 terrain conductivity is not definitive in detecting Target I; the high conductivity shown near the middle of Target I is within a gulley.

The log of STS-BH04 is shown in Figure 2-19, showing an oxidized tailings thickness of 1.31 m, overlying a thin reduced tailings interval, and finally colluvium. Schlumberger array sounding data centered at sta 119 m, sta 125 m, and sta 127 m, are plotted in Figure 2-23. These data are noisy due to the topographic effect of a gulley, which produces lateral resistivity inhomogeneity. Data from sta 119 m, closest to STS-BH04, were modeled and the 1D result and data fit are shown in Figure 2-23. The top 1.5 m surficial layer corresponds to the combined oxidized and reduced tailings thicknesses from the soil boring.

Target J

Figure 2-24 shows the interpreted Target J, its corresponding terrain conductivity color contour map overlay, and logs of soil borings STS-SB12 and STS-SB13, which were drilled into the area of the target. As seen before, Target J was interpreted based upon aerial photo coloration. There appears to be some correlation between Target J and high terrain conductivity as shown in the contour map. Based upon previous Target analyses, this high conductivity is likely not corresponding to tailings, but something else (e.g., saturation, underlying brown clay, etc.).

Schlumberger resistivity sounding data centered at sta 61 m and sta 75 m are plotted in Figure 2-25. Note that these data do not show the characteristic short electrode spacing "pull-up" as described for most soundings overlying tailings. In fact, the short electrode apparent resistivities indicate a surficial layer which has low resistivity as compared to the underlying strata. The 1D model for sta 75 m, which is closest to STS-SB12 shows a surficial 3.5 ohm-m, 2.25 m-thick layer, overlying 14 ohm-m material. As can be seen in the log of STS-SB12 (Figure 2-24), tailings mixed with brown clay occur here, and the thickness of that interval along with underlying oxidized tailings is 2.25 m. The log indicates that the mixed tailings/clay layer is underlain by a relatively thick section of brown clay. The modeled value of 14 ohm-m is only slightly lower than the resistivity of brown clay from other soundings from this study.

Soil boring STS-SB13 was drilled into the eastern lobe of Target J, as can be seen in Figure 2-24. The log of this boring indicates a tailings thickness of 1.77 m, again underlain by brown clay, with volcanics at depth. Schlumberger sounding data from multi-electrode resistivity Line 14, sta 151 m, sta 163 m, and sta 179 m are plotted in Figure 2-26. These data all show the characteristic "pull-up" of apparent resistivity at short electrode separations, consistent with tailings overlying brown clay. A 1D model of the sounding at sta 163 m, which was closest to STS-SB13 (Figure 2-24), is shown in Figure 2-26. This model, consistent with the soil boring, shows a 1.77 m, 26 ohm-m layer, underlain by 7.5 ohm-m. Again, this fits our conceptual model of resistive tailings overlying conductive strata below.

2.3.4 Volume Calculation of Tailings – Based on Targets A – J

A rough volume calculation for tailings in the study area was made. This was done by:

(1) Overlying a grid of cell size 2.5 by 2.5 m onto the study area,
(2) Computing areas of all Targets A – J,
(3) Determining the thickness of tailings within targets, and
(4) Computing the volumes.

Step (2) above, requires summing all whole cells within each Target area, and adding to that the sum of the contributions of all partial cells. The way this was done, was to add how many partial cells were along the perimeter of the Target, and sum how many were larger than 50% of a cell, and how many were less than 50% of a cell. The resultant area was the sum of the area of all whole cells, plus 0.75 times the area of all partial cells larger than 50%, plus 0.25 times the area of all partial cells with less than 50%.

Step (3) above was done by determining the maximum tailings thickness for each Target and dividing that value in half. This assumption is based upon a linear thickness gradient between the edge of a Target, and the value at the thickest point. Due to differential erosion of tailings surfaces, yielding rounded upper surfaces, this assumption will likely result in slightly underestimating the volume. Step (4) above is the simple multiplication of the Target area from Step (2), by the thickness determined in Step (3).

The area calculations were based on the grid shown for each Target. Figures 2-27, 2-28, and 2-29 show the grids for Targets A, B, and C, respectively. Figure 2-30 shows the grids for Targets D, E, and F. Figure 2- 31 shows the grid for Target I and the northern portion of Target G. Figure 2-32 shows the grid for the southern portion of Target G, and for Target H. Figure 2-33 shows the grid for Target J.

Table 2-1 shows the details of the volume calculations. As can be seen in the table, the method used yields a volume of 13689.6 cubic meters ($m^{3)}$, which is 483442.1 cubic feet (ft^3), or 17905.3 cubic yards (yd^3).

2.3.5 Surveyed Tailings Contacts vs. Targets A – J

A contractor provided surveyed contacts between the tailings and host material, along with elevation points within tailings in order to perform a volume calculation. Figure 2-34 shows their surveyed points, with a color code of green for tailings, and red for not-tailings.

The first thing to note is that the contracted survey did not extend to the west and south, therefore tailings near Targets D, F, and J were not surveyed. Also, note there is very good correspondence between Targets identified as part of this study and the contracted survey results.

A close-up of the northern part of the study area can be seen in Figure 2-35. Areas shown as rectangles with white dashed lines are labeled 1 through 4. Areas 1, 2, and 3 are tailings which were not identified in this survey, but were included in the contracted survey results. Area 4 is a portion of Target G which the surveyors identified as not-tailings.

Figure 2-36 shows a close-up of the southern portion of the study area, showing the relationships between the contracted survey results and the identified Targets from this study. As can be seen in the figure, there is good correlation between surveyed tailings and those identified as Targets. Exceptions in this southern portion include no survey results in Targets D, F, and J, as mentioned previously.

2.3.6 Surveyed Tailings Volume vs. Volume from This Study

Discrepancies between Targets identified in this study and surveyed tailings positions are suspected to be minor. The unidentified tailings from this study (labeled 1-3 in Figure 2-35), likely cancel out misinterpreted tailings from this study (label 4 in Figure 2-35).

A volume calculation was performed without Targets D, F, and J. The results were computed in the same manner as before, just leaving out those 3 Targets. The resulting volume was 8395.8 m^3, or 296493.7 ft^3, which is 10981.2 yd^3. This can be compared to a preliminary result from the contracted surveyors, which was 13000 yd^3 (email from David Edgerton, dated June 11, 2014). The estimate using the methods described in this report is lower by approximately 2000 yd^3. This perhaps is not too surprising since a straight line slope was assumed for each of the Targets from the highest point to the contact. This was anticipated to result in a lower volume (as mentioned in a previous section of this report), due to differential erosion producing convex upward tailings surfaces.

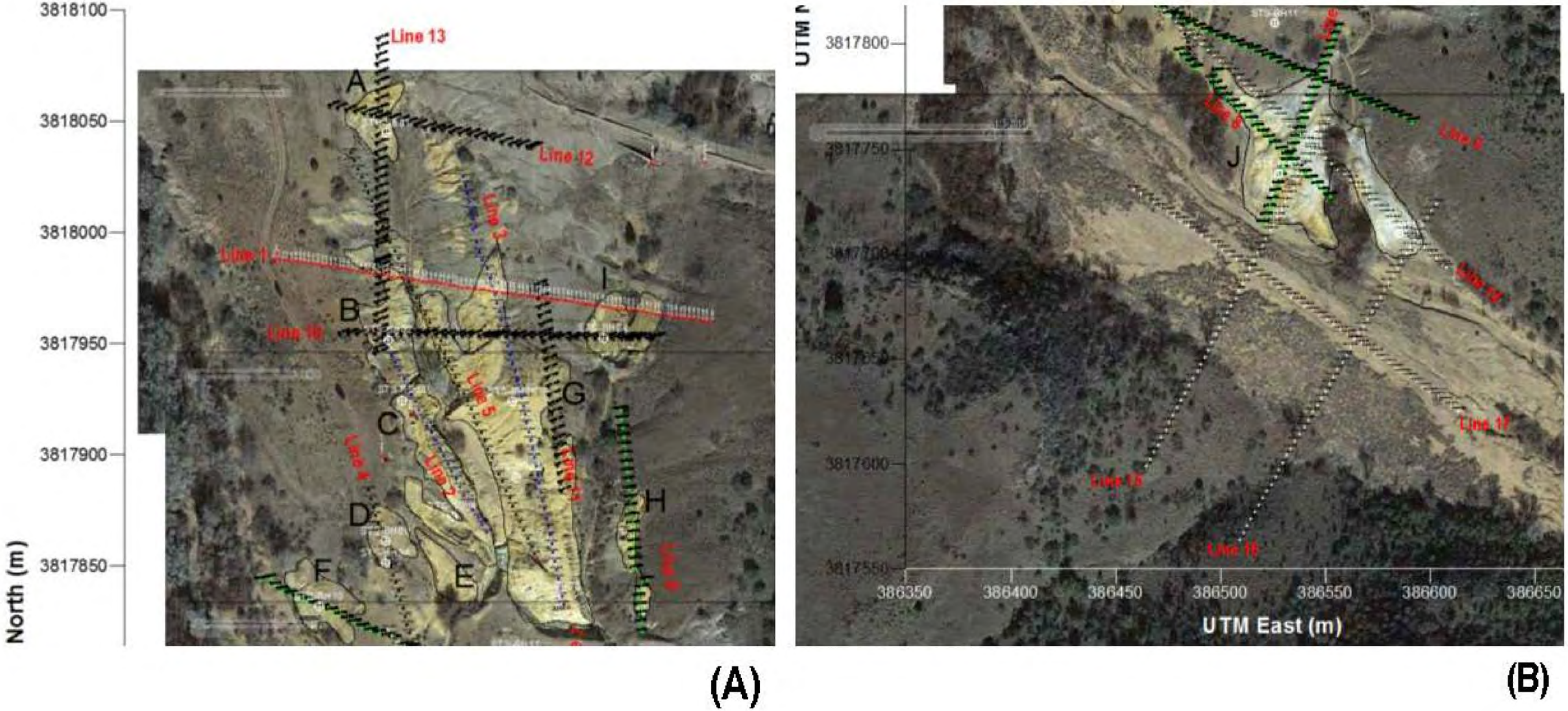

Figure 1. Geophysical resistivity Lines on basemap (Google Earth image). Shown are (A) Northern portion, and (B) Southern portion.

Data export from other software

Map Creation Date: 15 September 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-1

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 2-1
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

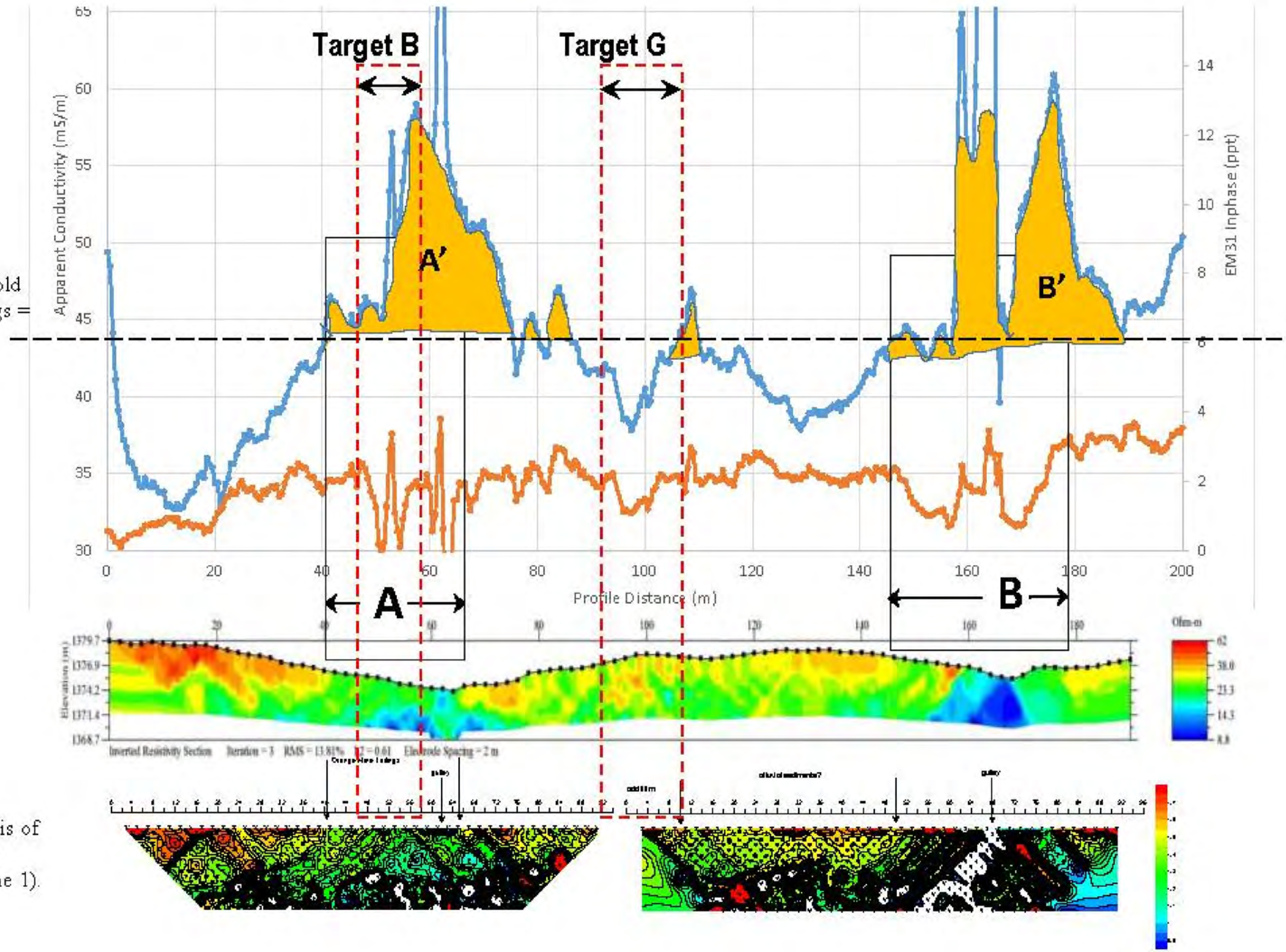

Figure 2. Analysis of test line 0N (also referred-to as Line 1).

Data export from other software

Map Creation Date: 15 September 2014

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W.A.# 0-146

Figure 2-2
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

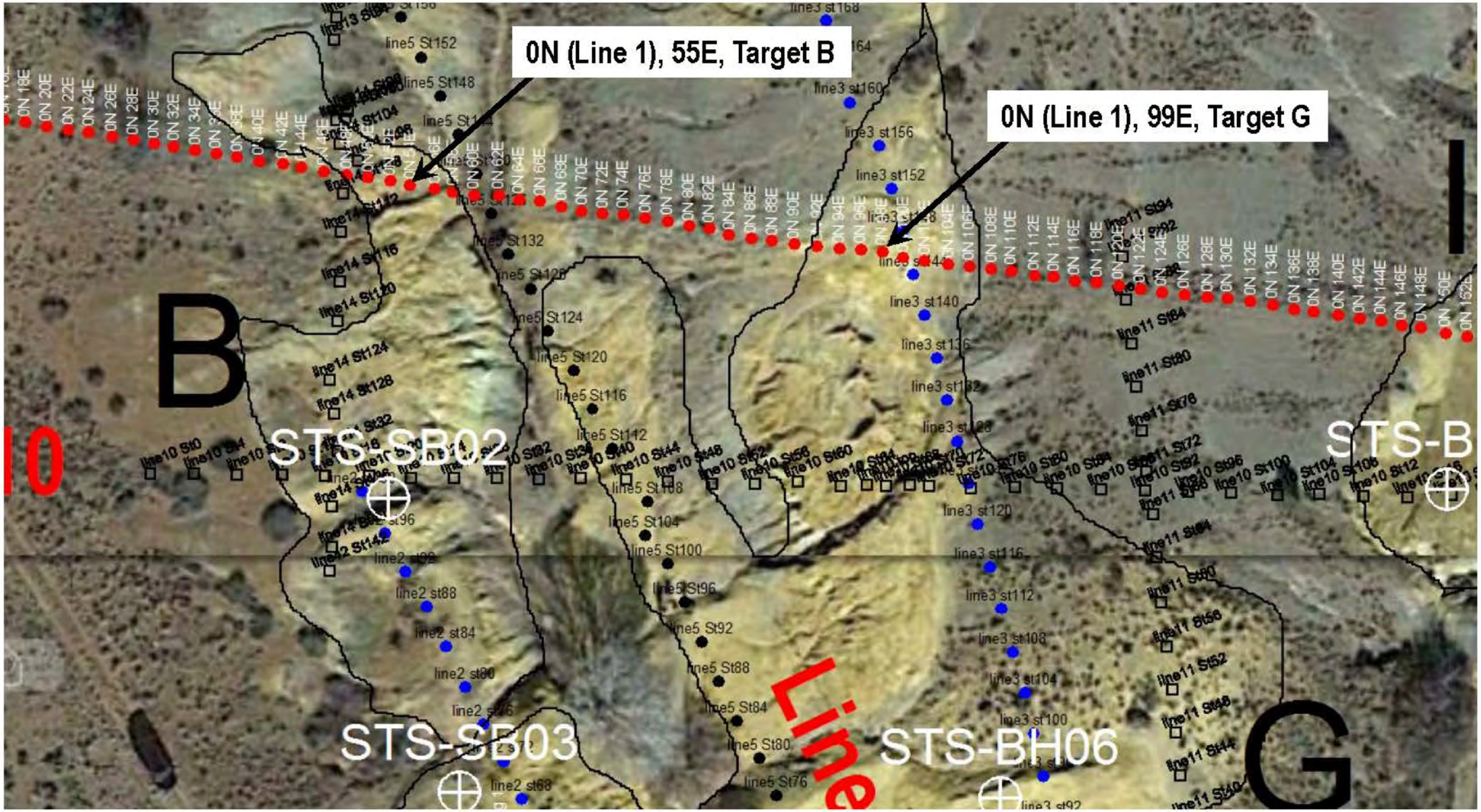

Figure 3. Analysis of EM31 response on test line 0N (also referred-to as Line 1). Station positions on basemap (Google Earth image).

Data export from other software

Map Creation Date: 15 September 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-3

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W.A.# 0-146

Figure 2-3
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

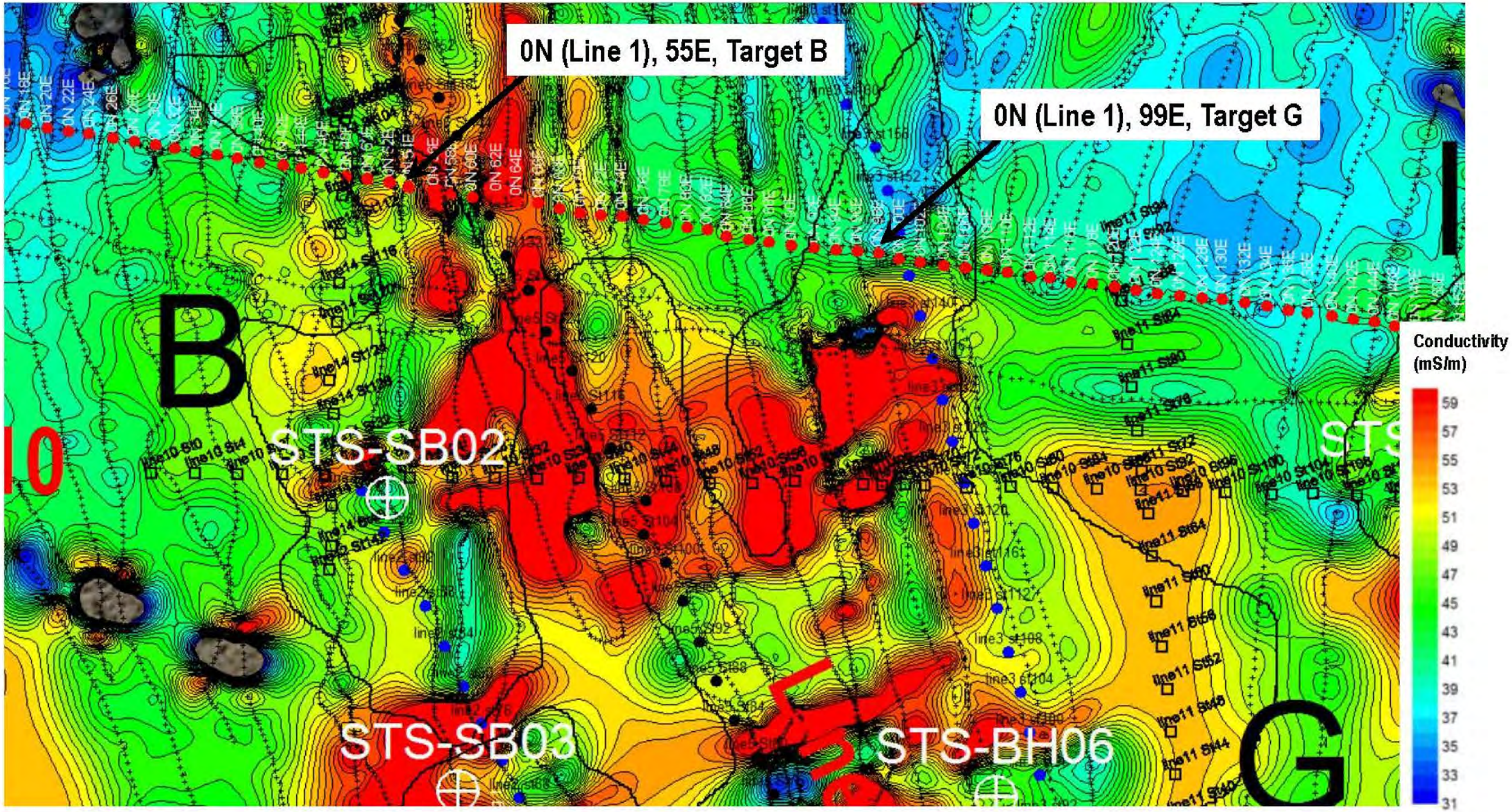

Figure 4. Analysis of EM31 response on test line 0N (also referred-to as Line 1). Conductivity overlay.

Data export from other software

Map Creation Date: 15 September 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysic\146_SEC2_Figure2-4

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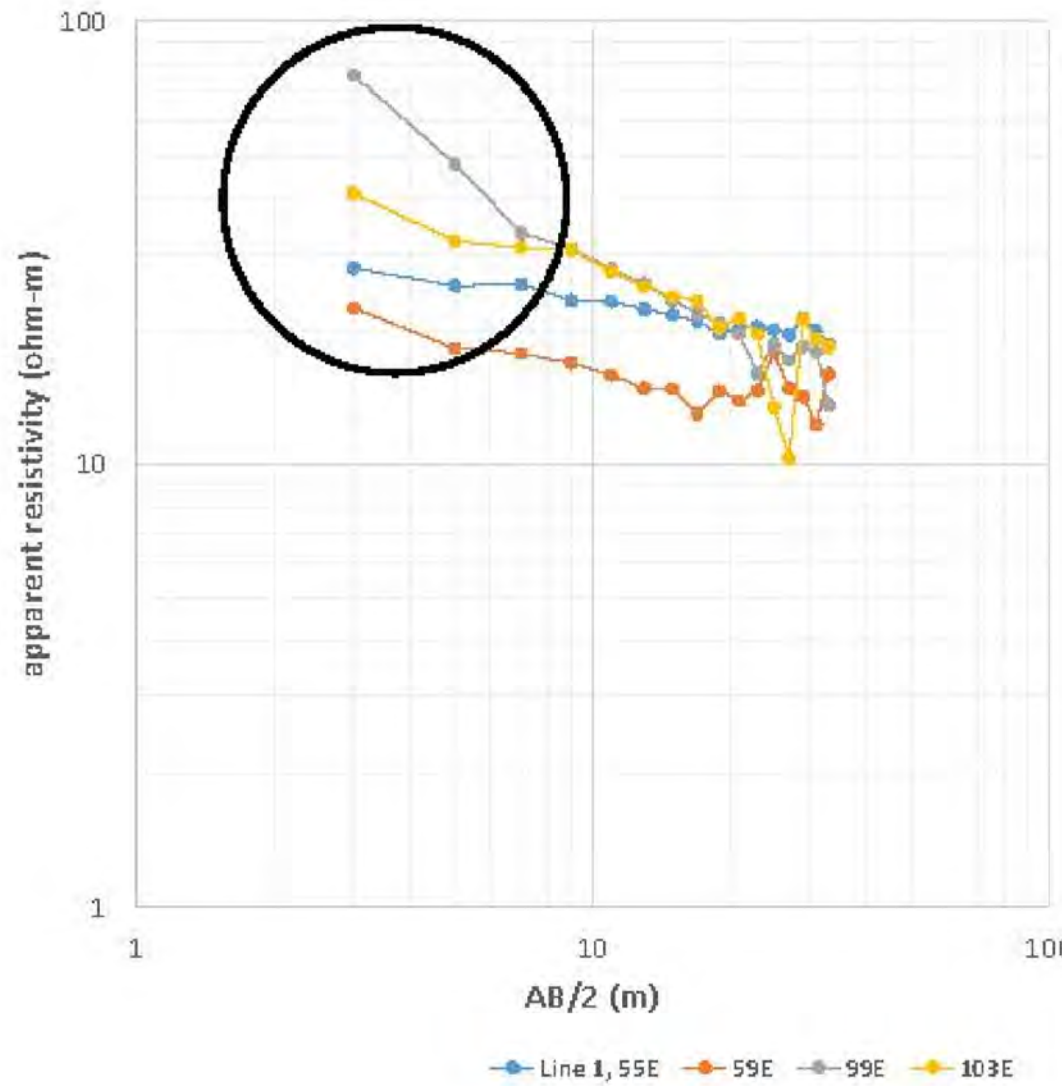
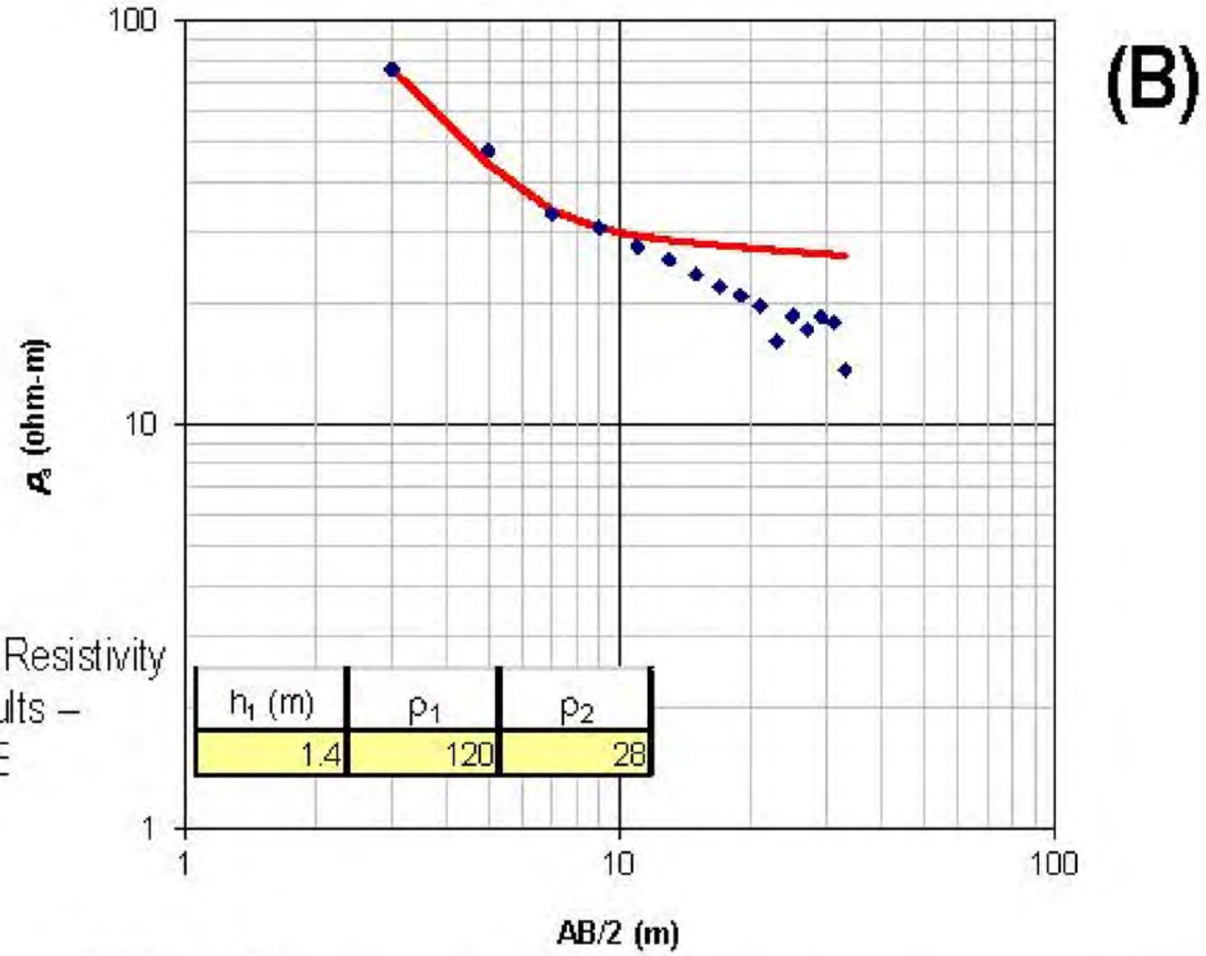
EP-W-09-031
W.A.# 0-146

Figure 2-4
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona





h_1 (m)	ρ_1	ρ_2
1.4	120	28

(C)

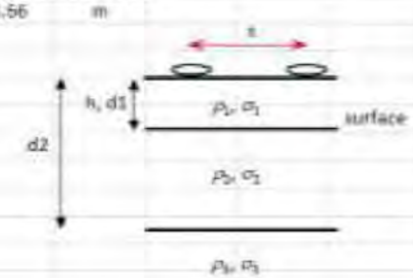
3-Layer EM31 Solution

σ_1	σ_2	σ_3	mS/m
0.5	20	167	calculated from resistivity

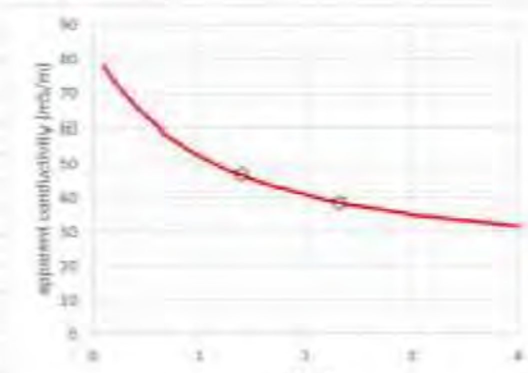
ρ_1	ρ_2	ρ_3	ohm-m
2000	50	6	← input

h	coil height	
0.93345	m	← measured in field

s	separation
3.66	m



thickness d2-d1	apparent conductivity	z1	z2	Rv(z1)	Rv(z2)	d1	d2
0.1	78.2	0.255041	1.107129	0.890806	0.411591	0.93345	1.03345
0.2	73.7	0.255041	1.214259	0.890806	0.380757	0.93345	1.13345
0.3	69.8	0.255041	1.321388	0.890806	0.353902	0.93345	1.23345
0.4	66.3	0.255041	1.428518	0.890806	0.330361	0.93345	1.33345
0.5	63.3	0.255041	1.535647	0.890806	0.309598	0.93345	1.43345
0.6	60.6	0.255041	1.642777	0.890806	0.291175	0.93345	1.53345
0.7	58.2	0.255041	1.749906	0.890806	0.274735	0.93345	1.63345
0.8	56.0	0.255041	1.857036	0.890806	0.259987	0.93345	1.73345
0.9	54.1	0.255041	1.964165	0.890806	0.246693	0.93345	1.83345
1	52.3	0.255041	2.071295	0.890806	0.234655	0.93345	1.93345
1.1	50.7	0.255041	2.178424	0.890806	0.223707	0.93345	2.03345
1.2	49.2	0.255041	2.285554	0.890806	0.213711	0.93345	2.13345
1.3	47.9	0.255041	2.392683	0.890806	0.204552	0.93345	2.23345
1.4	46.6	0.255041	2.499813	0.890806	0.19613	0.93345	2.33345
1.5	45.5	0.255041	2.606942	0.890806	0.188362	0.93345	2.43345
1.6	44.4	0.255041	2.714071	0.890806	0.181176	0.93345	2.53345
1.7	43.5	0.255041	2.821201	0.890806	0.17451	0.93345	2.63345
1.8	42.6	0.255041	2.92833	0.890806	0.16831	0.93345	2.73345
1.9	41.7	0.255041	3.03546	0.890806	0.16253	0.93345	2.83345
2	40.9	0.255041	3.142589	0.890806	0.157128	0.93345	2.93345



Test Point Line 1, 98E d2	measured apparent conductivity	
2.33	38.3	mS/m
1.4	46.6	

Layer 2 thickness= 1.4 m

Figure 5. Analysis of test line 0N (also referred-to as Line 1). (A) Schlumberger-array resistivity sounding data plots. (B) 2-layer modeling results for Line 1, sta 99E. (C) EM31 modeling results for test at Line 1, 98E.

Data export from other software

Map Creation Date: 15 Septemper 2014

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-5

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W.A.# 0-146

Figure 2-5
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

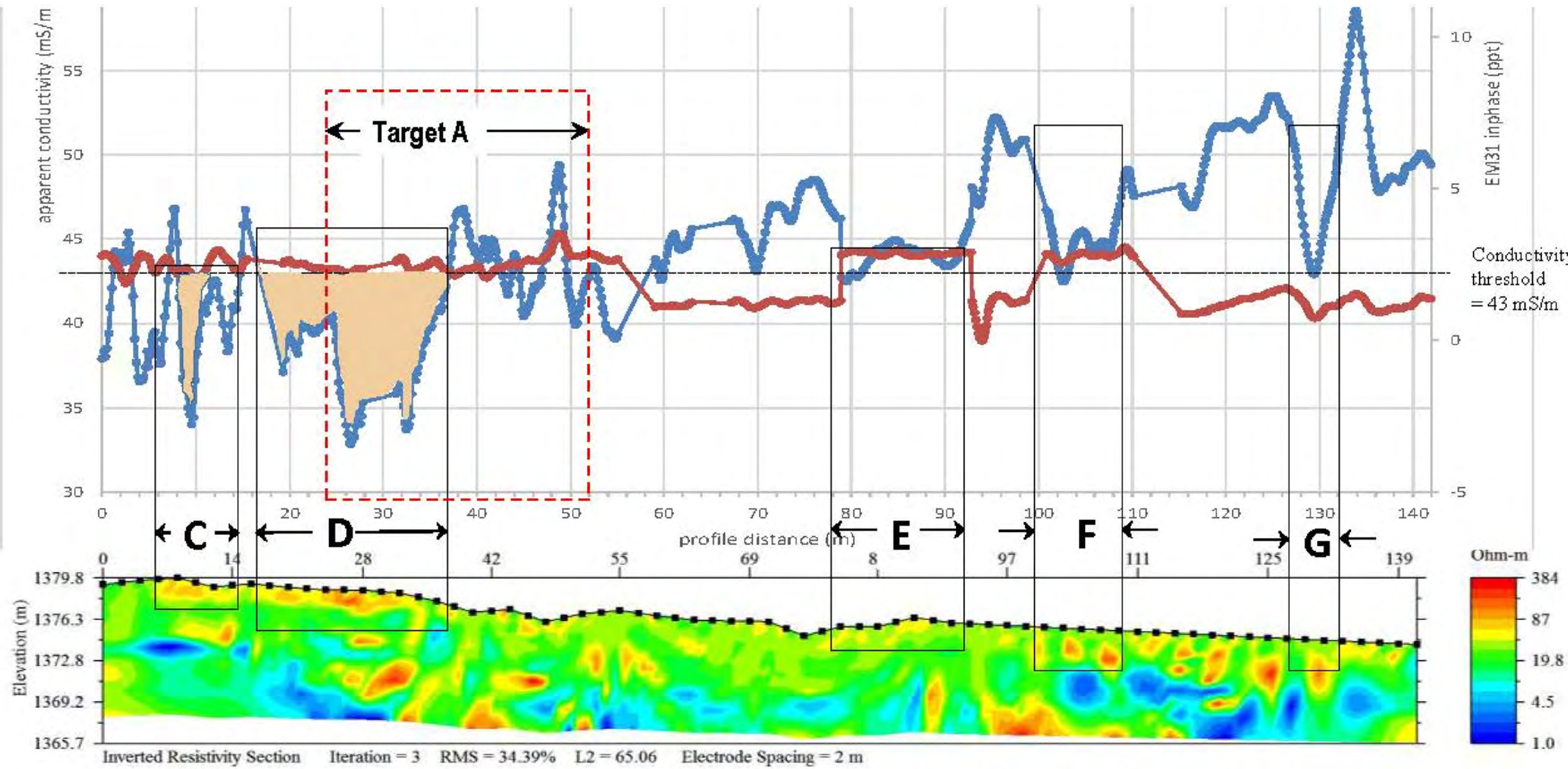

Figure 6. Analysis of Line 13. Apparent conductivity shown as the blue points and line.

Data export from other software

Map Creation Date: 15 September 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-6

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W.A.# 0-146

Figure 2-6
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

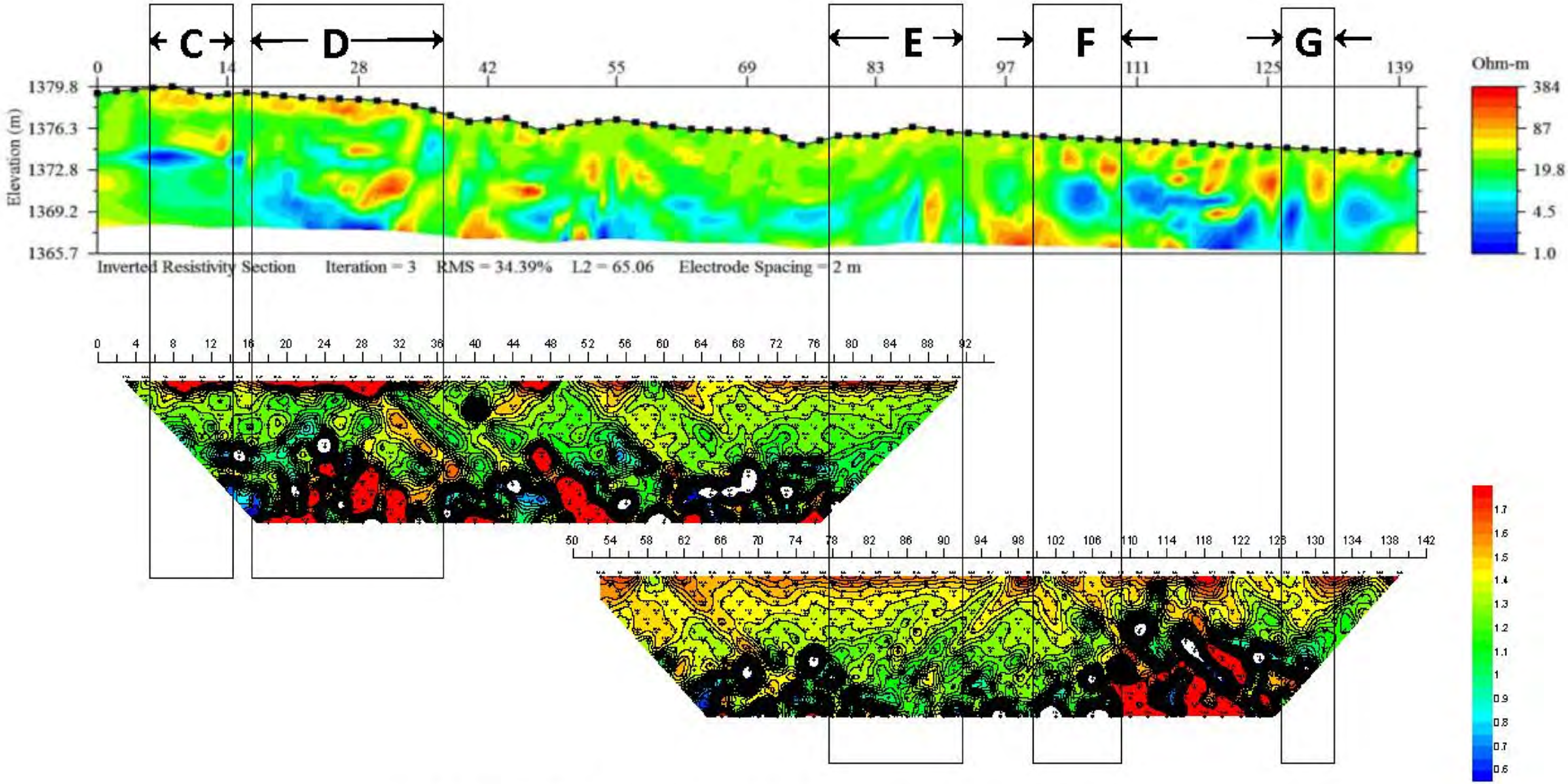

Figure 7. Analysis of Line 13 resistivity data and inverse model compared to pseudosectiions.

Data export from other software

Map Creation Date: 15 September 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-7

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Figure 2-7
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

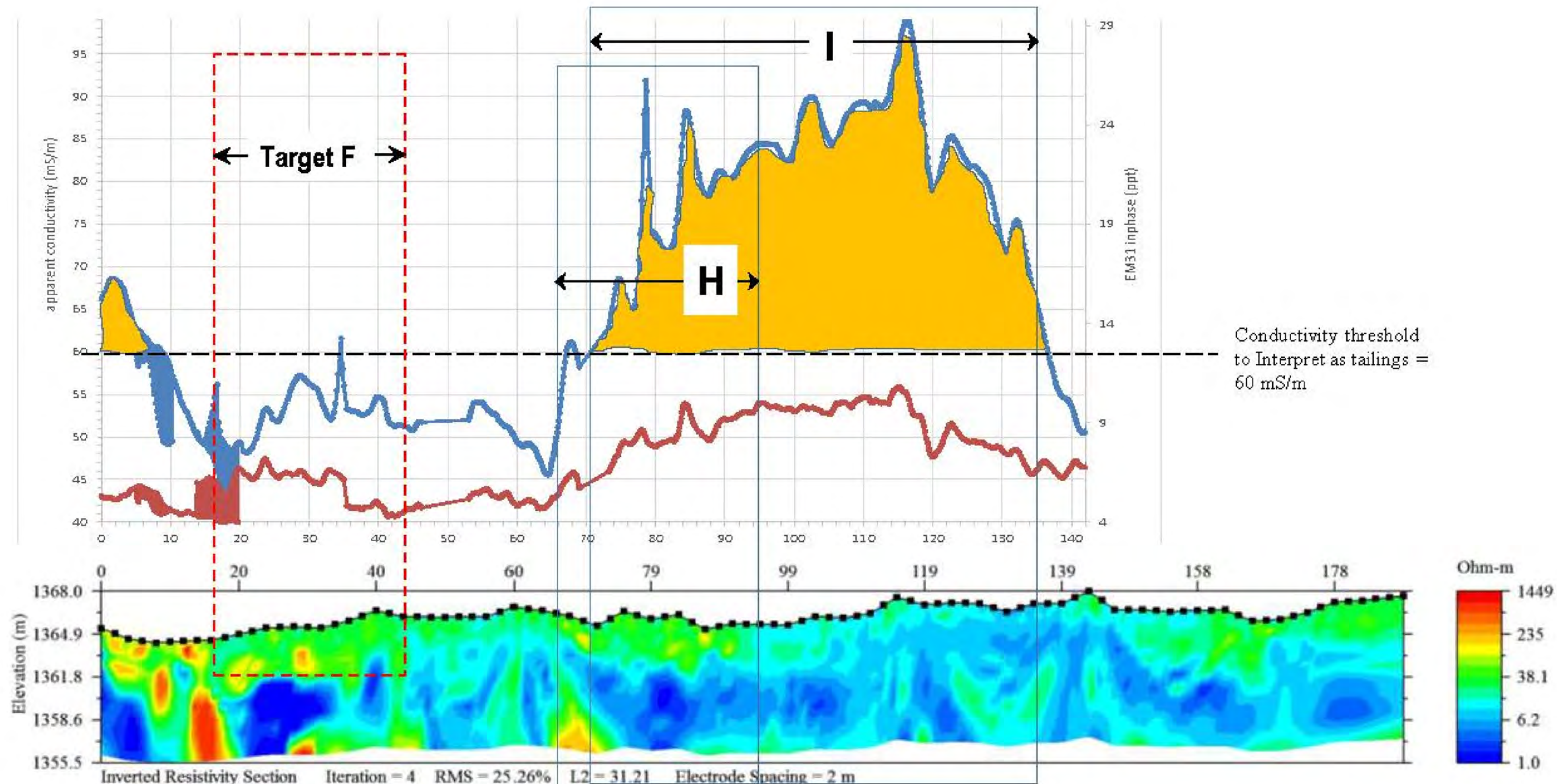

Figure 8. Analysis of Line 6. Apparent conductivity shown as the blue points and line.

Data export from other software

Map Creation Date: 15 September 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-8

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Figure 2-8
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

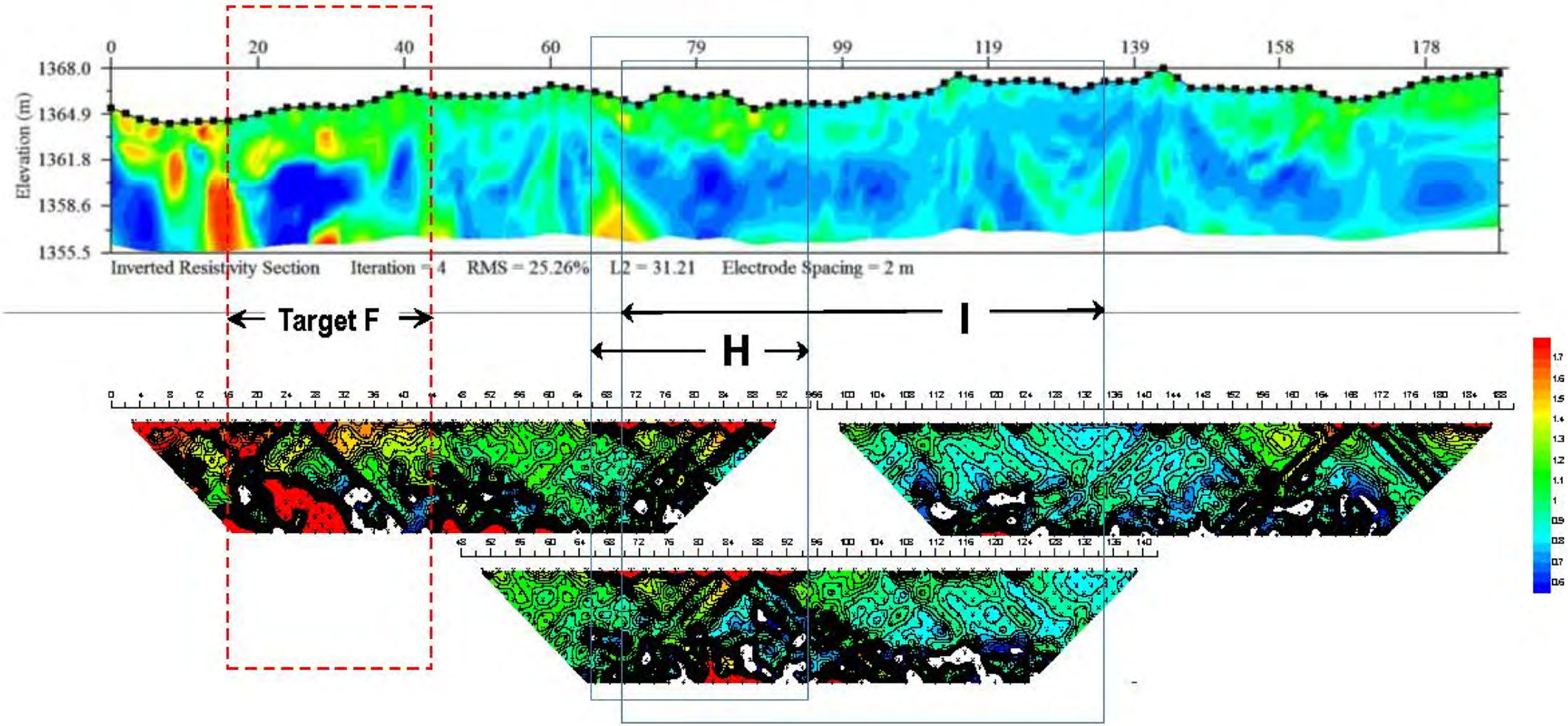

Figure 9. Analysis of Line 6 resistivity data and inverse model compared to pseudosections.

Data export from other software

Map Creation Date: 15 September 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-9

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Figure 2-9
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

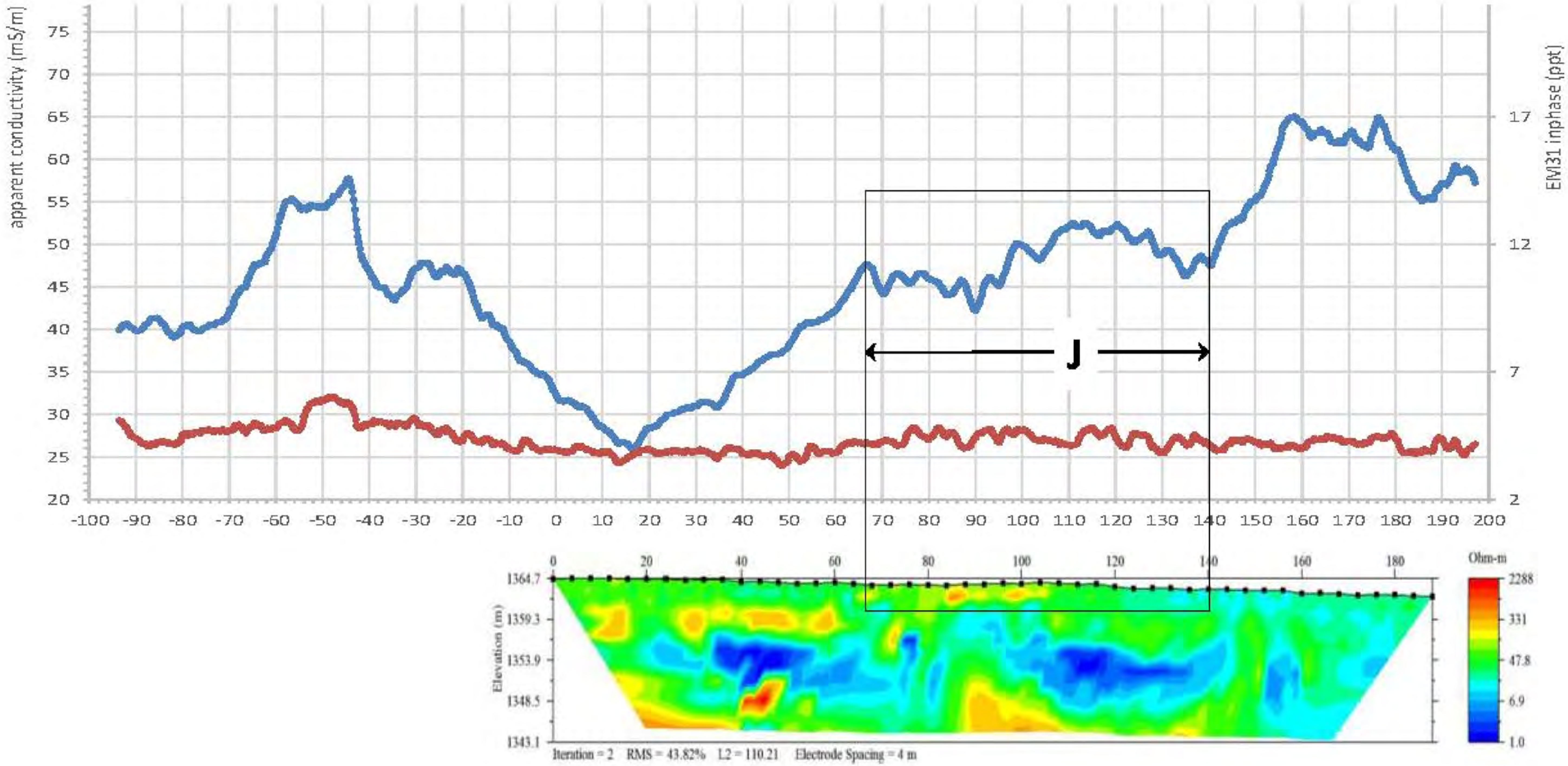

Figure 10. Analysis of Line 17. Apparent conductivity shown as the blue points and line.

Data export from other software

Map Creation Date: 15 Septemper 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-10

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Figure 2-10
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

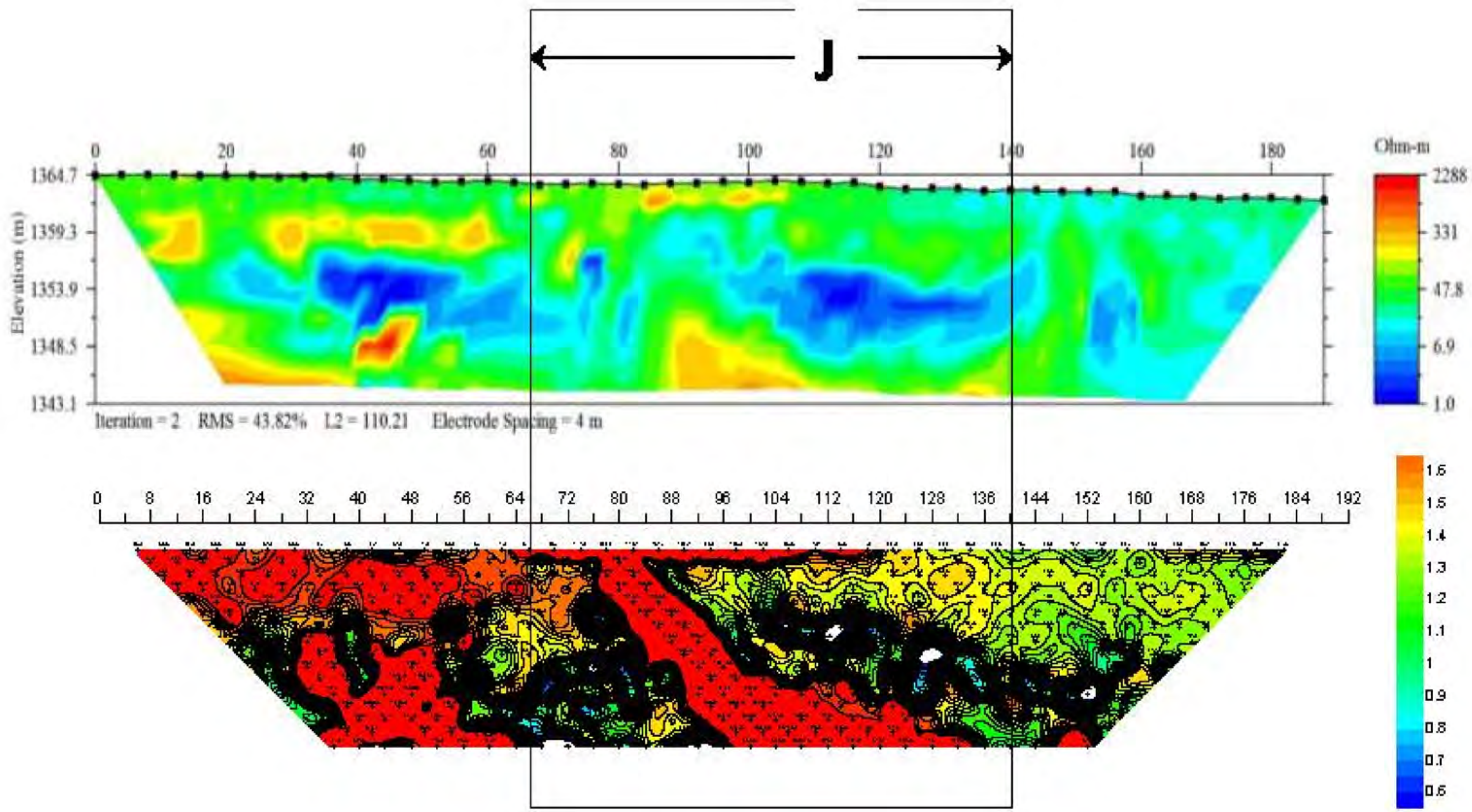

Figure 11. Analysis of Line 17 resistivity data and inverse model compared to pseudosection.

Data export from other software

Map Creation Date: 15 Septemper 2014

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Figure 2-11
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

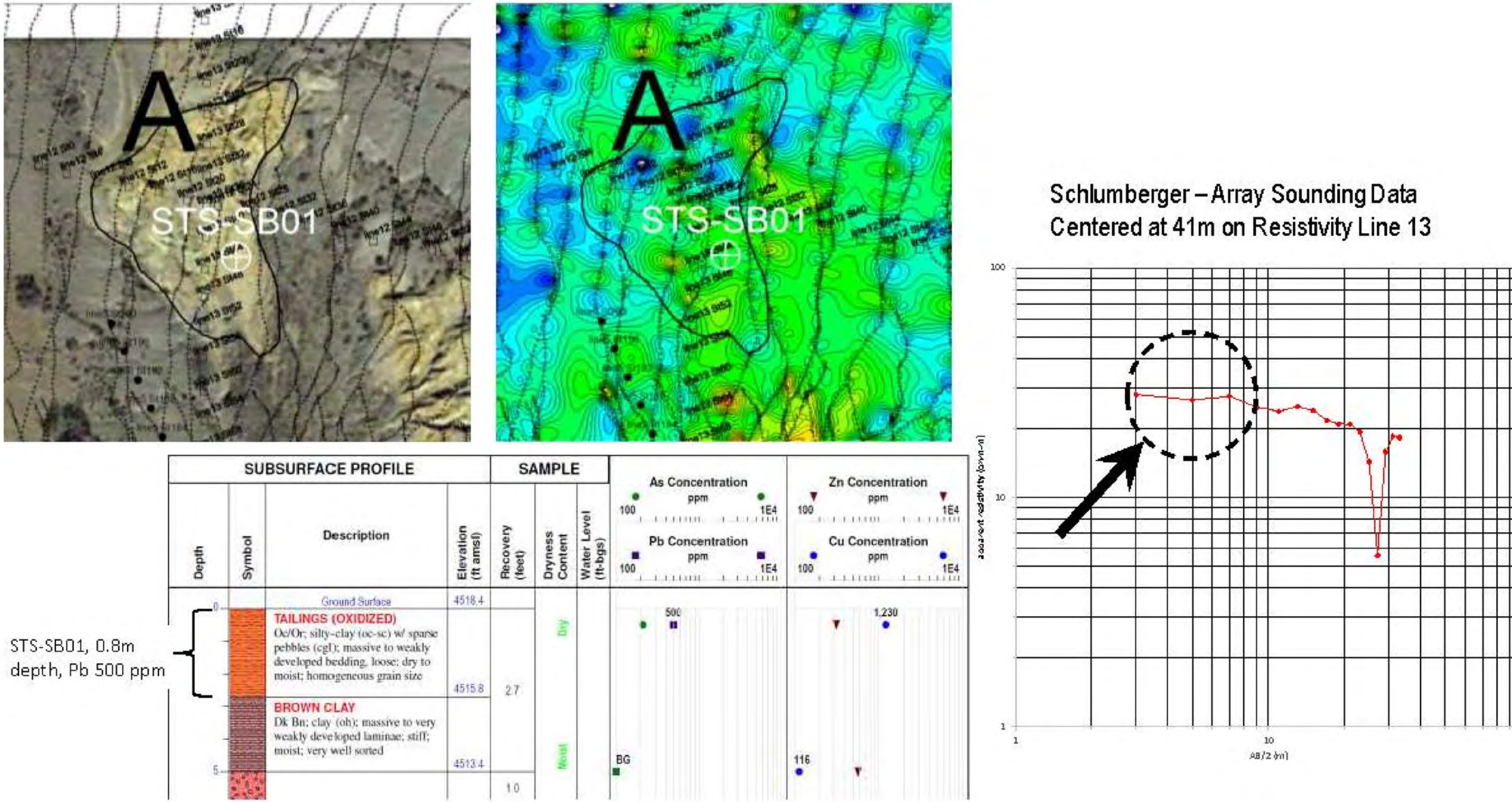

Figure 12. Analysis of Target A.

Data export from other software

Map Creation Date: 15 September 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-12

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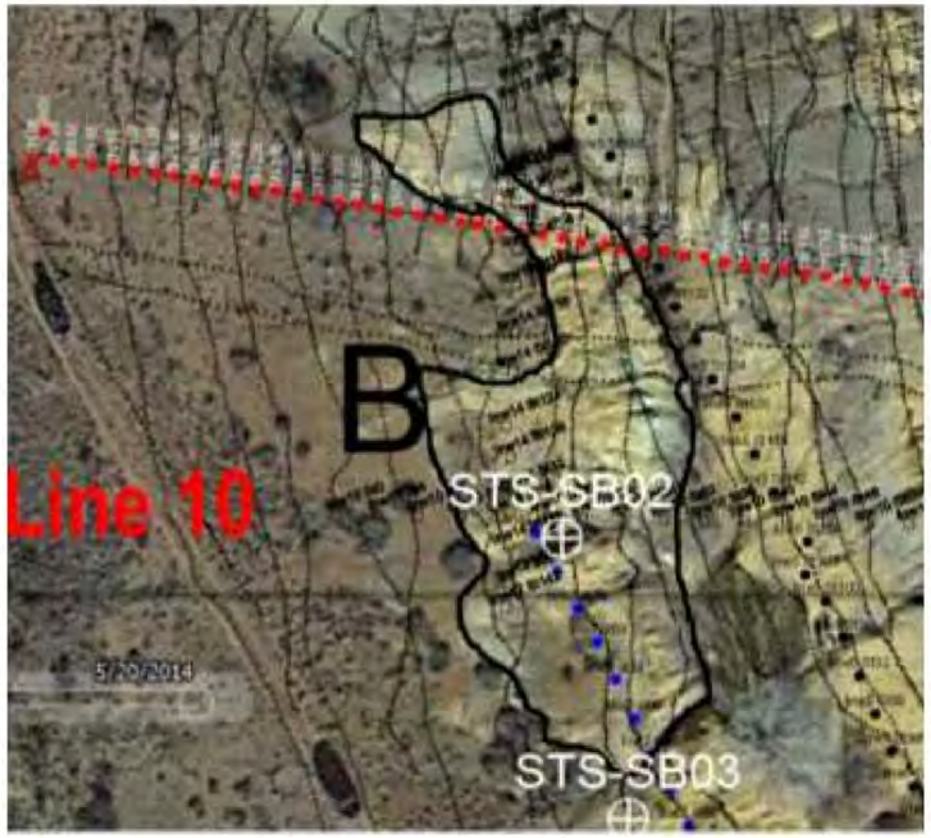
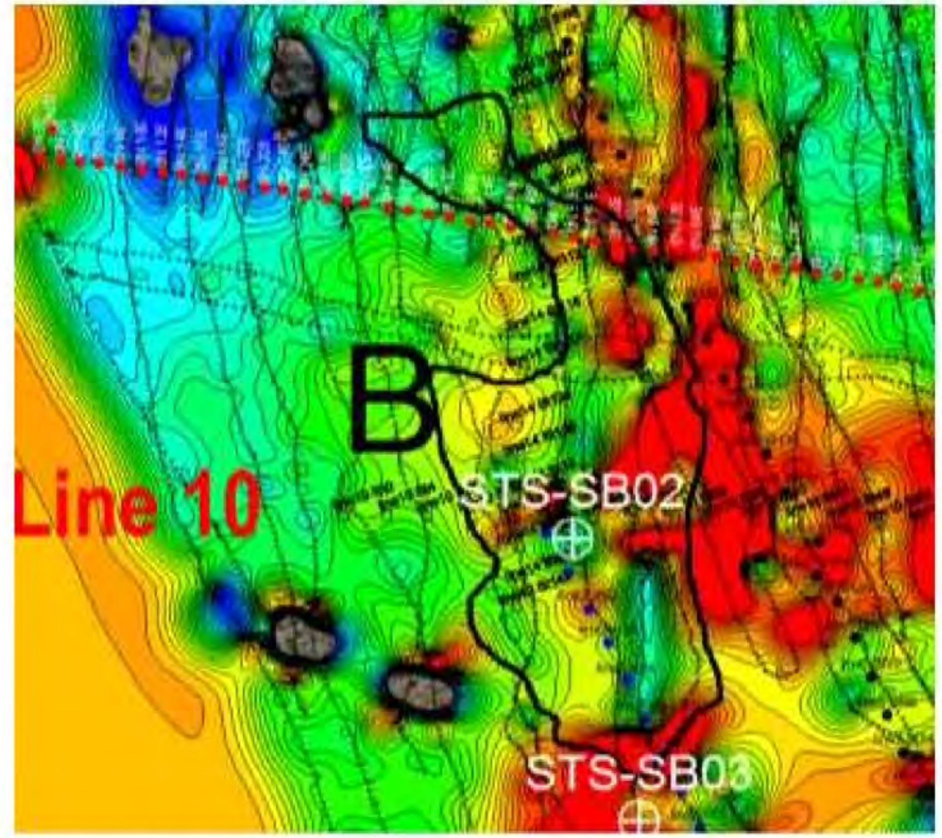
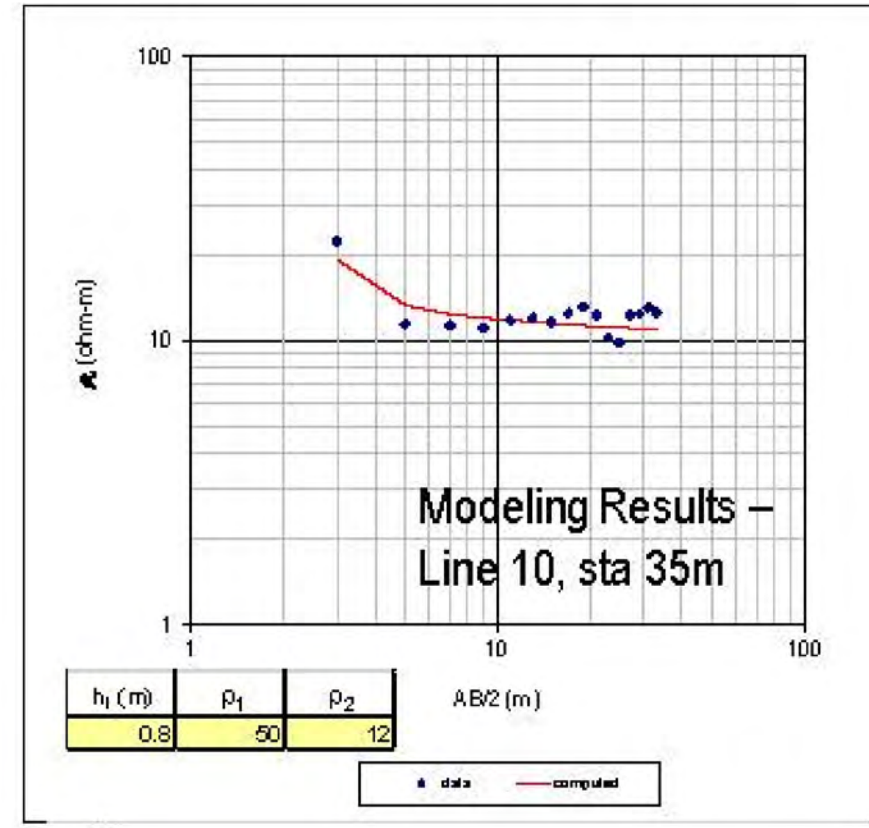
Figure 2-12
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona







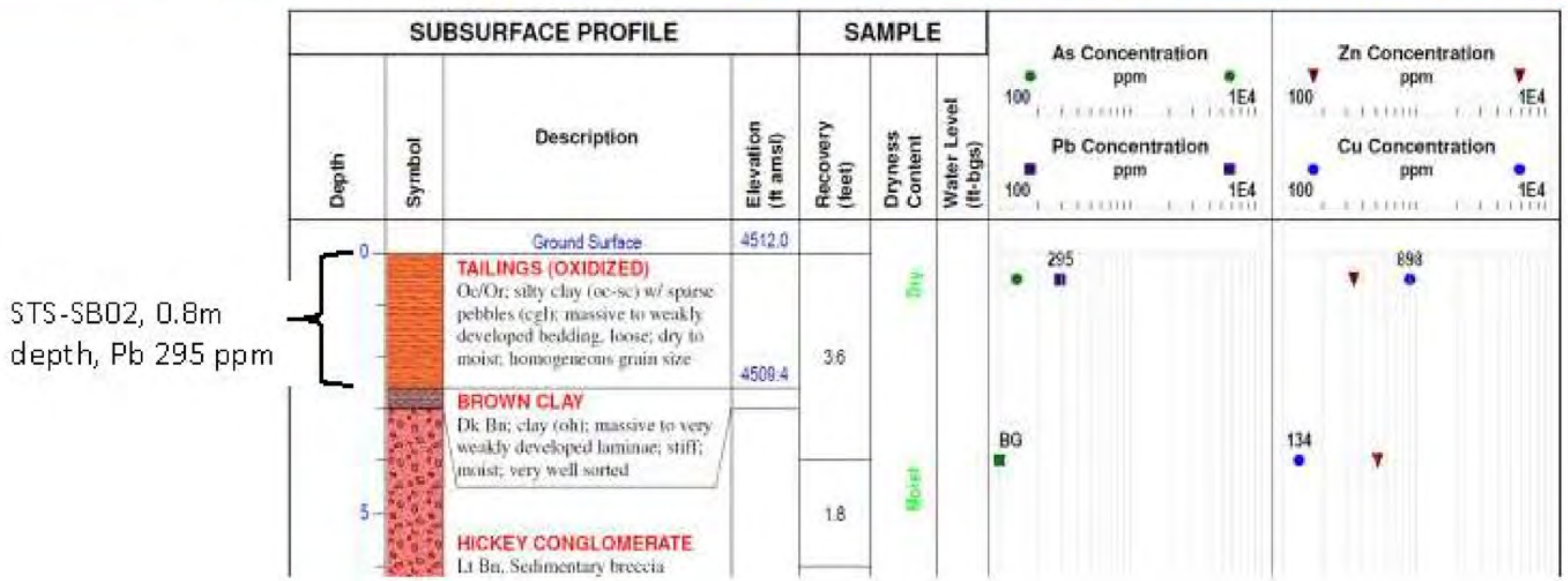
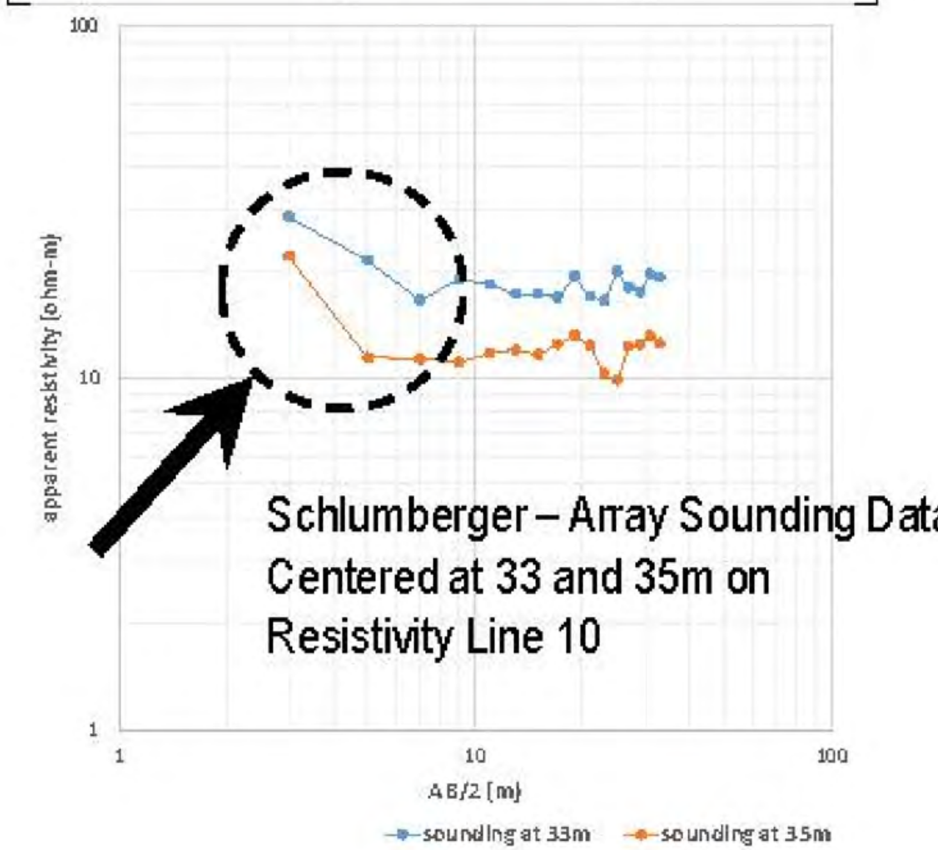


Figure 13. Analysis of Target B.



Data export from other software

Map Creation Date: 15 September 2014

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Figure 2-13
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

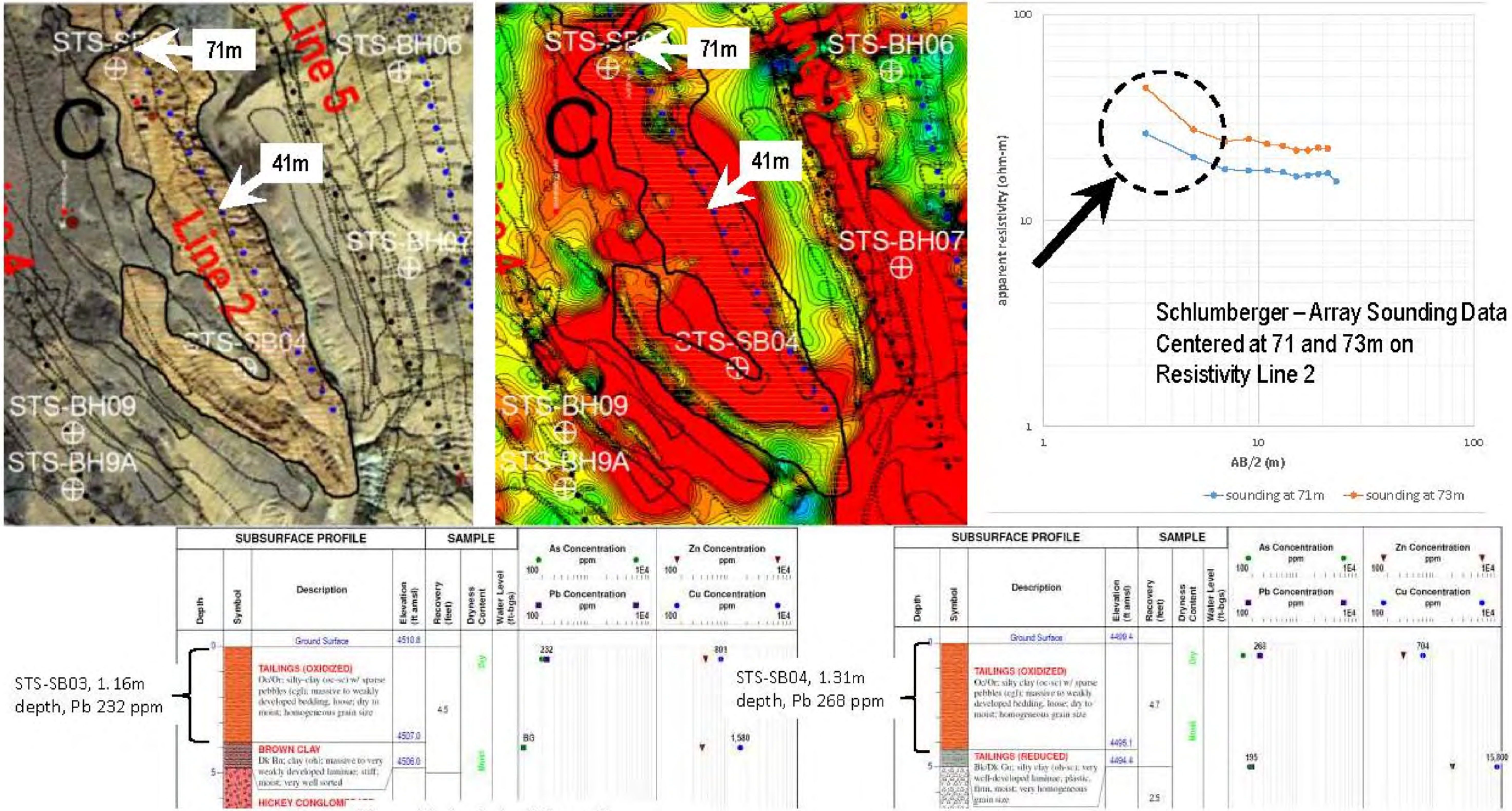

Figure 14. Analysis of Target C.

Data export from other software

Map Creation Date: 15 Septemper 2014

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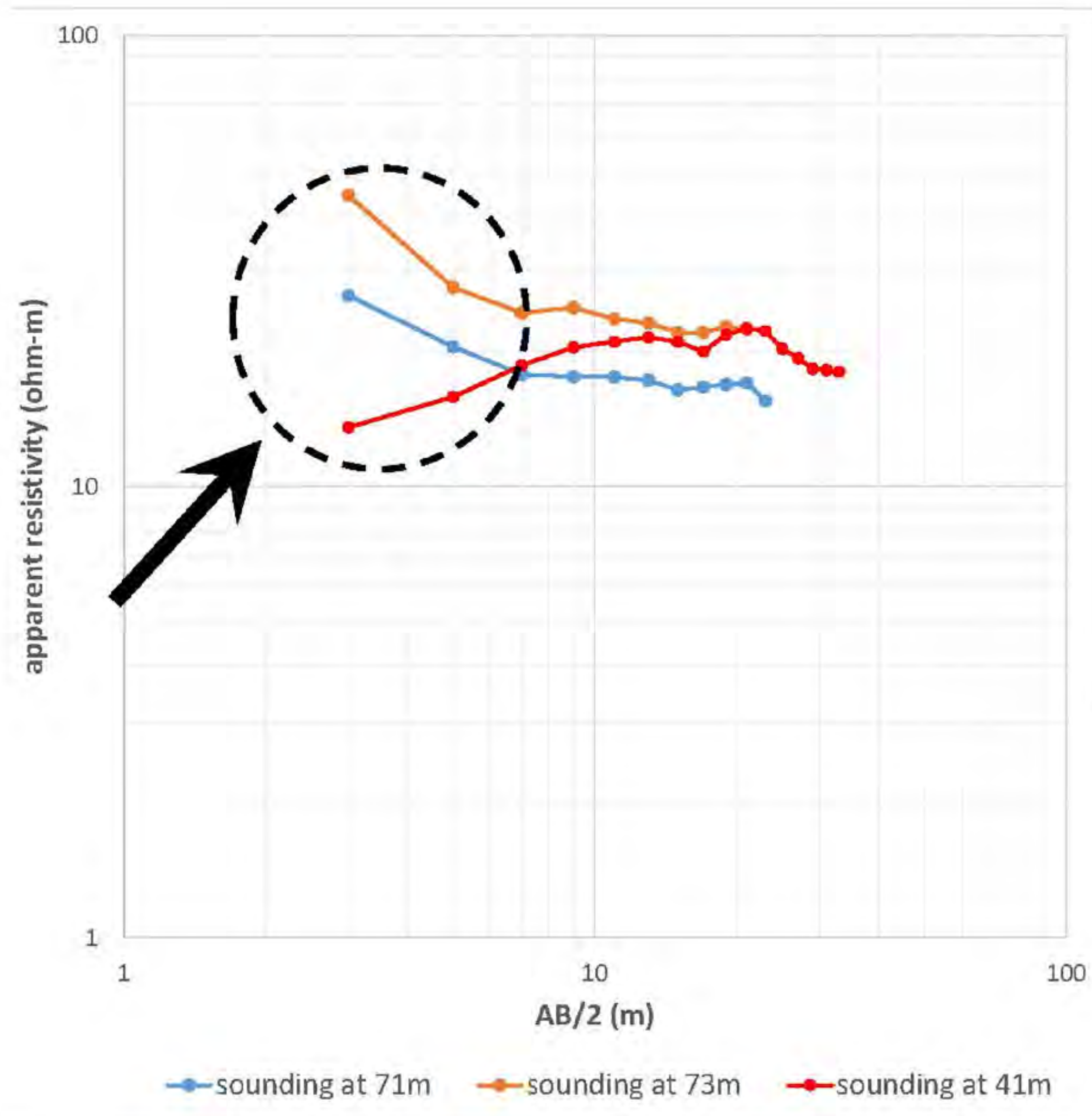
Figure 2-14
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona



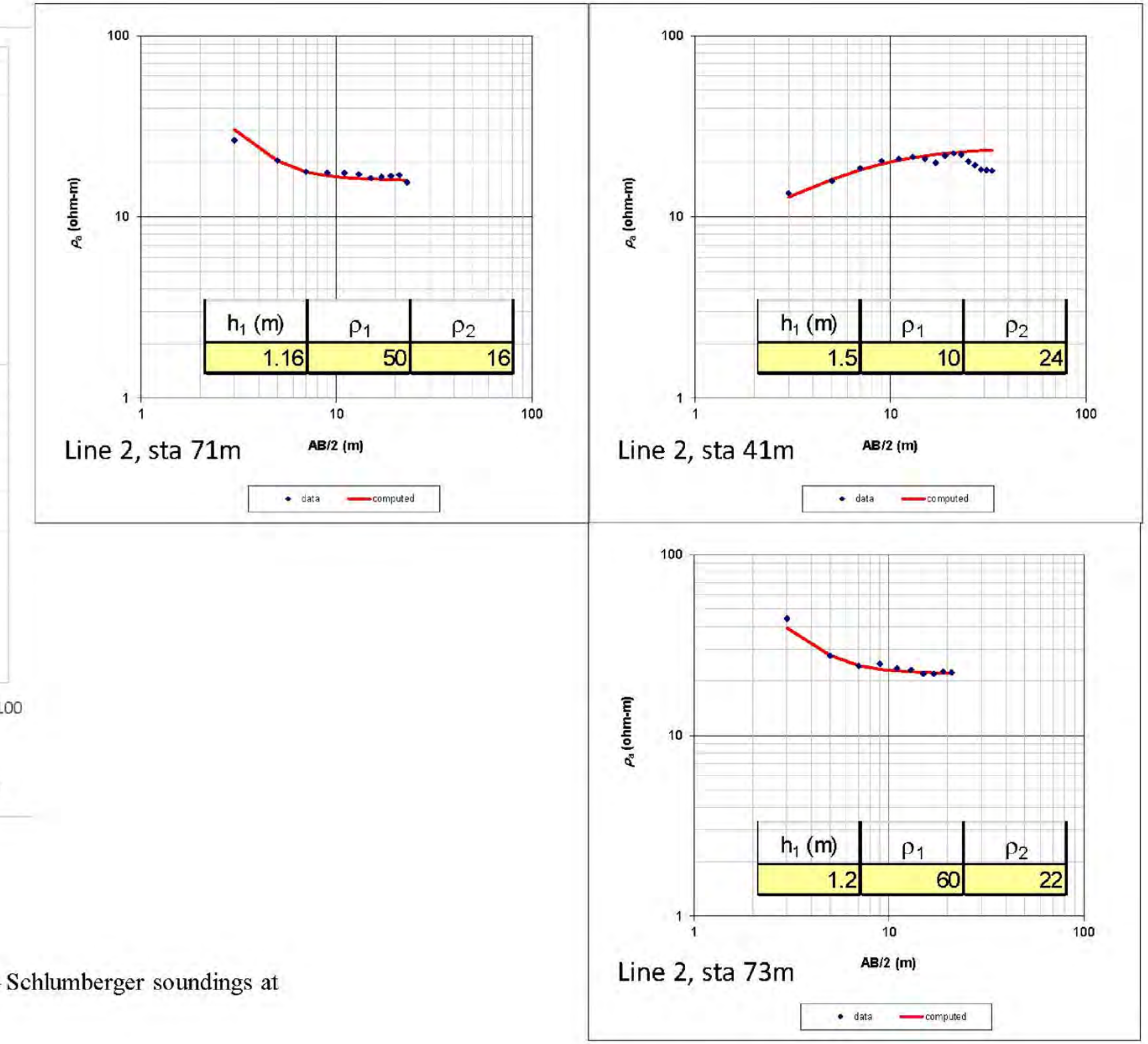


Figure 15. Analysis of Target C – modeling results – Schlumberger soundings at Line 2, stations 71, 73, and 41m.

Data export from other software

Map Creation Date: 15 September 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-15

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Figure 2-15
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

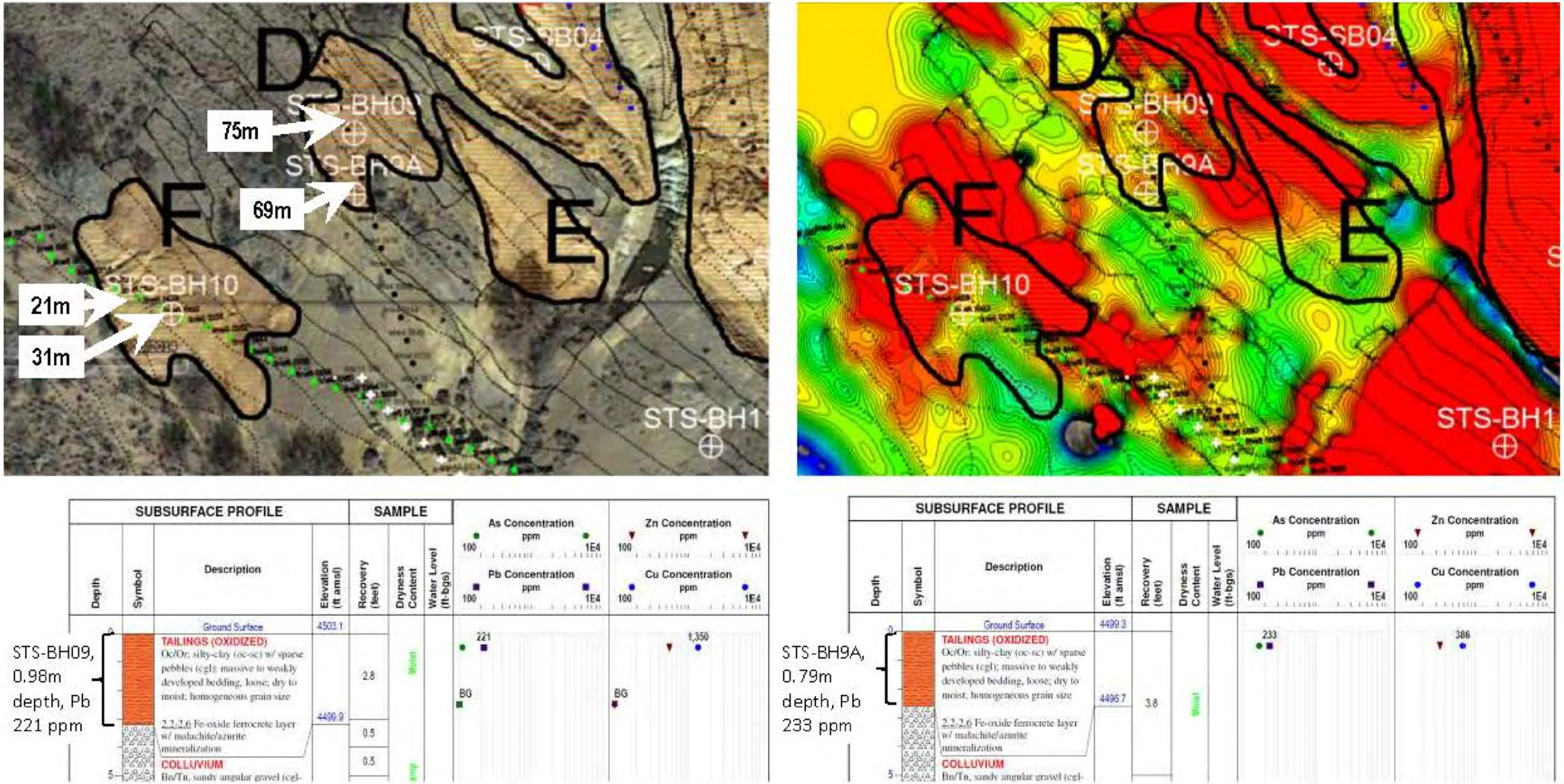

Figure 16. Analysis of Targets D, E, and F.

Data export from other software

Map Creation Date: 15 September 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-16

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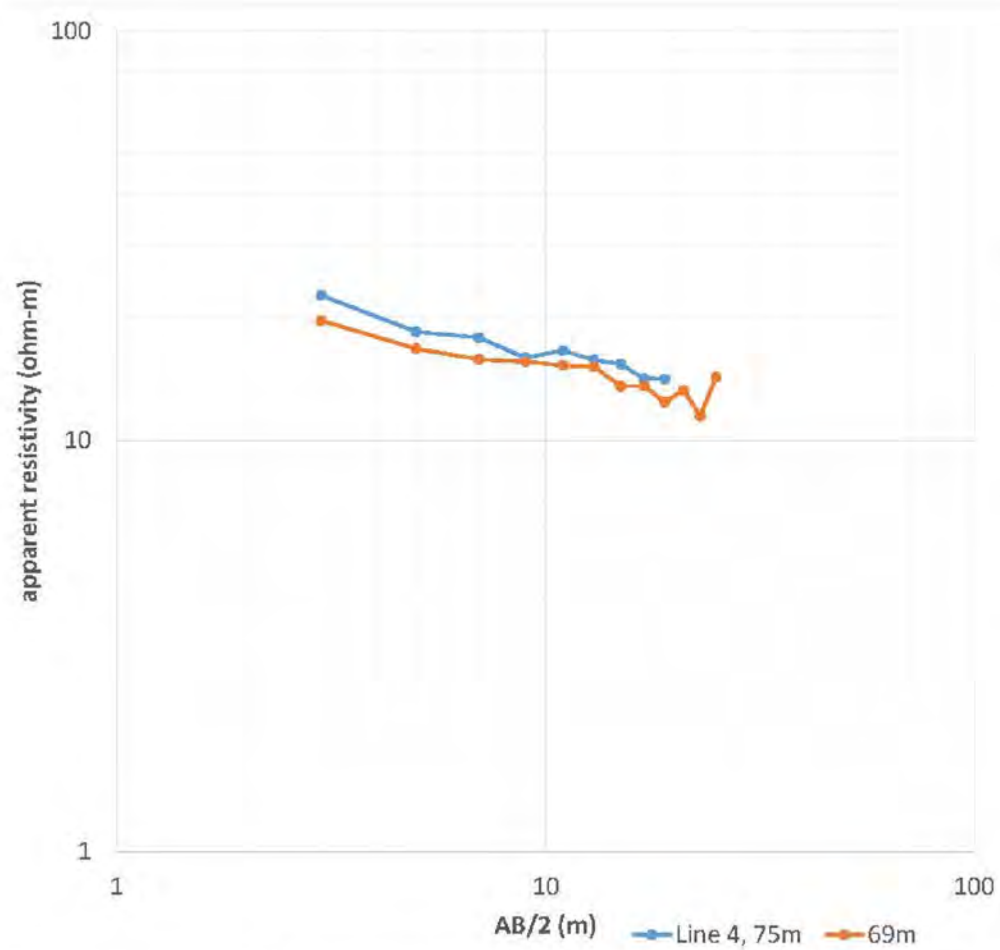
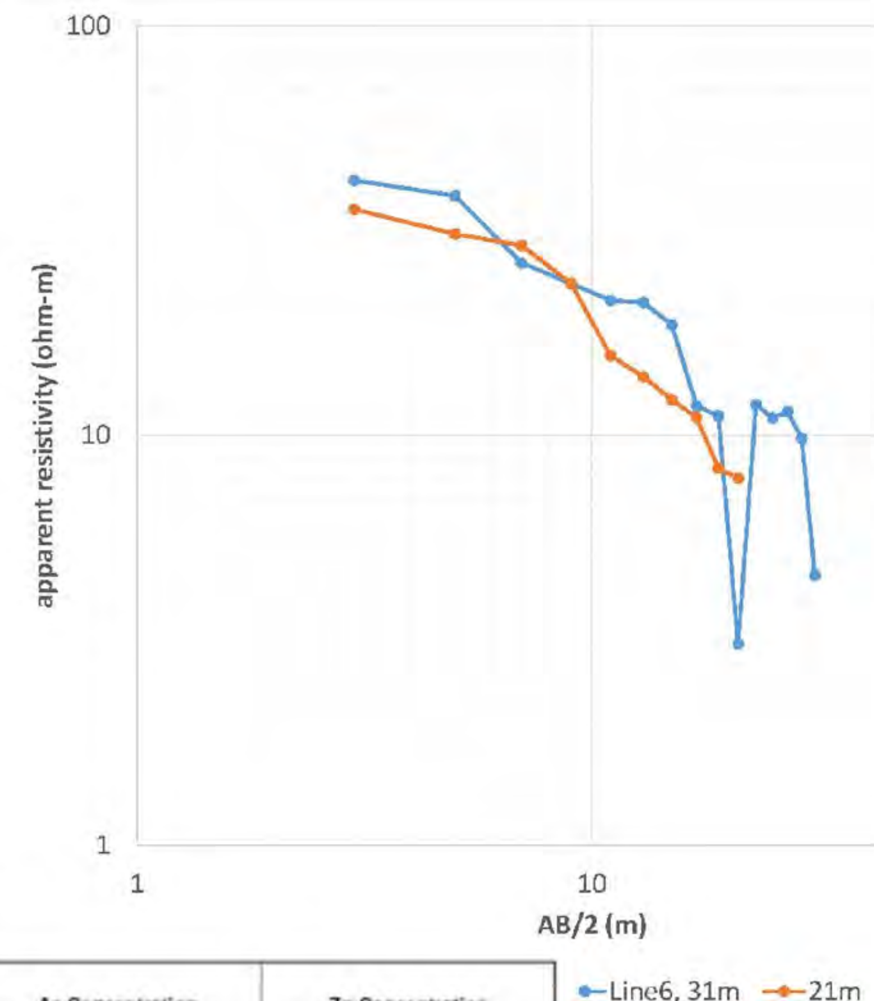
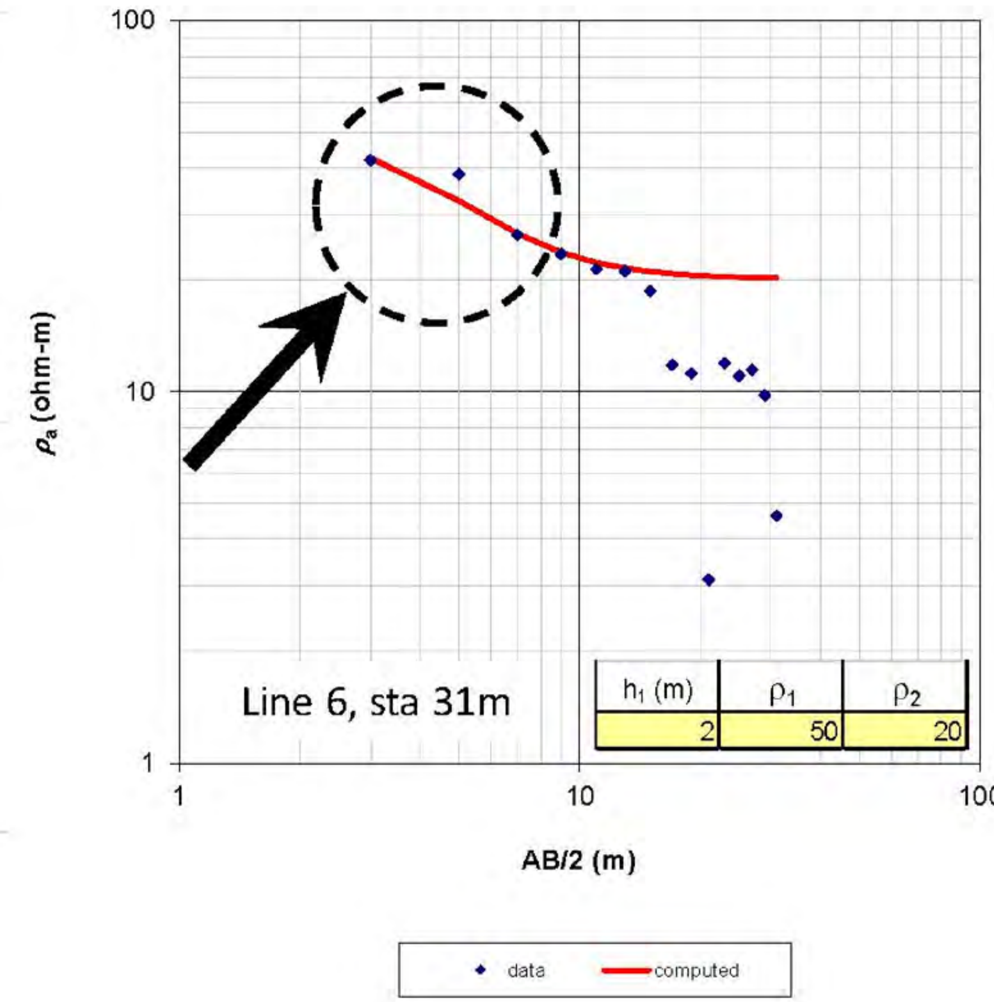
Figure 2-16
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona







STS-BH10, 1.28m depth, Pb 270 ppm

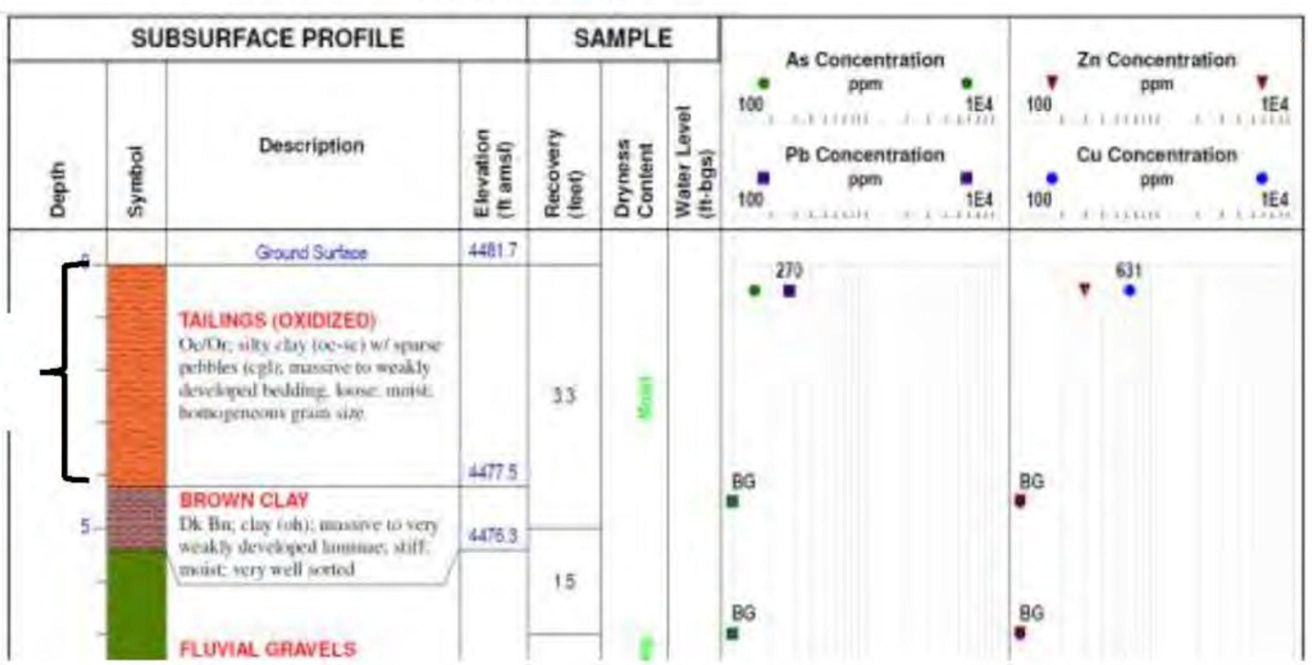


Figure 17. Analysis of Targets D, E, and F, continued.

Data export from other software

Map Creation Date: 15 September 2014

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Figure 2-17
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

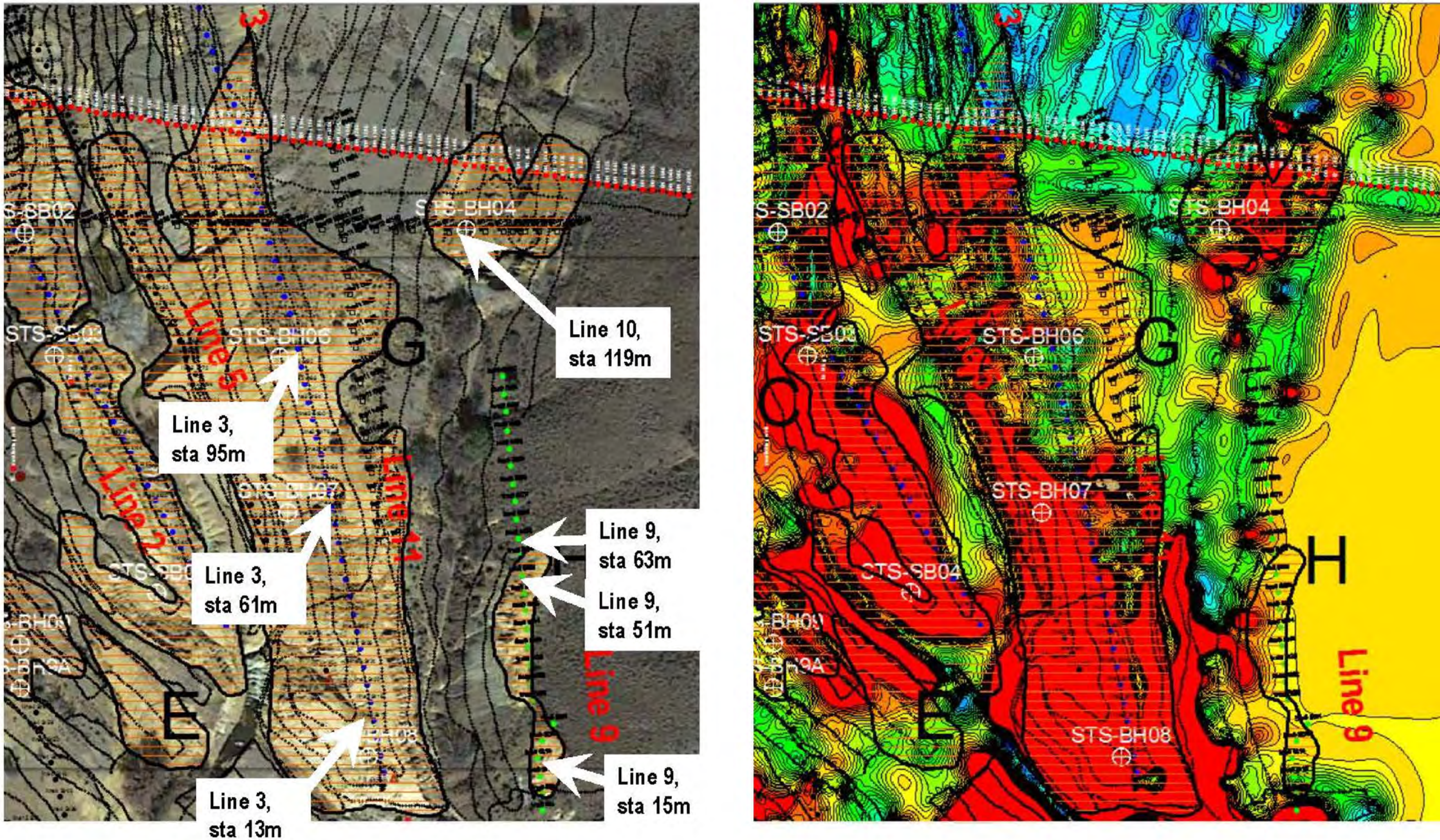

Figure 18. Analysis of Targets G, H, and I.

Data export from other software

Map Creation Date: 15 September 2014

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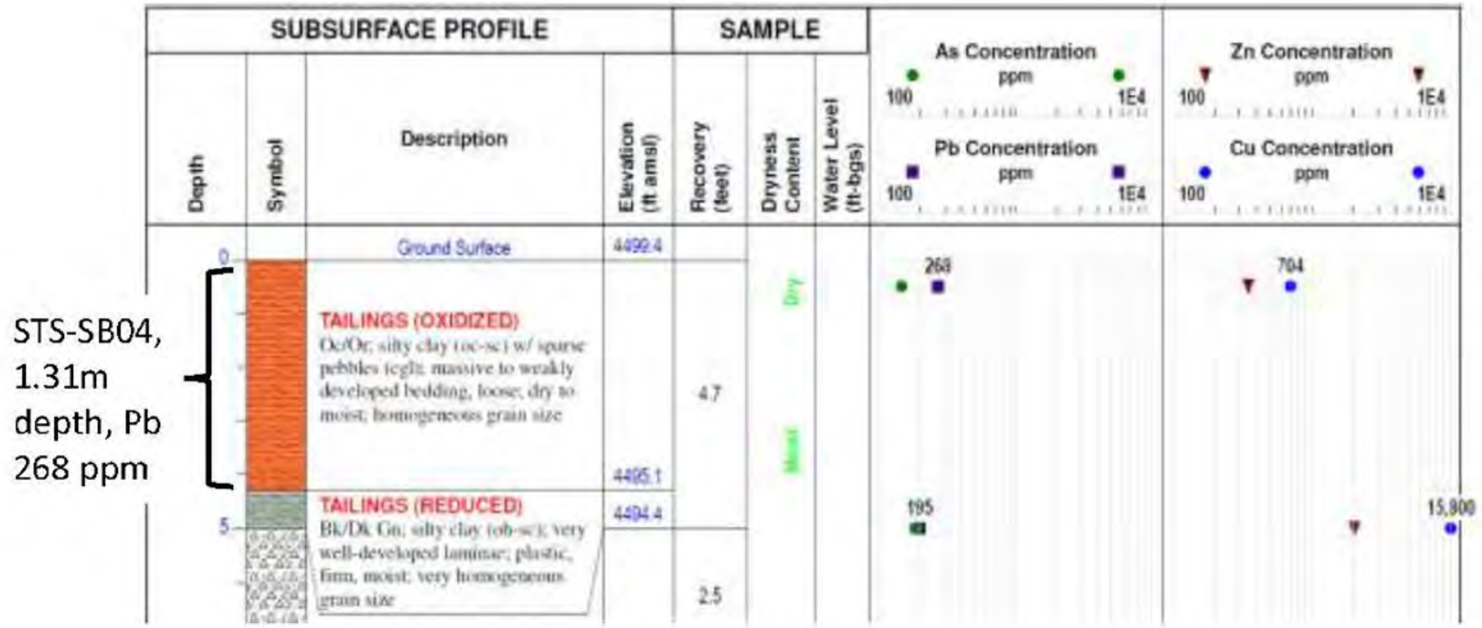
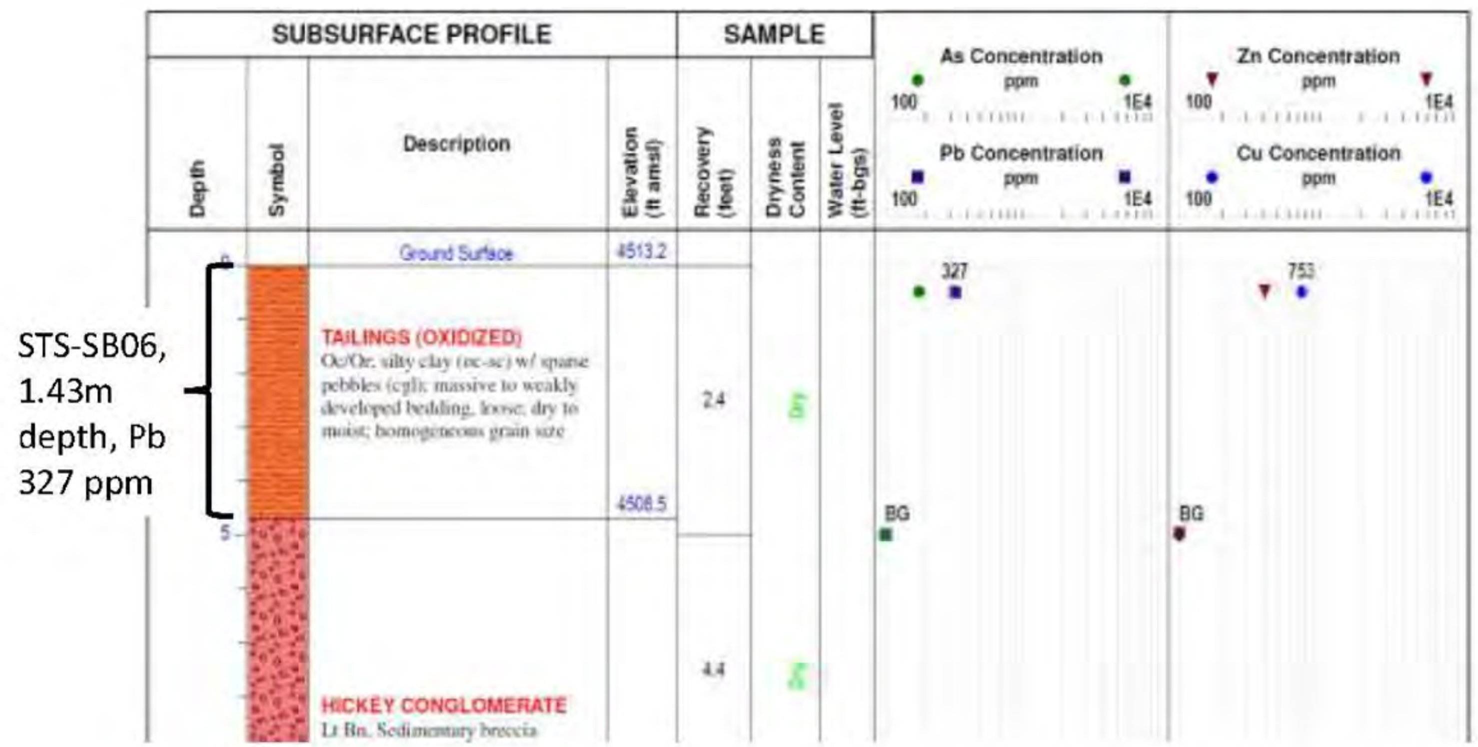
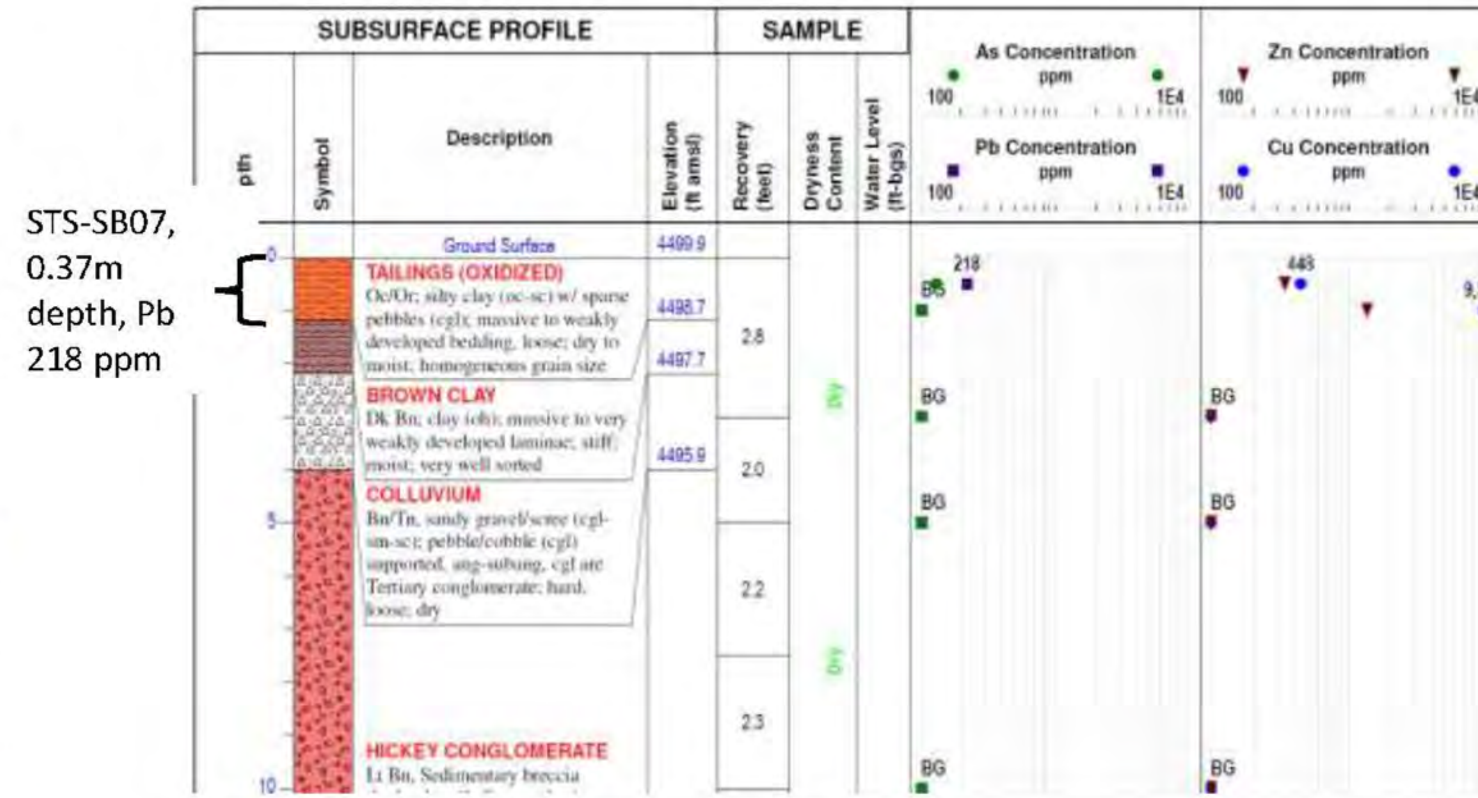
Figure 2-18
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona







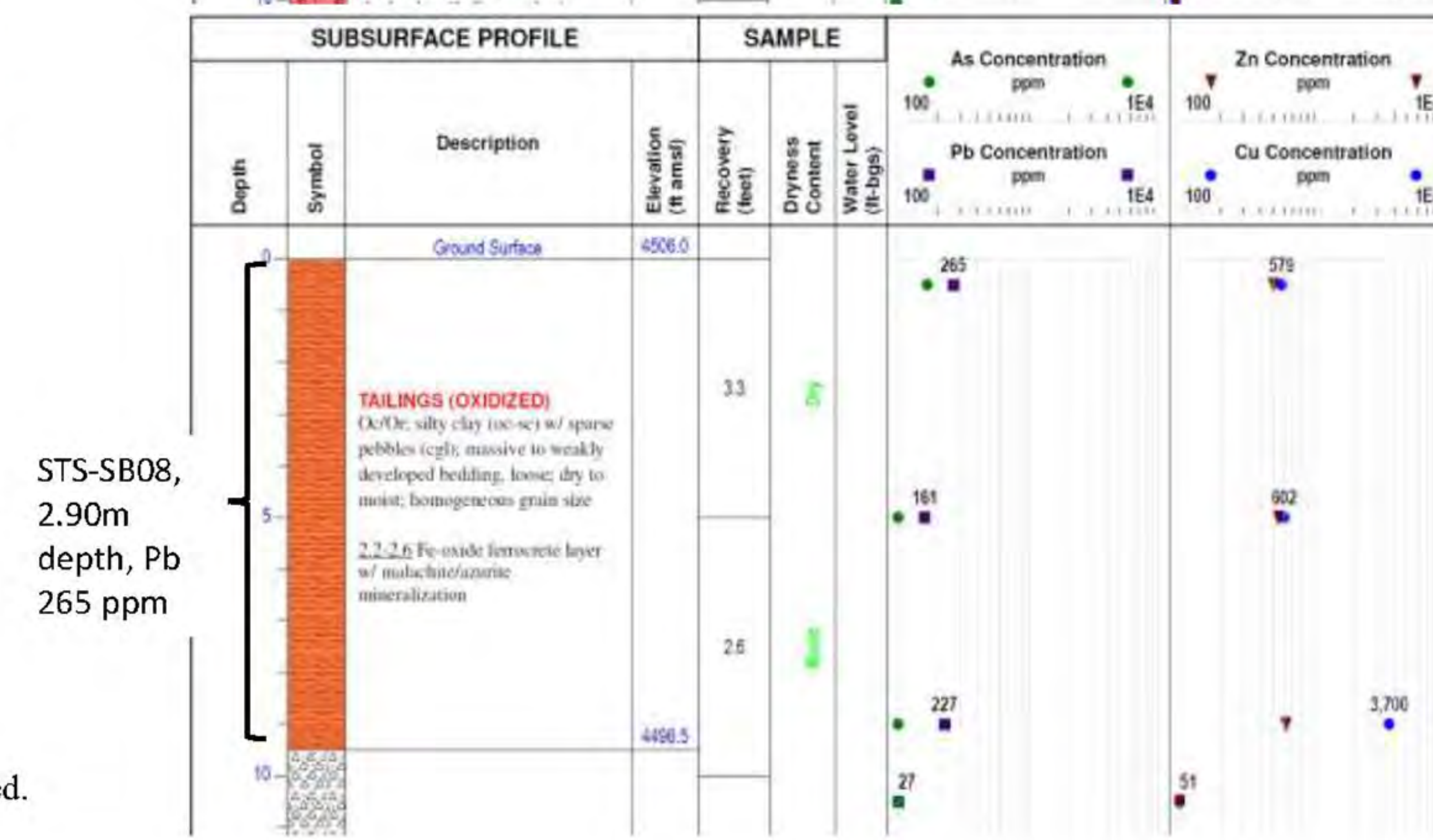


Figure 19. Analysis of Targets G, H, and I, continued.

Data export from other software

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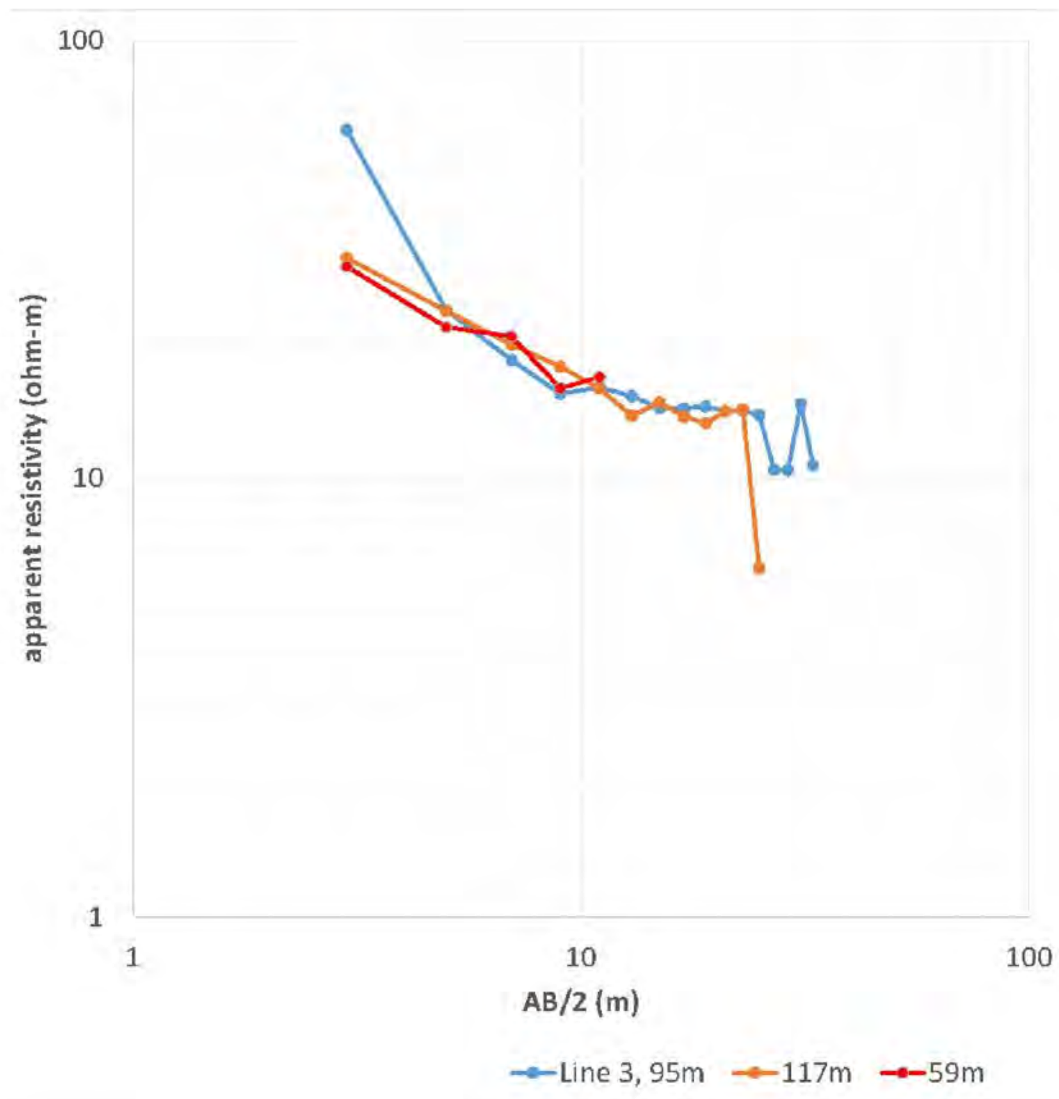
Figure 2-19
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona



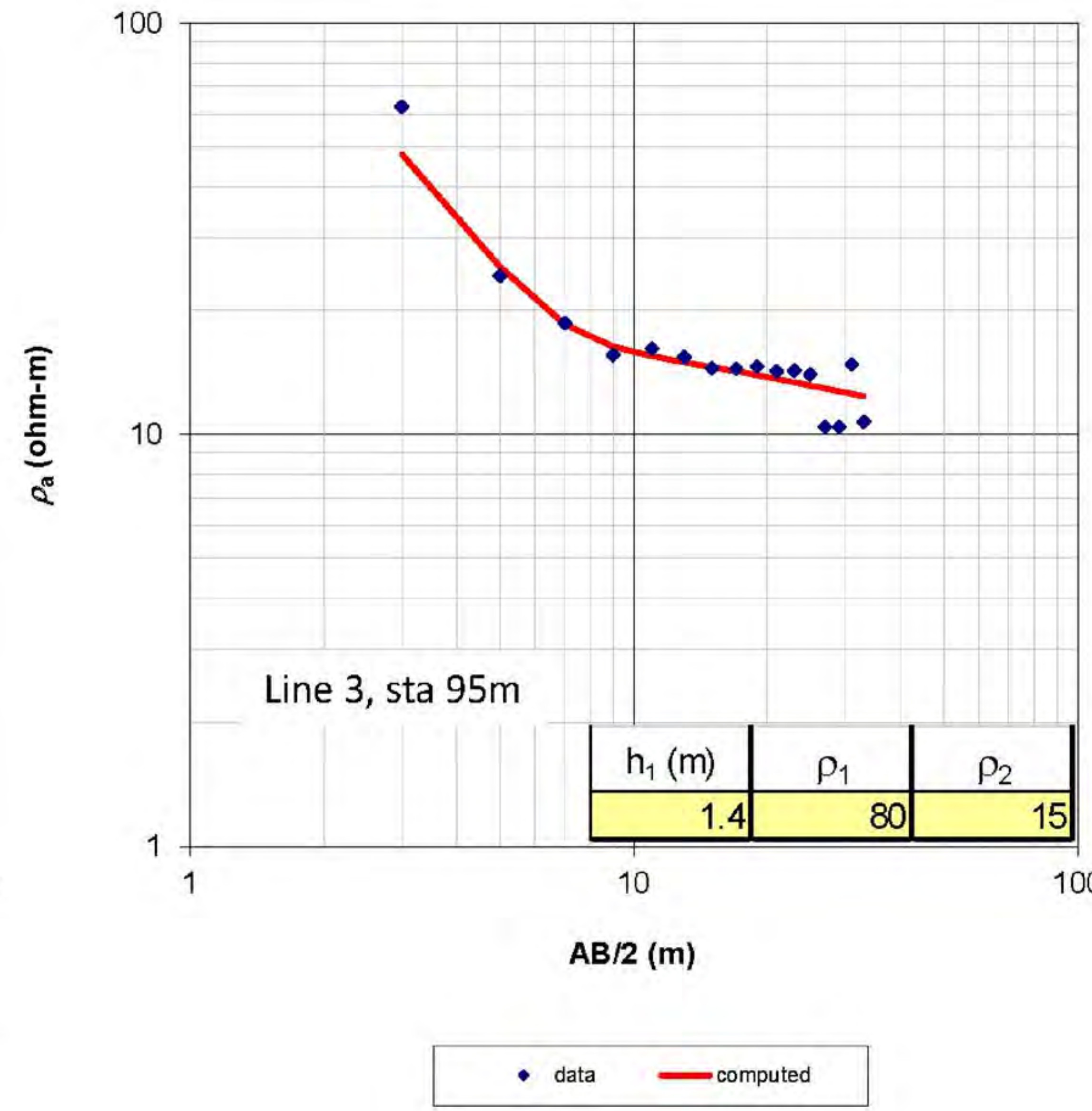


Figure 20. Analysis of Target G.

Data export from other software

Map Creation Date: 15 Septemper 2014

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Figure 2-20
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

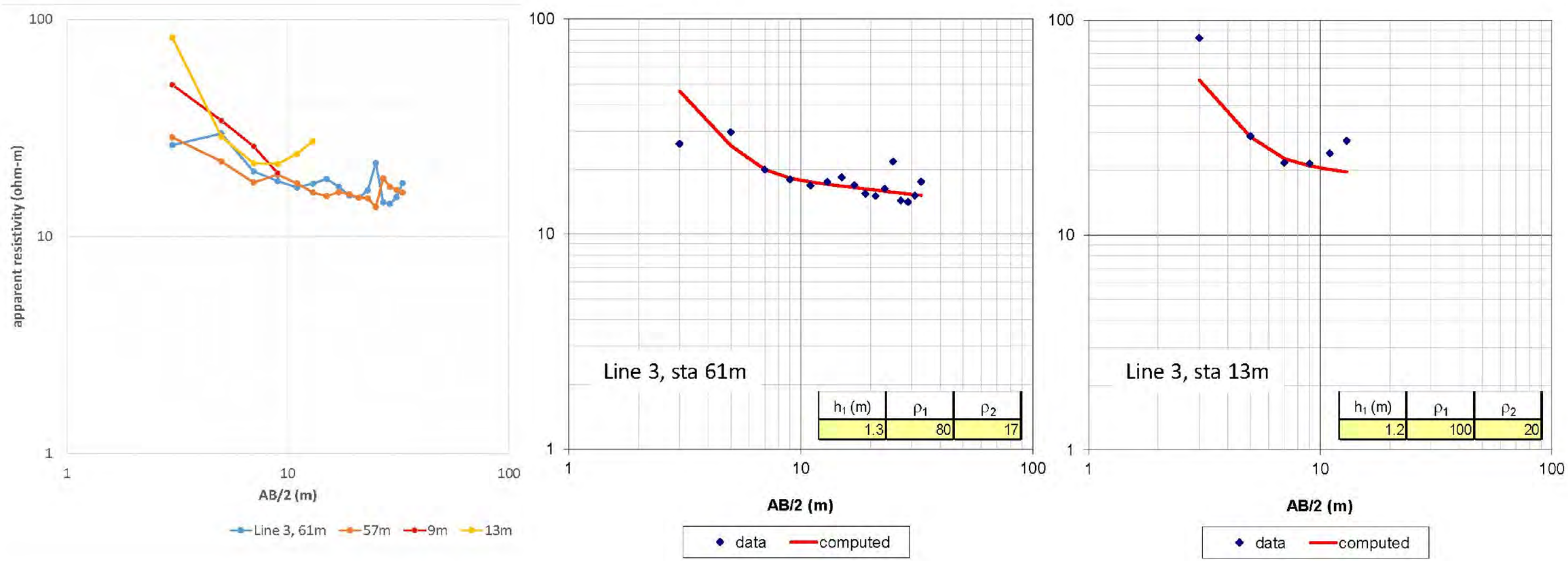

Figure 21. Analysis of Target G, continued.

Data export from other software

Map Creation Date: 15 September 2014

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Figure 2-21
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

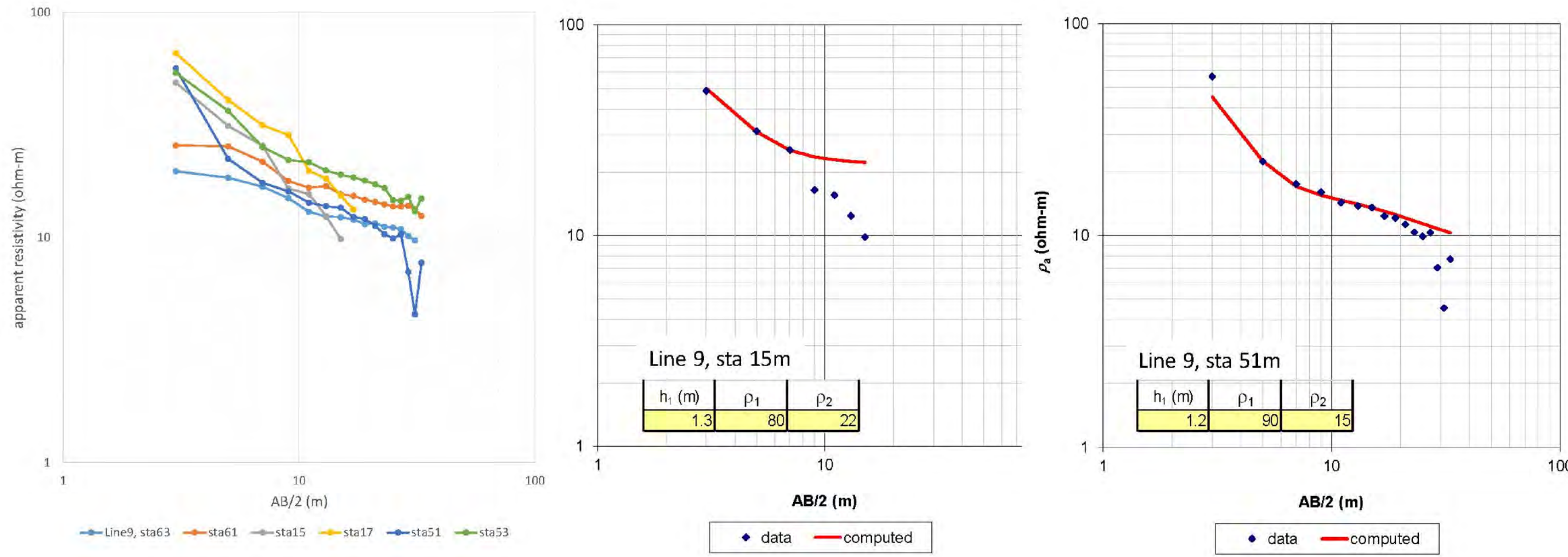

Figure 22. Analysis of Target H.

Data export from other software

Map Creation Date: 15 Septemper 2014

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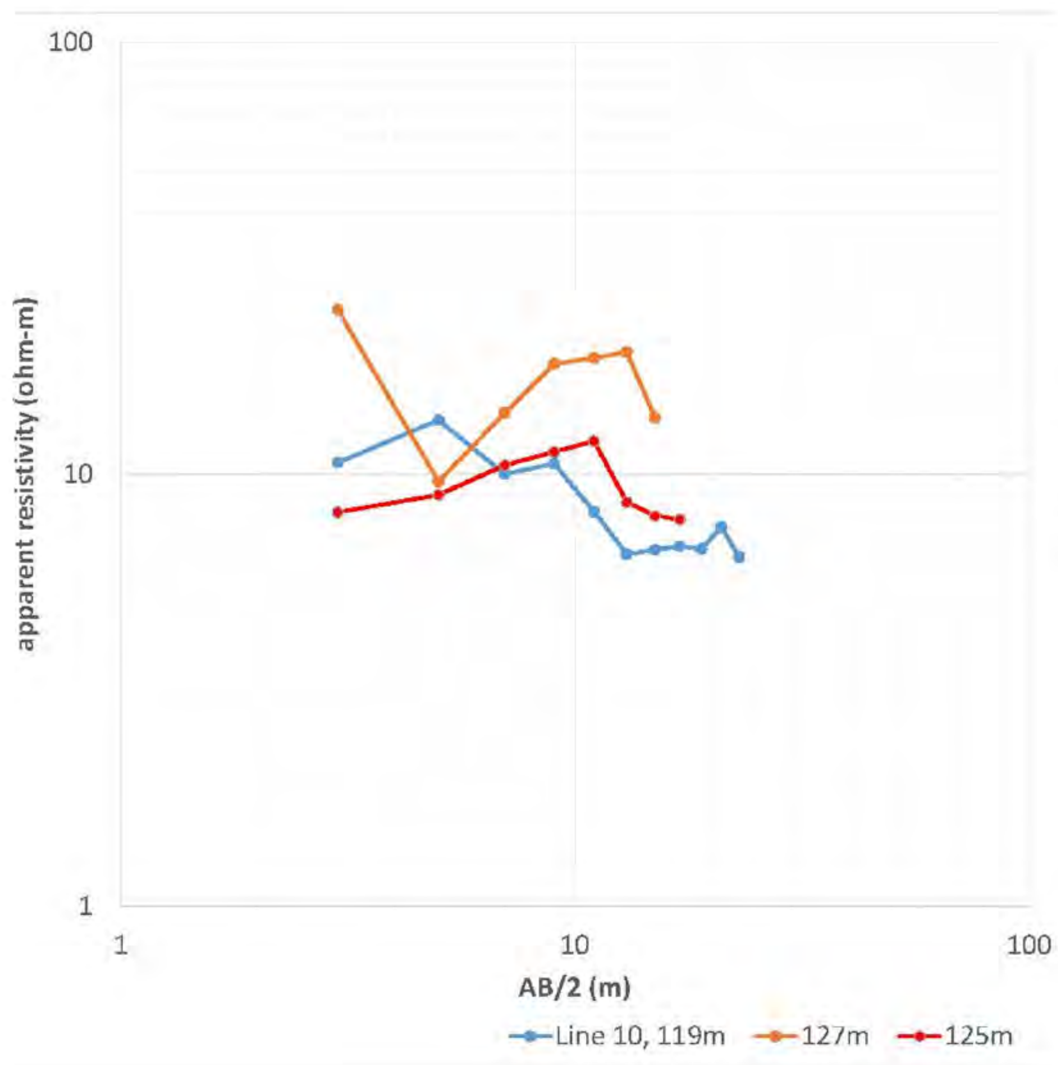
Figure2- 22
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona



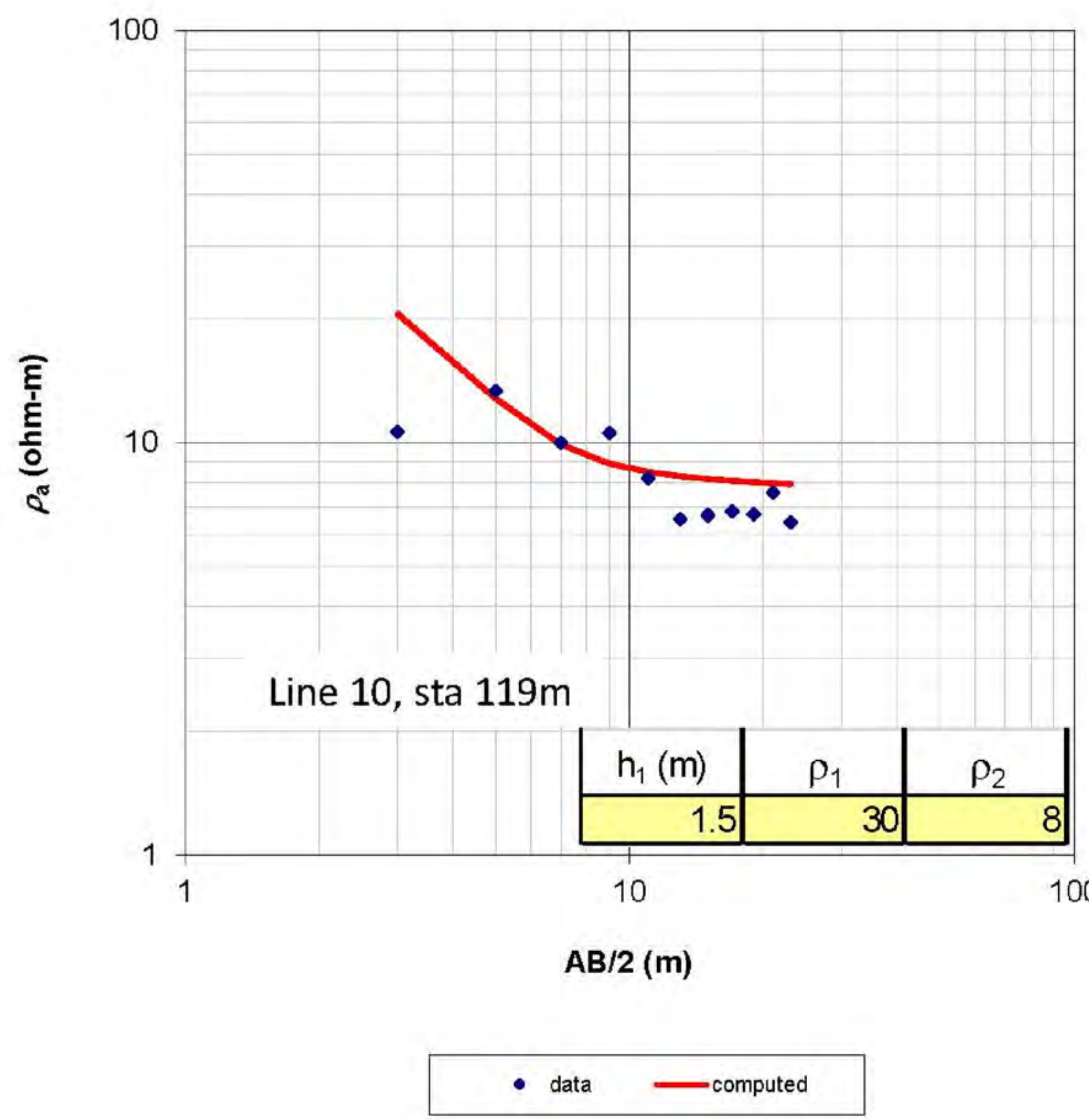


Figure 23. Analysis of Target I.

Data export from other software

Map Creation Date: 15 Septemper 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-23

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Figure 2-23
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

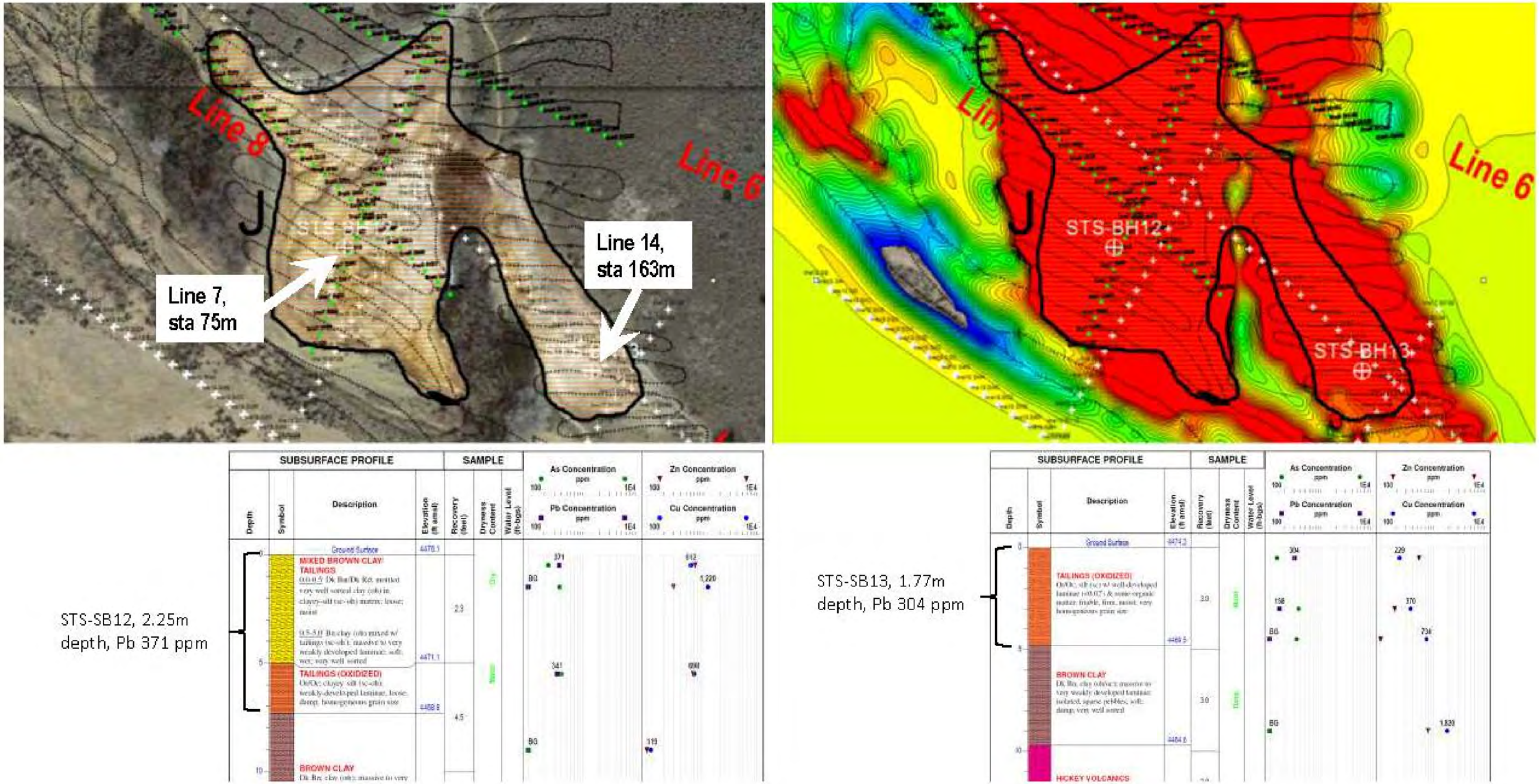

Figure 24. Analysis of Target J.

Data export from other software

Map Creation Date: 15 September 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-24

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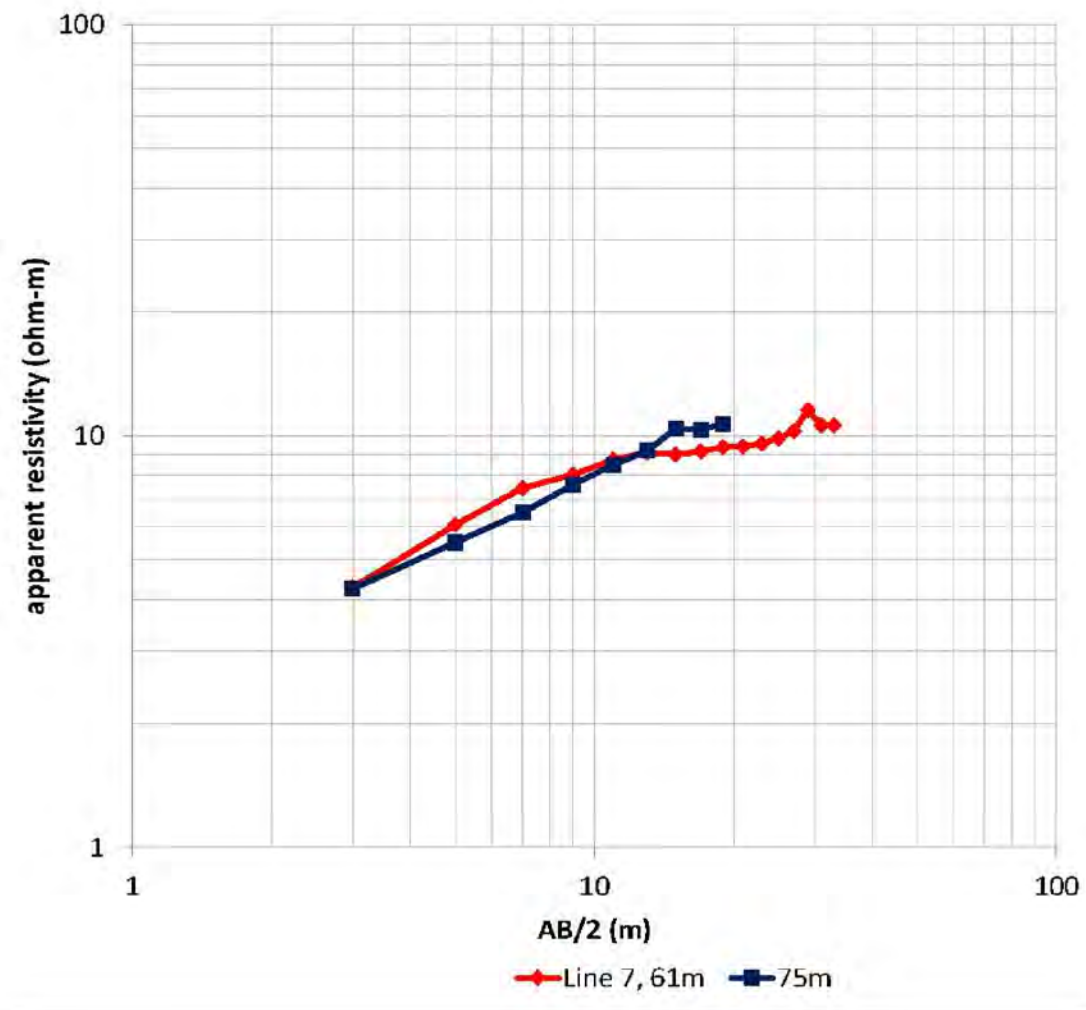
Figure 2-24
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona



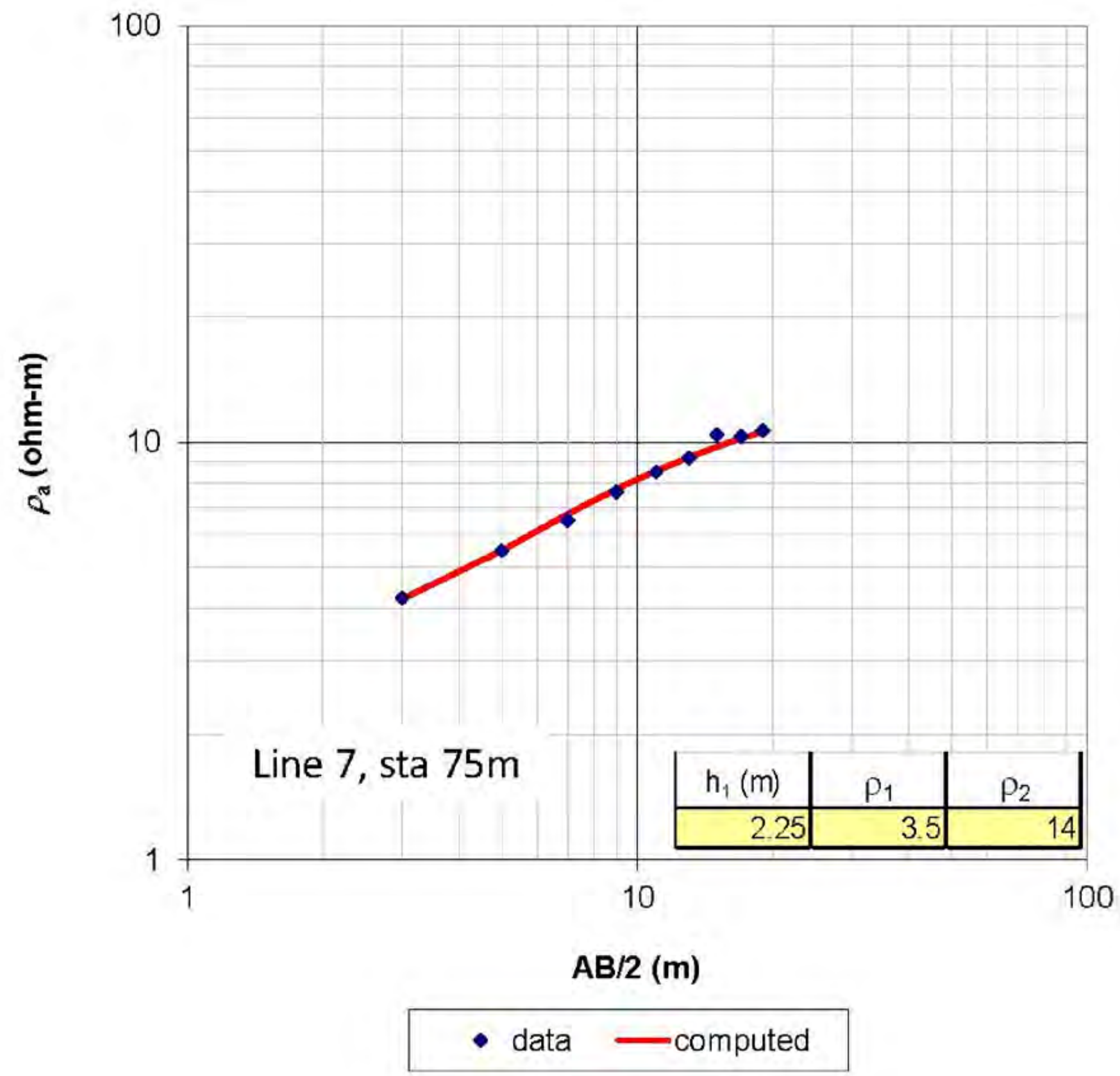


Figure 25. Analysis of Target J, continued.

Data export from other software

Map Creation Date: 15 September 2014

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Figure 2-25
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

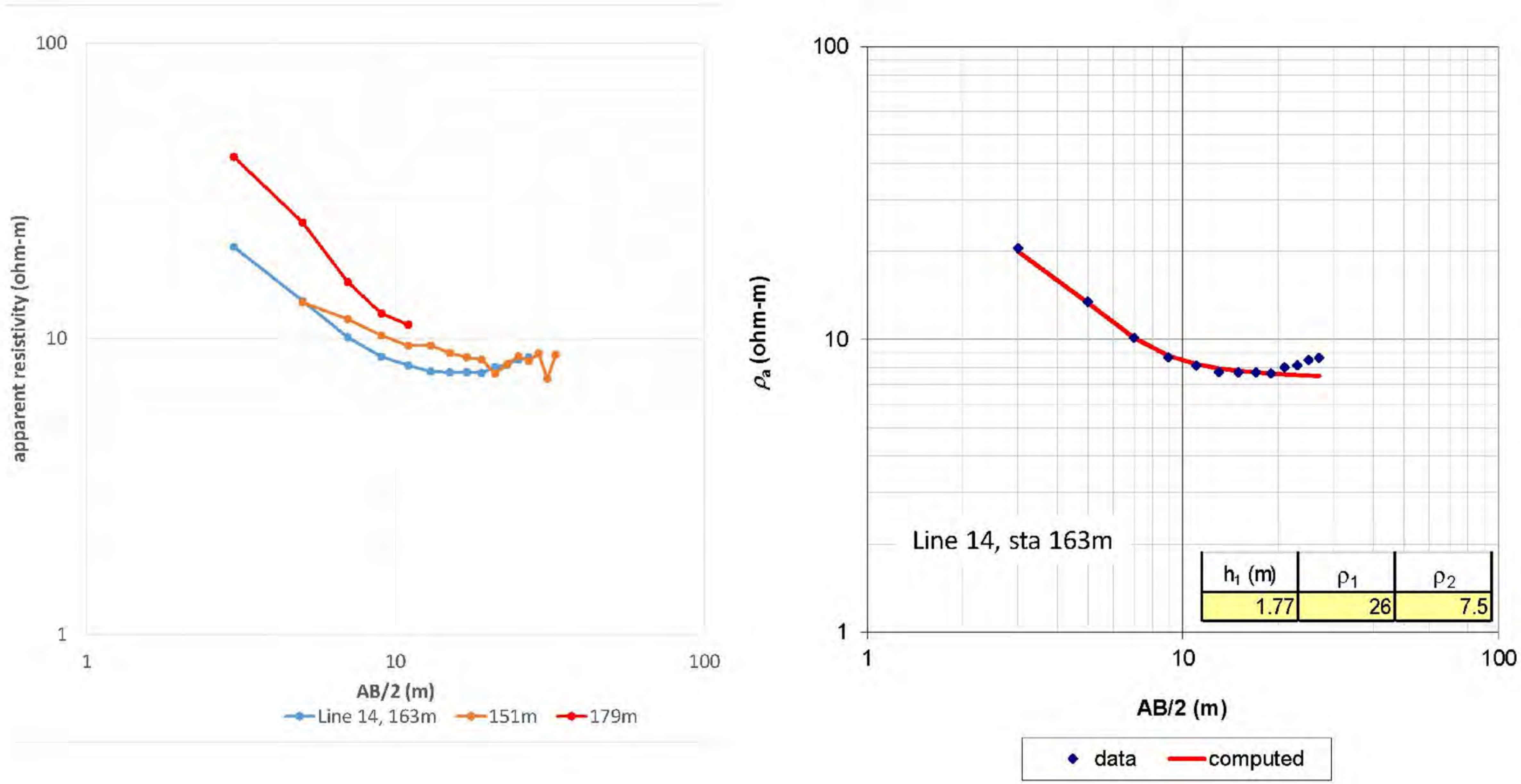

Figure 26. Analysis of Target J, continued.

Data export from other software

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Figure 2-26
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

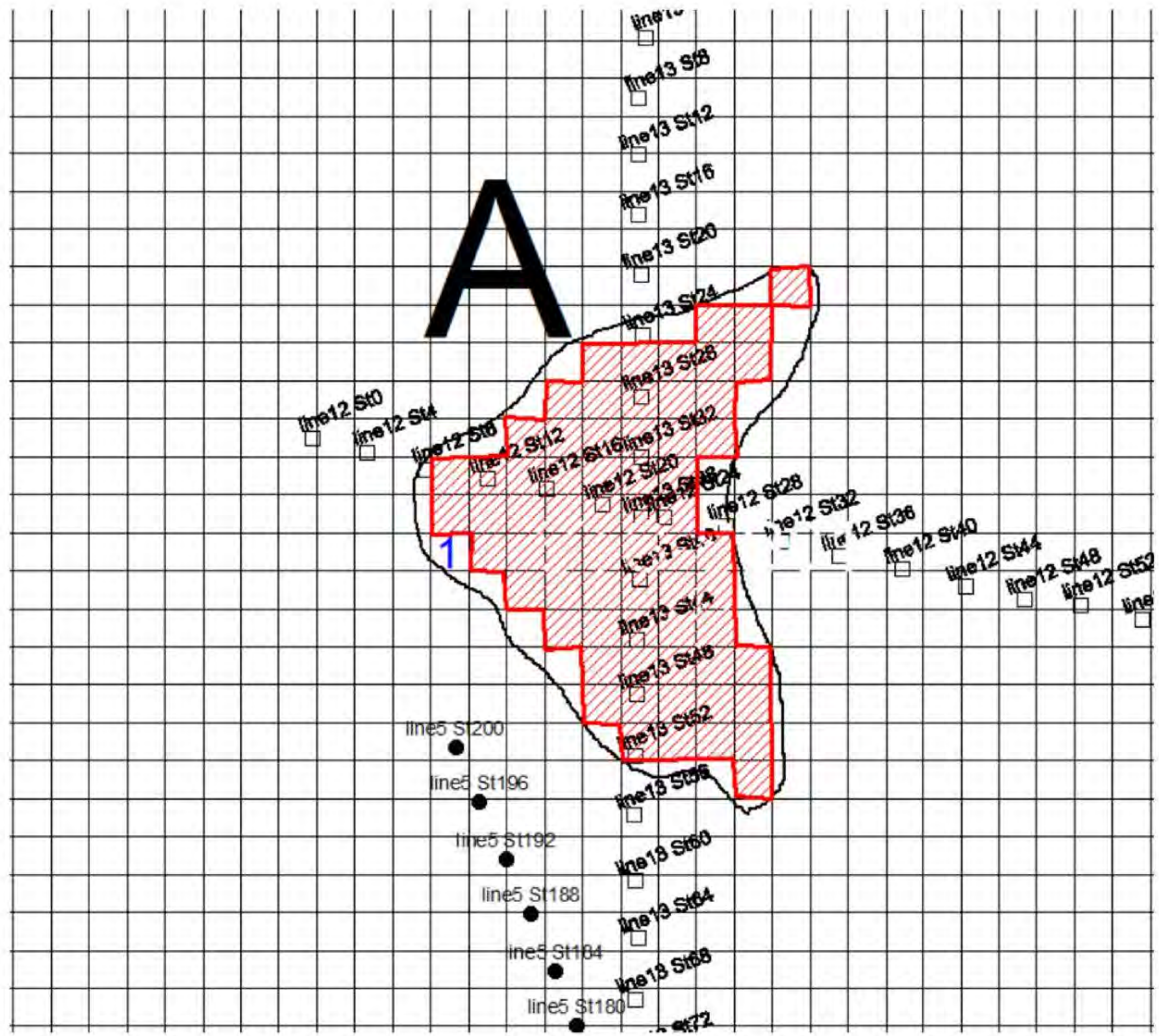

Figure 27. Volume calculation of Target A. Grid is 2.5m square. Red outlines whole cells, partial cells are those around the perimeter.

Data export from other software

Map Creation Date: 15 Septemper 2014

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MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-27

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Figure 2-27
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

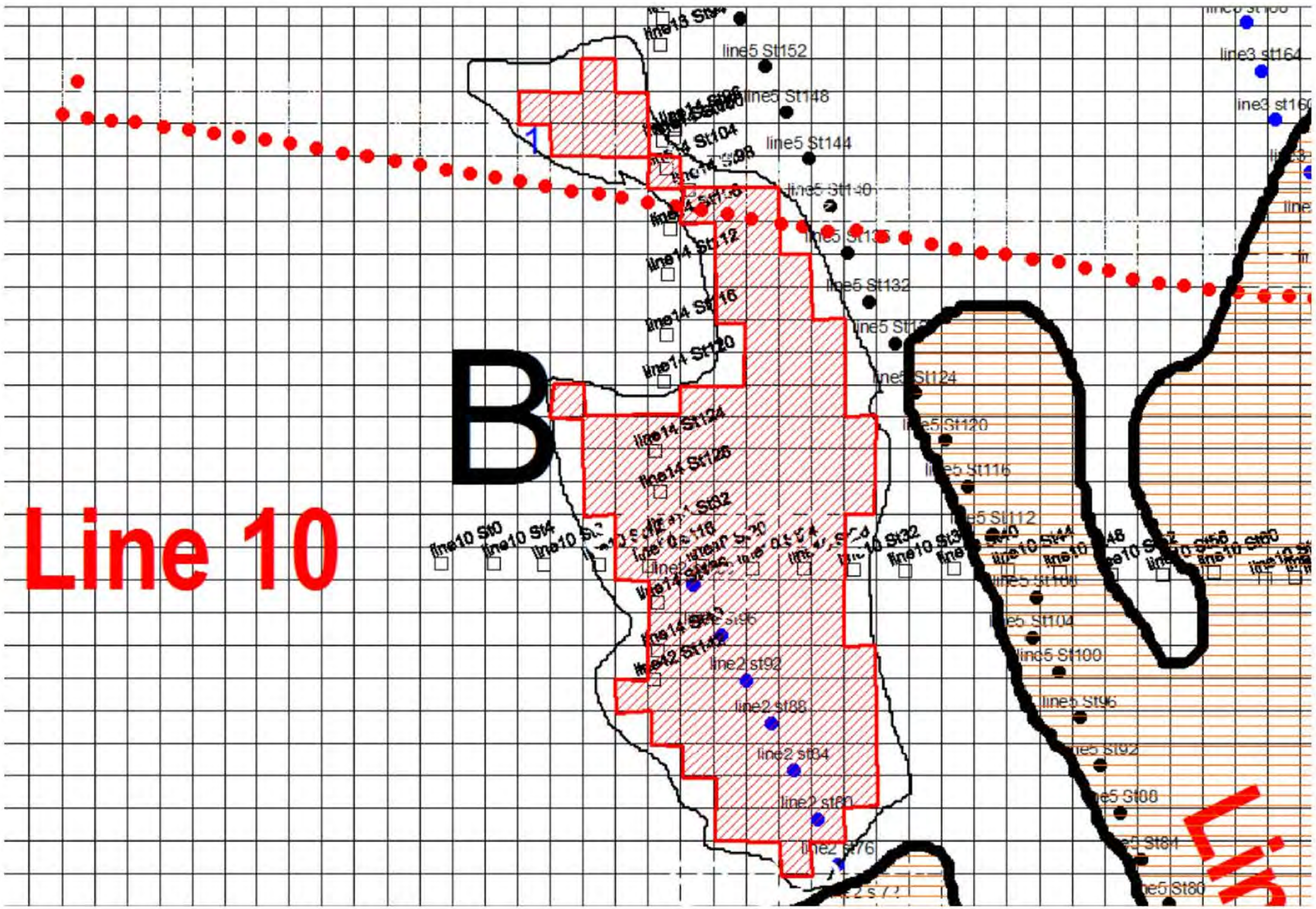

Figure 28. Volume calculation of Target B.

Data export from other software

Map Creation Date: 15 September 2014

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-28

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Figure 2-28
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

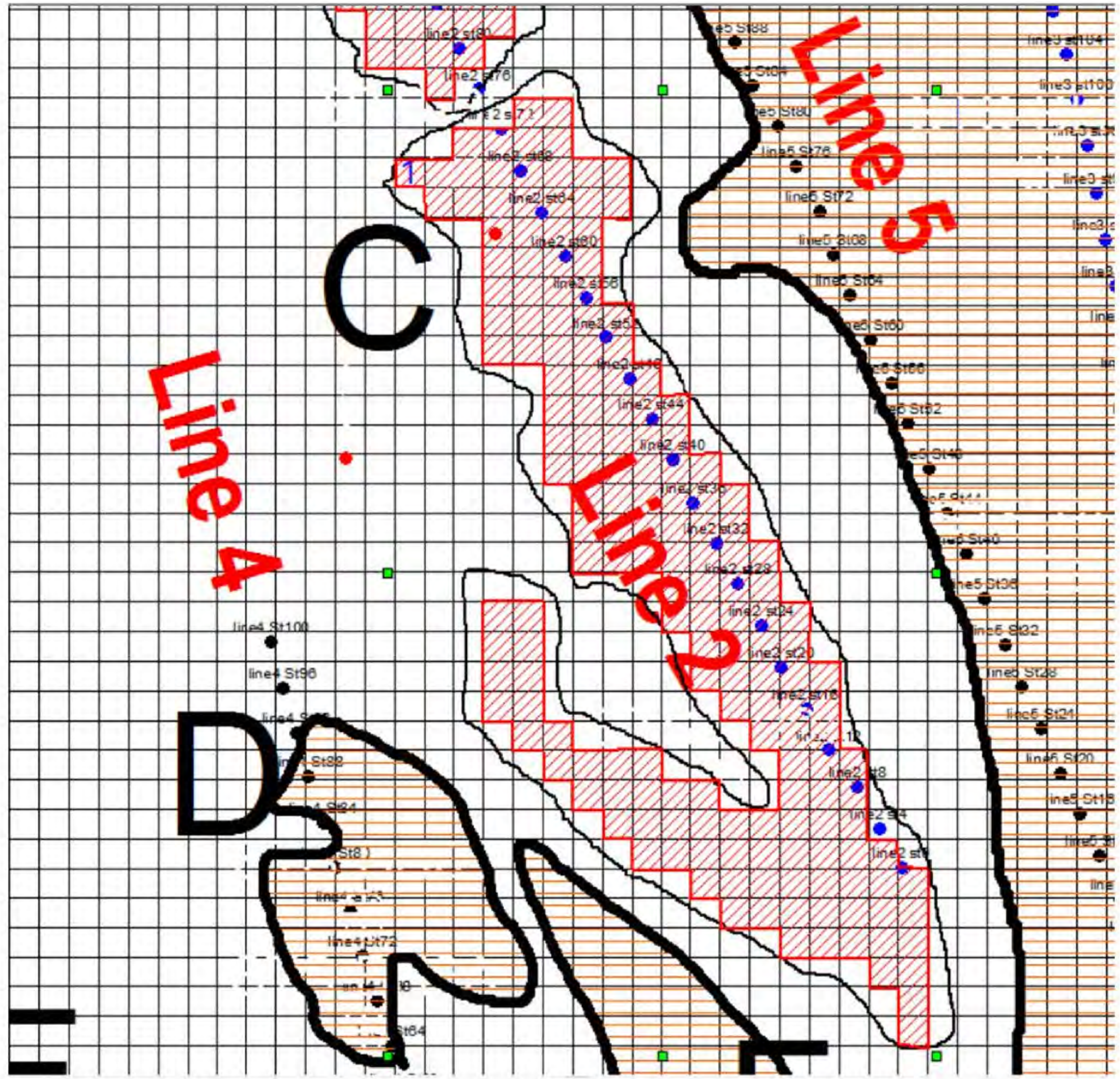

Figure 29. Volume calculation of Target C.

Data export from other software

Map Creation Date: 15 Septemper 2014

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-29

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Figure 2-29
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

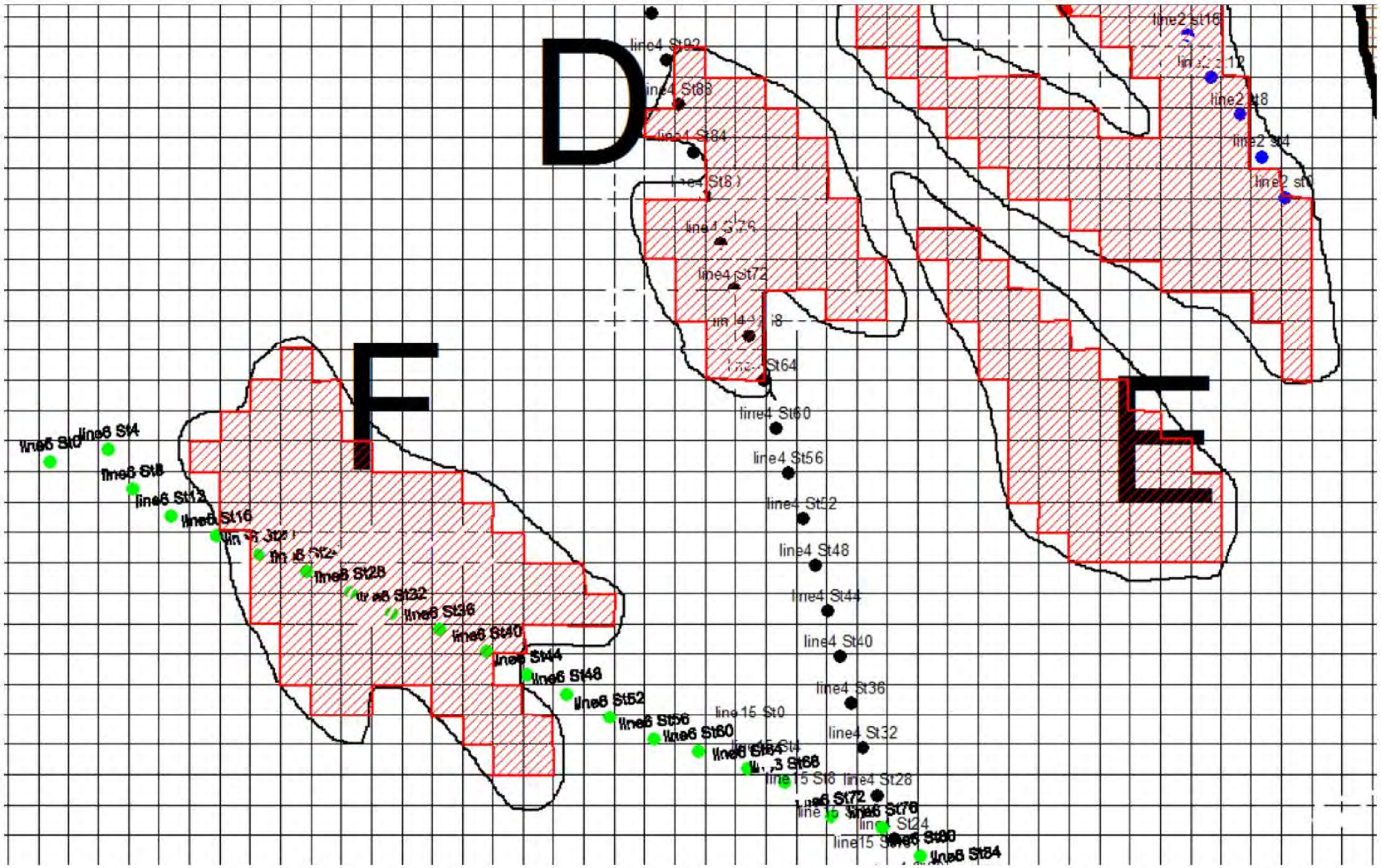

Figure 30. Volume calculation of Targets D, E, and F.

Data export from other software

Map Creation Date: 15 Septemper 2014

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-30

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Figure 2-30
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

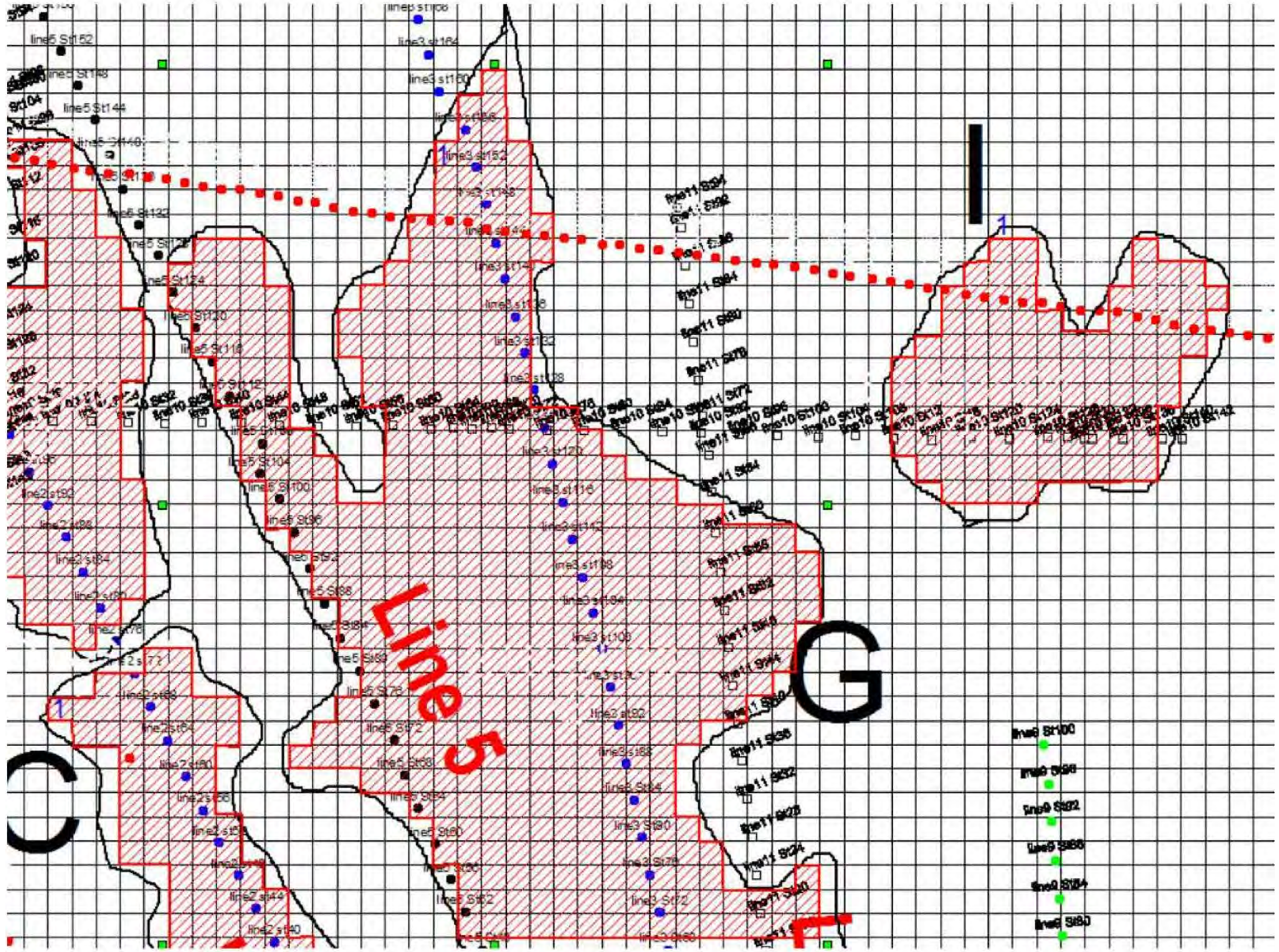

Figure 31. Volume calculation of Targets I, and G (northern).

Data export from other software

Map Creation Date: 15 September 2014

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-31

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Figure 2-31
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

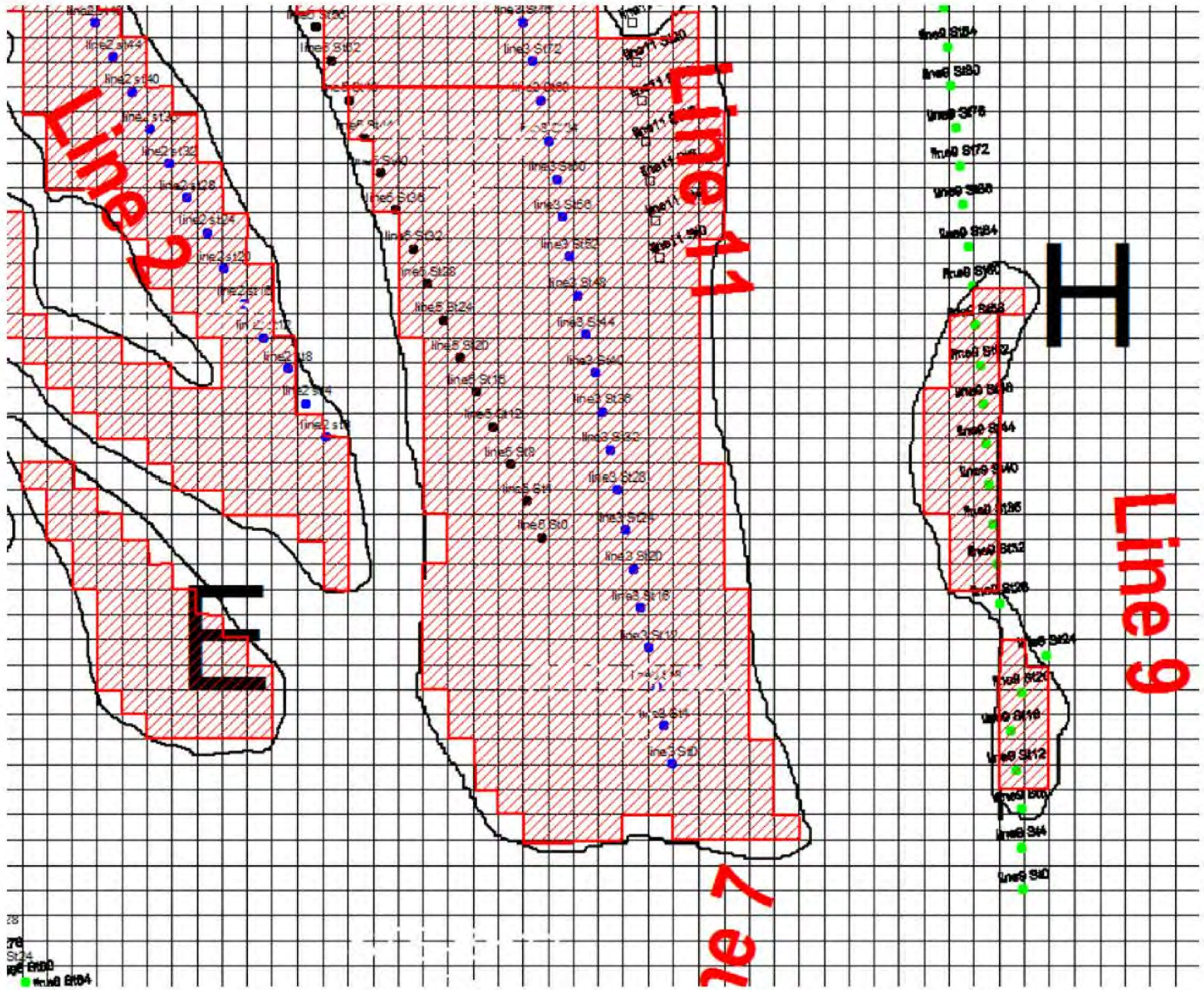

Figure 32. Volume calculation of Targets G (southern), and H.

Data export from other software

Map Creation Date: 15 September 2014

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-32

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Figure 2-32
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

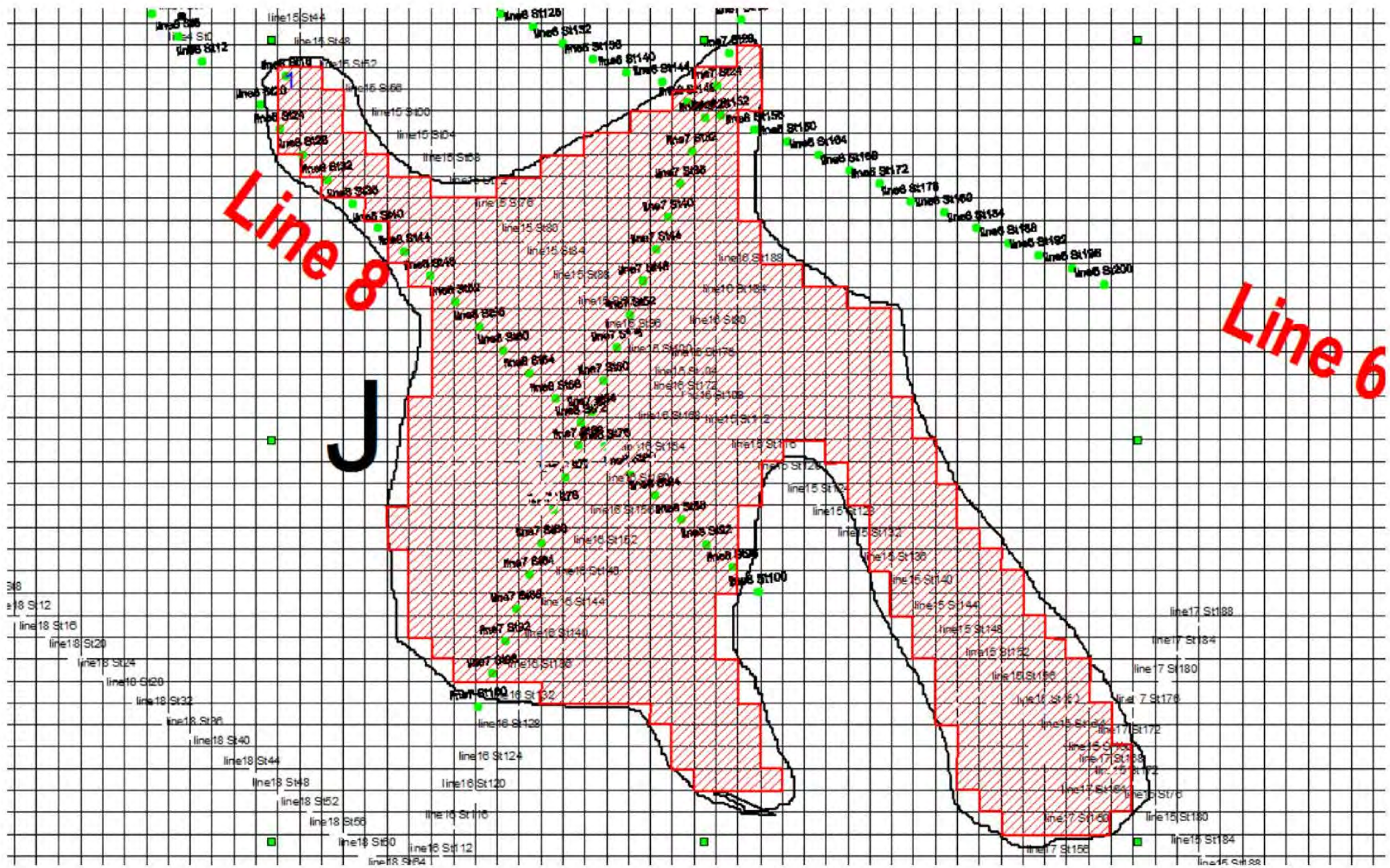

Figure 33. Volume calculation of Target J.

Data export from other software

Map Creation Date: 15 September 2014

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-33

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Figure 2-33
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

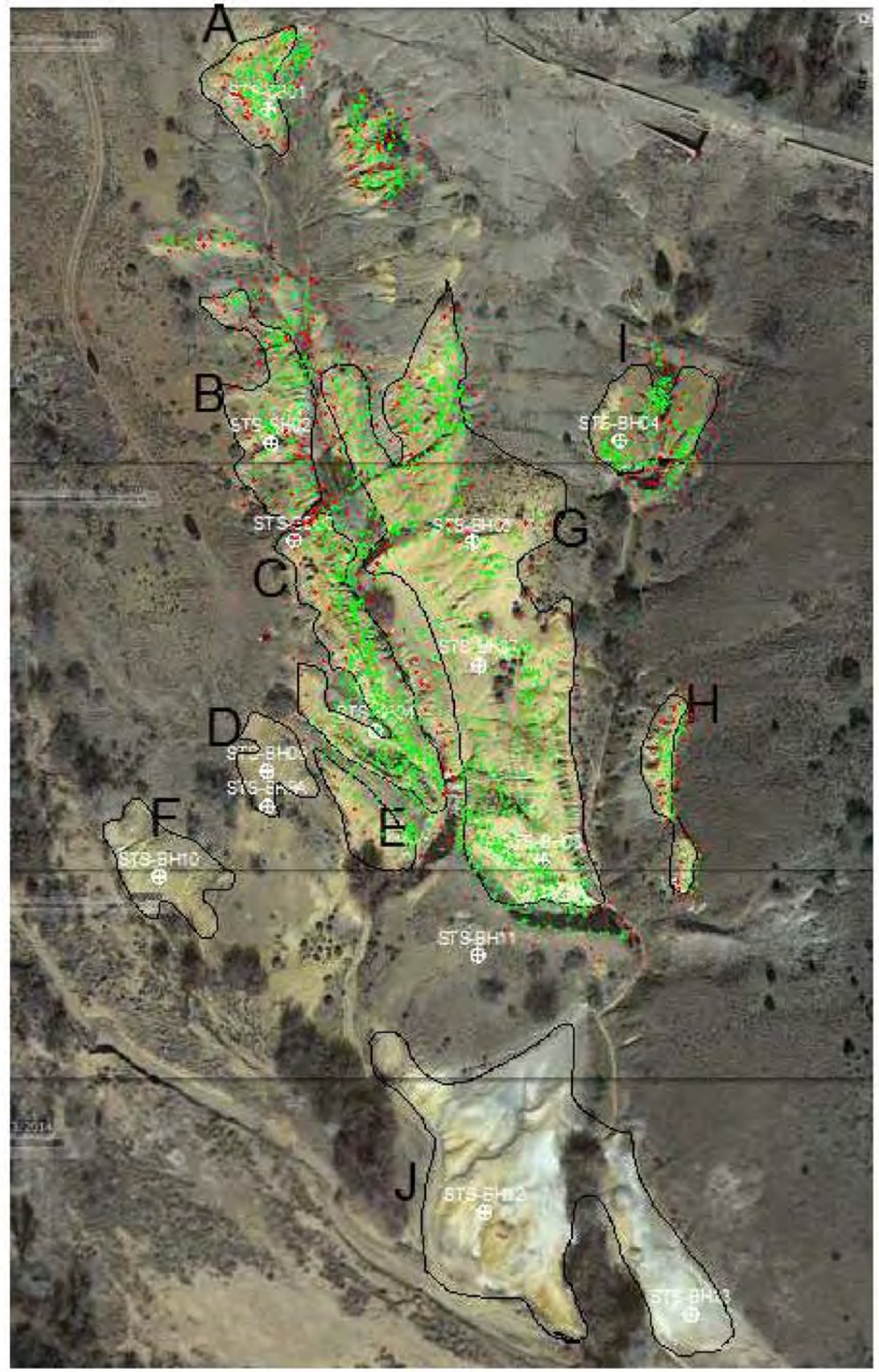

Figure 34. Contractor survey results – entire study area.

Data export from other software

Map Creation Date: 15 September 2014

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-34

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Figure 2-34
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

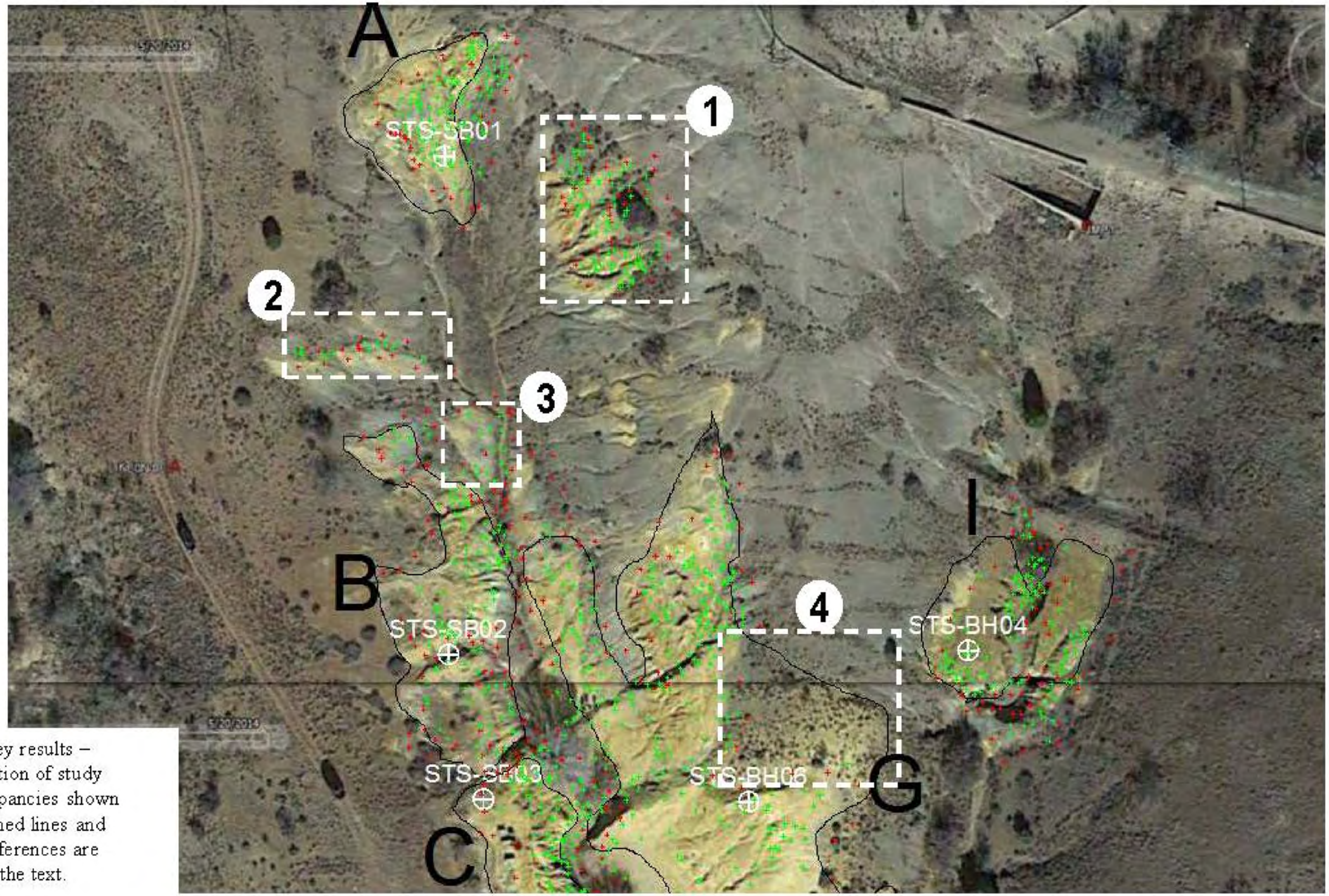

Figure 35. Contractor survey results – northern portion of study area. Discrepancies shown as white dashed lines and numbered references are discussed in the text.

Data export from other software

Map Creation Date: 15 September 2014

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-35

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Figure 2-35
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

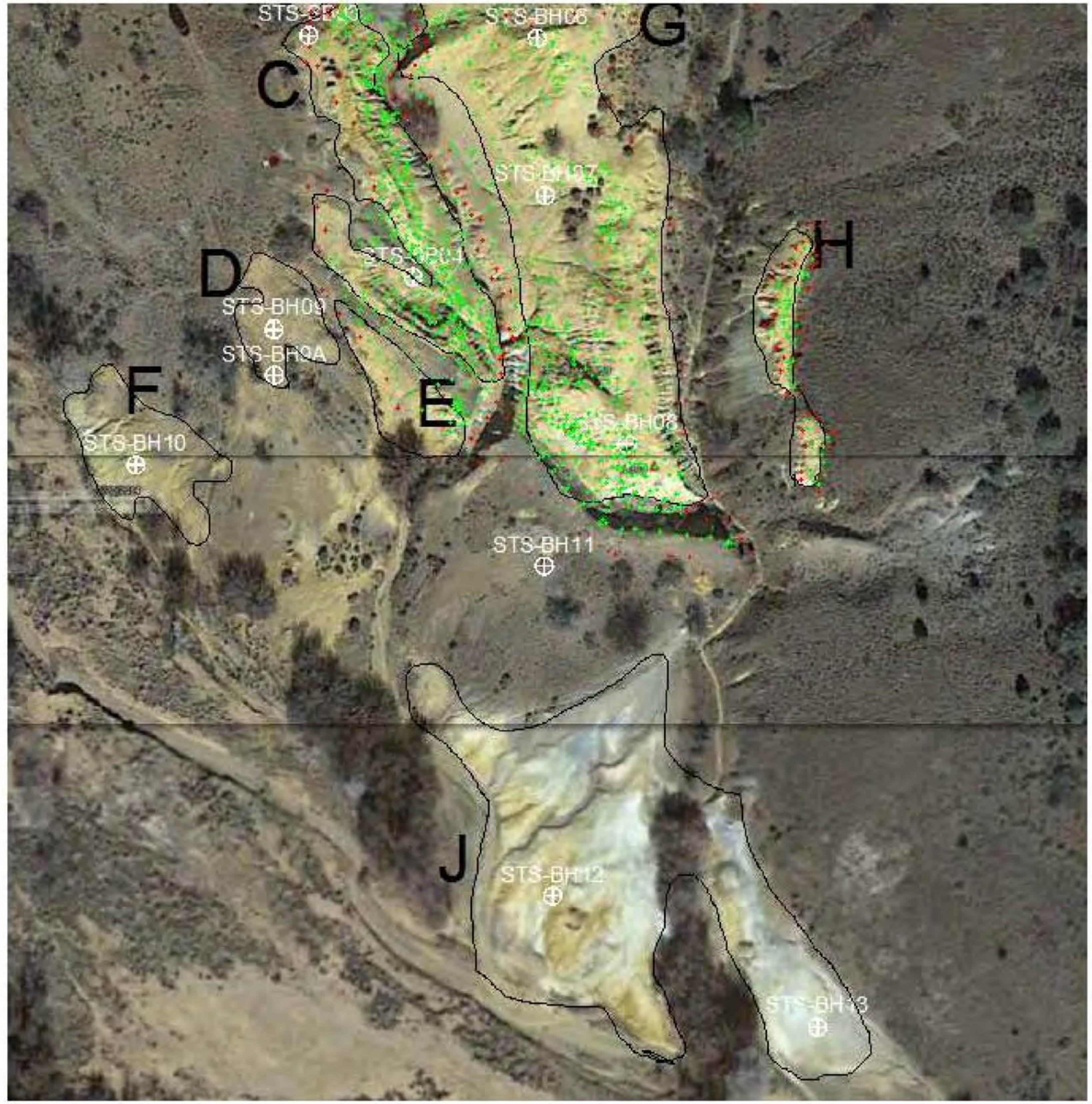

Figure 36. Contractor survey results – southern portion of study area.

Data export from other software

Map Creation Date: 15 September 2014

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-36

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Figure 2-36
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

TABLE 1. Area Calculations / Volume Calculations

		whole cells	partial cells All	<50%	>50%	(m^2) Area per cell	(m^2) Area Total	Control pt. Thickness type	(m) value	(m) value used	(m^3) Total Volume	(ft^3)	($yard^3$)	
Area A		66	44	26	18	6.25	537.5	STS-SB01	0.8	0.8	215.0	7592.7	281.2	
Area B		123	79	32	47	6.25	1039.1	STS-SB02	0.8	0.8	415.6	14677.7	543.6	
Area C		174	111	46	65	6.25	1464.1	STS-SB03	1.16	1.31	959.0	33865.4	1254.3	
								STS-SB04	1.31					
Area D		47	32	19	13	6.25	384.4	STS-BH09	0.98	0.98	188.3	6651.3	246.3	
								STS-BH09A	0.79					
Area E		47	38	19	19	6.25	412.5	none available		1	206.3	7283.7	269.8	
Area F		88	49	25	24	6.25	701.6	STS-BH10	1.28	1.28	449.0	15856.3	587.3	
Area G	north	443	119	56	63	6.25	3151.6	STS-BH06	1.43	1.43	2253.4	79576.9	2947.3	
	south	365	63	25	38	6.25	2498.4	STS-BH07	0.37	2.9	3622.7	127935.7	4738.4	
								STS-BH08	2.9					
Area H		40	37	21	16	6.25	357.8	Line 9, sta 15m	1.3	1.3	232.6	8213.4	304.2	
								Schlumberger 1D model						
Area I		99	44	24	20	6.25	750.0	STS-BH04	1.31	1.31	491.3	17348.3	642.5	
Area J		581	157	73	84	6.25	4139.1	STS-BH12	2.25	2.25	4656.4	164440.8	6090.4	
								STS-BH13	1.77					
											13689.6	483442.1	17905.3	Total Volume
											(m^3)	(ft^3)	($yard^3$)	

Figure 37. Table 1. Volume calculation.

Data export from other software

Map Creation Date: 15 September 2014

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC2_Surface_Geophysics\146_SEC2_Figure2-37

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Figure 2-37
Geophysics Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona

SECTION 3 - Dross, Plateau Soils, and Slag Investigations

3.1 INTRODUCTION

The Humboldt Smelter (HS) property is located on a bluff along the Agua Fria River in the Town of Dewey-Humboldt, Arizona (Figure 3-1). The HS property covers 190 acres, which includes the lower reaches of the Chaparral Gulch Arroyo. The Chaparral Gulch Arroyo drains into the Agua Fria River, but was dammed to form an impoundment that stored tailings waste that was generated from the smelter.

3.1.1 Background

The original HS was constructed in 1899 to process copper (Cu) ore from the Big Bug Mining District (BBMD) located near Mayer, AZ (Creasey, 1951; Anderson and Blacet, 1972). In 1904, the HS was destroyed by a fire, rebuilt, and redesigned with equipment upgrades to increase the smelters Cu production (ACS, 2008). From 1905 to 1937, copper-ore shipped from the BBMD to the HS by rail-line was both concentrated and smelted on site. Pyrite-rich waste (tailings) was stockpiled in an impoundment constructed south of the smelter by damming the Chaparral Gulch Arroyo downstream of the HS, approximately 1,200 feet above the confluence of the Agua Fria River (ACS, 2008).

By 1937, ore reserves from the BBMD were exhausted and smelting operations at the HS ceased. In 1942, a private individual (C.H. Dunning) acquired the 190-acre smelter property and used a new metallurgical technology to extract recoverable Cu from tailings stored on the property. The reworking of the Cu-rich tailings continued until the end of World War II and the facility closed. During this time many of the buildings associated with the early HS smelting operation were demolished for tax reasons. The property remained abandoned until 1958, when it was purchased by the Southwestern Industrial Iron and Chemical Company (SWII & CC).

The SWII & CC planned to recover metals and sulfur from tailings stored on the nearby Iron King Mine (IKM), but went bankrupt before going into production. In 1961, the property and facility were purchased by the Chem-Metal Company (CMC), which included the acquisition of multiple stockpiles of zinc (Zn) dross that had been brought to the HS property for processing. The CMC facility was designed to recover Zn from the dross, using a hydrochloric acid leaching technology. The facility eventually expanded operations to include the recovery of aluminum (Al) from the dross. The recovery process utilized magnets and jigs as a density concentrator and then shipped the Al-concentrate offsite for refining. The CMC facility closed in 1970.

The Galbraith Lumber Company of Phoenix then purchased the property. The company operated a sawmill onsite and produce wooden pallets until the facility closed 1974 (ACS, 2008). In 2003, Greenfields Enterprises purchased the HS property. No operations are currently active at the smelter property.

3.1.2 Objectives

The objectives of the investigation were as follows:

1. Evaluate the dross material by:
   - Delineating the spatial extents, volume and the primary contaminant(s) in the dross;
   - Delineating the spatial extents, and volume of contaminated soils beyond the dross, and determining if contamination in non-dross materials can be attributable to the dross; and
2. Evaluate the plateau soils (non-dross) by:

- Characterizing the nature and extent of arsenic (As) and lead (Pb) contamination in the soils (non-dross); and
- Characterizing the basic geotechnical properties of the soil (non-dross) covering the plateau area where a containment cell for the dross may be built. (Note: Data from the geotechnical testing will be used in the future Feasibility Study (FS) for a conceptual design of the containment cell.)

3. Evaluate the slag pile by:
   - Assessing the stability of the main slag pile given that cracks are present; and
   - Confirming that differences exist in the chemical characteristics between the main and satellite slag piles, as identified in the previous Remedial Investigation (RI) Report for the site.

3.2 METHODOLOGY

3.2.1 Dross Investigation

A review of historical records (ACS, 2008) indicated the dross was stockpiled on the HS site for processing; therefore visibly exposed in most areas. The majority of the dross is relatively homogeneous, white to light gray ash that is easily discernable from the underlying non-dross soil. However to the west and south of the smelter stack, the dross is heterogeneous mixed with charred wood, metals, black cinder grit, and other debris.

Sampling Grid

Prior to visiting the HS site, the surficial (horizontal) extents of the dross were mapped on a Landsat image, and a 100-by-100-foot 'base-grid' was plotted over the main dross stockpile surrounding the smelter stack. The base-grid consisted of approximately 50 sample locations, and those locations were imported as 'way points' into a Trimble™ Global Positioning System (GPS) receiver.

On February 10, 50 sampling locations in the preliminary grid were located with a GPS and marked with pin flags in the main dross stockpile (Figure 3-2). Where feasible, sample locations that were inaccessible due to structural impediments or health and safety concerns were moved. Based on the analytical data, the sampling grid was later expanded (horizontal step-outs) as needed in an attempt to delineate the full extent of contamination. In addition, intra-grid sampling locations were added in certain areas to improve data mapping resolution.

Soil Boring and Sampling

At each sample location, hand-auger borings were advanced through the dross, where present, approximately one foot into the underling non-dross soil, or to refusal. The contact between dross and non-dross soil is very sharp and easily recognized in the hand-auger borings. Where depth permitted, samples were collected from the surface and at one-foot intervals to the final depth. Up to three samples were initially submitted for analysis: one surface (zero to six inches), one intermediate between the surface and total depth and one at total depth. Locations where the initial depth samples exceeded the Pb and/or As threshold were revisited and additional deeper samples collected (vertical step-outs). At seven of these locations, a sonic drilling rig was used to advance the boring deeper.

Upon completion, each boring was backfilled with the extracted soil and graded to match the surrounding surface. The sample locations were resurveyed to identify the final coordinates that are archived in the Scribe database. A total of 140 hand-auger borings were completed on the HS property during this assessment (Table 3-1).

Sample Locations and Sample Identification

Figure 3-2 shows the 140 boring locations and the unique alphanumeric label that was assigned to each location. All sample locations have the prefix 'ASH-'. Sample locations that were revisited have two, co-located, sample identifiers (Table 3-2).

Each sample was assigned a unique identifier consisting of the sample location label, followed by a trailing number that identified the depth of sample collection. For example, ASH-HA027-0 was taken from the surface at sample location ASH-HA027 and was collected using a hand auger. Borings that were revisited with the sonic rig have 'SB' as a partial identifier in their label. All sample locations are identified in Scribe by their alphanumeric label and geospatial coordinates.

Dross/Non-dross Soil Analyses

Soil samples collected for the dross investigation can be identified in the Scribe database by the label as described above. A total of 299 soil samples were collected from the 140 hand-auger borings (Figure 3-2). All samples were placed in plastic, zip-lock baggies and were labelled with the date and time of collection and the sampler's name. Sample analyses are summarized in Table 3-3. Samples were submitted to on-site laboratory for x-ray fluorescence (XRF) analysis of metals including Cu, chromium (Cr), Zn, manganese (Mn), Pb, As, and iron (Fe). Twenty percent (%) of the samples were submitted to a fixed laboratory for confirmation TAL metals analysis. All sample analytical results are archived in the Scribe database (Appendix A).

3.2.2 Plateau Soils

The primary objective of the plateau soils (non-dross) investigation was to provide analytical and test results that can be used to develop the conceptual design for a containment cell to store the dross material.

Sampling Method

Cascade Drilling (Phoenix, Arizona) completed sonic borings at five locations in the plateau area between February 26 and 27, 2014 (Table 3-1 and Figure 3-2). The sonic borings were completed using a Prosonic/Boart Longyear 200C track-mounted sonic rig (ASTM D 6914).

Each boring was logged for lithology, moisture conditions, and the occurrence and depth of non-dross soil. Sampling depths were determined from field observations. Boring depths ranged from 2 to 7.5 feet and all ended in the Hickey Formation (either basin fill or basalt). After soil sampling was completed, the borings were backfilled to grade with hydrated bentonite chips. Survey coordinates for the boring locations are recorded in the Scribe database (Appendix A) and boring logs attached as Appendix 3-A.

The volume of contaminated soil was determined by first normalizing As and Pb concentrations to their perspective soil cleanup threshold (As = 200 mg/kg and Pb = 400 mg/kg) then plotting the larger of the two ratios (e.g., As_n = As/200 mg/kg or Pb_n = Pb/400 mg/kg). A normalized ratio for either As_n or Pb_n greater than one (> 1) indicates the soil exceeds the cleanup threshold.

Plateau Soil Analyses

Soil (non-dross) samples collected from the plateau area are identified in the Scribe database by the sampling prefix 'PS-'. A total of 11 soil (non-dross) samples were collected from five boring locations (Figure 3-2). Soil samples were collected and placed in plastic, zip-lock baggies for analyses. Sample analyses are summarized in Table 3-3. Analytical and test results for soil (non-dross) samples collected from the plateau area are recorded in the Scribe database (Appendix A).

3.2.3 Slag Pile

Two slag piles exist on HS property. The main slag pile is located directly north to northeast of the smelter stack and a smaller satellite slag pile is located about 1,375 feet southeast of the smelter stack (Table 3-1 and Figure 3-2). The slag is characterized as a vitrified mass with properties similar to a massive rock formation. The slag investigation had two objectives:

1. Assess the stability of the main slag pile overhanging the bluff north of the smelter stack; and
2. Determine the chemical character and variation between the main and satellite slag piles.

Geotechnical Survey

There are large cracks in the top of the main slag pile that may be the result of cooling rather than mass wasting. To determine if the cracks are widening, metal pins were installed at five locations, on each side of the major cracks for a total of 10 pins. The horizontal coordinates and elevations of the pins were surveyed by a subcontractor to sub-millimeter accuracy in April 2014 and will again be re-surveyed in April or May 2015 to determine if the slag cracks expanded or remained unchanged during a planned 12-month monitoring period. This work and additional surveying of the cracks is presented in Section 14, *Survey Report*.

Slag Analyses

Slag samples are identified in the Scribe database by the sampling prefix 'SL-'. Three slag samples were collected from the surface, one from the main slag pile and two from the satellite slag pile (Table 3-1 and Figure 3-2). Slag samples were collected and placed in plastic, zip-lock baggies for analyses. Sample analyses are summarized in Table 3-3. Analytical and test results for samples collected for the slag pile investigation are recorded in the Scribe database (Appendix A) and are not discussed further in this document.

Analytical Results

Based on analytical results, Pb is the primary contaminant that exceeds threshold concentrations in the majority of the dross samples. In non-dross soil samples, the signature of the contamination changes with both Pb and As concentrations being elevated. This suggests the dross is not the source of contamination in non-dross soils.

3.2.4 Volume Estimate

The volume of the dross and total contaminated soil (combined dross and non-dross) was estimated separately from the XRF results. The dross volume was estimated by integrating the dross thickness from the boring logs over the dross area using a hollow-body volume estimate. The total contamination soil volume was estimated using XRF analytical results for only Pb and As to build a solid-body model. The details of the estimation methods are presented in Appendix 3-B.

Based on the hollow-body model, dross volume is estimated to be 1,272,770 cubic feet (ft^3) or 47,140 cubic yards (yd^3). An independent solid-body modeling method was used as a check, and this approach estimated the dross volume to be 1,259,228 ft^3 (46,638 yd^3).

A solid-body estimate of the total contaminated soil (dross and non-dross) was preformed to estimate the volume of contaminated material on the HS property. Contaminated soil was defined by XRF results for either Pb and/or As that exceeded threshold concentrations. The estimate of contaminated soil, based on the solid-body model for the HS property, is 5,576,175 ft^3 or 206,525 yd^3 (Figure 3-4). Note that this estimate is low because the boundaries of contamination to the south and southeast on the plateau are undefined.

Areal Distribution of Contamination

The areal extent of the dross that was delineated from Landsat imagery was augmented by field observations (Figure 3-3). The dross tends to be aggregated in small piles across the impacted area. This feature was captured during the survey by delineating the piles using GPS and the dross appears to be well defined (Figure 3-3). The surface of the solid-body model that was generated for the total contaminated soil volume estimate, defines the areal extent of the total contaminated soil on HS property based on the 140 hand auger borings (Figure 3-5). However, this estimate is low because the extent of the total soil contamination is not fully defined to the south and southeast plateau area (Figure 3-5).

3.3 REFERENCES

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TABLES

TABLE 3-1
SAMPLE LOCATIONS AT THE HUMBOLDT SMELTER SITE
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

SAMPLE LOCATIONS	SUB-TASKS			REMARKS
	DROSS STOCKPILE	PLATEAU SOILS	SLAG PILE	
Surface Sample Only[1]	na	na	3	
Hand-Augered Boring[1, 2]	140	---	---	16 locations extended deeper and combined into single locations (see text)
Sonic Core[3, 4]	10 (7 locations)	5	---	3 redrills in dross area (ASH-SB01B, ASH-SB04B and ASH-05B)
TOTAL GRID LOCATIONS[5]	**140**	**5**	**--**	140 hand-auger and 5 sonic coring locations were used for the volume estimates.

na = Not Applicable

1. All hand-augering and Plateau Soil coring locations include a surface sample.
2. 16 hand-auger locations were revisited and extended deeper into clean soil.
3. Ten sonic borings were drilled in the dross area because the thickness exceeded 5 feet at previous sampled locations.
4. Five sonic borings locations in the plateau area are not associated with hand-auger locations.
5. 145 sample locations were used to constructed the hollow- and solid-body models for the dross and contaminted soil volume estimates.

TABLE 3-2
XRF RESULTS FOR SOILS AT THE
HUMBOLDT SMELTER PROPERTY
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Bore	Depth	As	Pb	As_n or Pb_n	Material
ASH-AB23	0.17	15	368	0.92	DROSS
ASH-AB23	2.67	13	69	0.17	Non-Dross
ASH-B02	0.17	31	359	0.90	DROSS
ASH-B02	3.67	32	637	1.59	DROSS
ASH-B02	4.17	31	184	0.46	Non-Dross
ASH-B03	0.17	28	674	1.69	DROSS
ASH-B03	2.67	19	80	0.20	Non-Dross
ASH-C07	0.17	57	334	0.84	Non-Dross
ASH-C08	0.17	31	376	0.94	Non-Dross
ASH-C09	0.17	30	354	0.89	DROSS
ASH-C09	1.17	51	182	0.46	Non-Dross
ASH-C11	0.17	49	576	1.44	DROSS
ASH-C11	1.17	146	392	0.98	Non-Dross
ASH-C12	1.17	67	673	1.68	Non-Dross
ASH-C13	0.17	80	668	1.67	DROSS
ASH-D04	0.17	32	552	1.38	Non-Dross
ASH-D05	0.17	18	586	1.47	DROSS
ASH-D05	2.17	34	168	0.42	Non-Dross
ASH-D06	0.17	25	696	1.74	DROSS
ASH-D06	1.17	33	80	0.20	Non-Dross
ASH-D07	0.17	29	481	1.20	DROSS
ASH-D07	1.17	49	314	0.79	Non-Dross
ASH-D08	0.17	45	510	1.28	DROSS
ASH-D08	1.67	51	201	0.50	Non-Dross
ASH-D09	0.17	56	722	1.81	DROSS
ASH-D09	2.17	37	482	1.21	DROSS
ASH-D09	3.17	110	354	0.89	Non-Dross
ASH-D10	0.17	31	459	1.15	DROSS
ASH-D10	2.67	44	495	1.24	DROSS
ASH-D10	9.17	45	160	0.40	Non-Dross
ASH-D11	0.17	36	594	1.49	DROSS
ASH-D11	1.17	260	611	1.53	Non-Dross
ASH-D12	0.17	363	1,170	2.93	DROSS
ASH-E06	0.17	27	653	1.63	DROSS
ASH-E06	4.17	16	262	0.66	DROSS
ASH-E06	5.67	35	233	0.58	Non-Dross
ASH-E08	0.17	25	436	1.09	DROSS
ASH-E08	2.17	110	801	2.00	DROSS

TABLE 3-2
XRF RESULTS FOR SOILS AT THE
HUMBOLDT SMELTER PROPERTY
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Bore	Depth	As	Pb	As_n or Pb_n	Material
ASH-E08	3.67	99	296	0.74	Non-Dross
ASH-EF03	0.17	217	479	1.20	Non-Dross
ASH-EF03	1.66	183	341	0.92	Non-Dross
ASH-EF05	0.17	38	550	1.38	DROSS
ASH-EF05	1.67	30	168	0.42	Non-Dross
ASH-EF89	0.17	28	612	1.53	DROSS
ASH-EF89	3.17	36	805	2.01	DROSS
ASH-EF89	7.17	65	276	0.69	Non-Dross
ASH-F07	0.17	24	534	1.34	DROSS
ASH-F07	2.17	21	323	0.81	DROSS
ASH-F07	3.17	25	145	0.36	Non-Dross
ASH-F08	0.17	20	357	0.89	DROSS
ASH-F08	2.17	19	335	0.84	DROSS
ASH-F09	0.17	24	547	1.37	DROSS
ASH-F09	4.17	29	457	1.14	DROSS
ASH-F09	6.67	52	111	0.28	Non-Dross
ASH-F10	0.17	25	572	1.43	DROSS
ASH-F10	0.83	607	1,430	3.58	Non-Dross
ASH-F56	0.17	25	559	1.40	DROSS
ASH-F56	0.67	92	529	1.32	Non-Dross
ASH-G08	0.17	26	714	1.79	DROSS
ASH-G08	1.67	19	71	0.18	Non-Dross
ASH-GH05	0.17	76	456	1.14	DROSS
ASH-GH05	0.83	15	50	0.13	Non-Dross
ASH-HA023	0.17	274	4,560	11.40	Non-Dross
ASH-HA024	0.17	193	1,420	3.55	Non-Dross
ASH-HA025	0.17	108	416	1.04	Non-Dross
ASH-HA026	0.17	273	675	1.69	Non-Dross
ASH-HA026	1.17	40	78	0.20	Non-Dross
ASH-HA027	0.17	163	329	0.82	Non-Dross
ASH-HA027	1.17	114	107	0.57	Non-Dross
ASH-HA028	0.17	234	856	2.14	Non-Dross
ASH-HA028	1.17	132	358	0.90	Non-Dross
ASH-HA029	0.17	273	567	1.42	Non-Dross
ASH-HA029	1.17	104	244	0.61	Non-Dross
ASH-HA030	0.17	419	3,650	9.13	Non-Dross
ASH-HA030	1.17	272	1,250	3.13	Non-Dross

TABLE 3-2
XRF RESULTS FOR SOILS AT THE
HUMBOLDT SMELTER PROPERTY
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Bore	Depth	As	Pb	As_n or Pb_n	Material
ASH-HA031	0.17	552	1,310	3.28	Non-Dross
ASH-HA032	0.17	928	6,320	15.80	Non-Dross
ASH-HA033	0.17	285	789	1.97	Non-Dross
ASH-HA034	0.17	611	706	3.06	Non-Dross
ASH-HA035	0.17	265	118	1.33	Non-Dross
ASH-HA036	0.17	227	545	1.36	Non-Dross
ASH-HA037	0.17	122	64	0.61	Non-Dross
ASH-HA037	1.17	42	46	0.21	Non-Dross
ASH-HA038	0.17	800	974	4.00	Non-Dross
ASH-HA038	1.17	287	165	1.44	Non-Dross
ASH-HA039	0.17	384	549	1.92	Non-Dross
ASH-HA039	1.17	335	432	1.68	Non-Dross
ASH-HA040	0.17	57	360	0.90	Non-Dross
ASH-HA041	0.17	124	465	1.16	Non-Dross
ASH-HA042	0.17	324	906	2.27	Non-Dross
ASH-HA044	0.17	889	4,280	10.70	Non-Dross
ASH-HA044	1.17	211	500	1.25	Non-Dross
ASH-HA045	0.17	13	357	0.89	Non-Dross
ASH-HA045	1.17	25	369	0.92	Non-Dross
ASH-HA046	0.17	24	520	1.30	Non-Dross
ASH-HA046	1.17	471	1,110	2.78	Non-Dross
ASH-HA047	0.17	619	4,130	10.33	Non-Dross
ASH-HA047	1.17	282	552	1.41	Non-Dross
ASH-HA048	0.17	29	29	0.15	Non-Dross
ASH-HA048	1.17	35	40	0.18	Non-Dross
ASH-HA049	0.17	44	93	0.23	Non-Dross
ASH-HA049	1.17	213	1,700	4.25	Non-Dross
ASH-HAC04	0.17	114	288	0.72	Non-Dross
ASH-HAC05	0.17	93	500	1.25	Non-Dross
ASH-HAC05	1.17	38	75	0.19	Non-Dross
ASH-HAC06	0.17	122	427	1.07	Non-Dross
ASH-HAC06	1.17	35	29	0.18	Non-Dross
ASH-HAD04	0.17	47	126	0.32	Non-Dross
ASH-HAD04	1.17	28	31	0.14	Non-Dross
ASH-HAD13	0.17	88	592	1.48	Non-Dross
ASH-HAE04	0.17	27	32	0.14	Non-Dross
ASH-HAE04	1.17	424	1,630	4.08	Non-Dross

TABLE 3-2
XRF RESULTS FOR SOILS AT THE
HUMBOLDT SMELTER PROPERTY
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Bore	Depth	As	Pb	As_n or Pb_n	Material
ASH-HAE04	2.17	227	1,060	2.65	Non-Dross
ASH-HAE10/E10	0.17	28	583	1.46	DROSS
ASH-HAE10/E10	1.17	383	1,180	2.95	Non-Dross
ASH-HAE10/E10	2.17	71	150	0.38	Non-Dross
ASH-HAE10/E10	3.17	287	629	1.57	Non-Dross
ASH-HAE11	0.17	82	237	0.59	Non-Dross
ASH-HAE11	1.17	900	1,220	4.50	Non-Dross
ASH-HAE11	2.17	93	222	0.56	Non-Dross
ASH-HAF04	0.17	104	619	1.55	DROSS
ASH-HAF04	1.17	81	165	0.41	Non-Dross
ASH-HAF11	0.17	14,800	19,800	74.00	Non-Dross
ASH-HAF12	0.17	306	549	1.53	Non-Dross
ASH-HAF12	1.17	304	525	1.52	Non-Dross
ASH-HAG04	0.17	177	197	0.89	Non-Dross
ASH-HAG04	1.17	66	81	0.33	Non-Dross
ASH-HAG05	0.17	89	847	2.12	Non-Dross
ASH-HAG06	0.17	109	396	0.99	Non-Dross
ASH-HAG11	0.17	108	665	1.66	Non-Dross
ASH-HAG11	1.17	471	1,160	2.90	Non-Dross
ASH-HAG11	2.17	645	1,170	3.23	Non-Dross
ASH-HAH05	0.17	22	409	1.02	DROSS
ASH-HAH05	2.17	13	27	0.07	Non-Dross
ASH-HAH07	0.17	46	650	1.63	DROSS
ASH-HAH09/H09	0.17	26	380	0.95	DROSS
ASH-HAH09/H09	2.17	33	481	1.20	Non-Dross
ASH-HAH09/H09	3.17	20	747	1.87	Non-Dross
ASH-HAH09/H09	3.97	194	553	1.38	Non-Dross
ASH-HAJ10/J10	0.17	94	472	1.18	DROSS
ASH-HAJ10/J10	0.83	256	507	1.28	Non-Dross
ASH-HAJ10/J10	1.17	374	446	1.87	Non-Dross
ASH-HAJ10/J10	3.17	40	77	0.20	Non-Dross
ASH-HAK12/K12	0.17	159	451	1.13	Non-Dross
ASH-HAK12/K12	1.17	142	207	0.71	Non-Dross
ASH-HAK12/K12	2.17	104	138	0.52	Non-Dross
ASH-HAK13/K13	0.17	266	484	1.33	Non-Dross
ASH-HAK13/K13	1.17	275	483	1.38	Non-Dross
ASH-HAK13/K13	2.17	73	135	0.37	Non-Dross

TABLE 3-2
XRF RESULTS FOR SOILS AT THE
HUMBOLDT SMELTER PROPERTY
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Bore	Depth	As	Pb	As_n or Pb_n	Material
ASH-HAK14	0.17	69	455	1.14	Non-Dross
ASH-HAK14	1.17	62	243	0.61	Non-Dross
ASH-HAL08	0.17	36	441	1.10	Non-Dross
ASH-HAL08	1.17	30	233	0.58	Non-Dross
ASH-HAL11/L11	0.17	185	656	1.64	DROSS
ASH-HAL11/L11	1.17	980	507	3.45	Non-Dross
ASH-HAL11/L11	1.17	689	1,030	3.45	Non-Dross
ASH-HAL11/L11	2.67	76	66	0.38	Non-Dross
ASH-HAL12/L12	0.17	39	127	0.32	Non-Dross
ASH-HAL12/L12	0.17	214	406	0.32	Non-Dross
ASH-HAL12/L12	0.17	39	127	1.07	Non-Dross
ASH-HAL12/L12	1.17	290	393	1.45	Non-Dross
ASH-HAL12/L12	2.17	50	85	0.25	Non-Dross
ASH-HAL13/L13	0.17	256	505	1.28	Non-Dross
ASH-HAL13/L13	1.17	144	189	0.72	Non-Dross
ASH-HAL13/L13	2.17	32	55	0.16	Non-Dross
ASH-HAL14	0.17	241	336	1.21	Non-Dross
ASH-HAL14	1.17	335	277	1.68	Non-Dross
ASH-HAL14	2.17	292	213	1.46	Non-Dross
ASH-HAM08	0.17	64	517	1.29	DROSS
ASH-HAM08	2.67	48	432	1.08	Non-Dross
ASH-HAM09	0.17	75	439	1.10	Non-Dross
ASH-HAM09	1.17	75	267	0.67	Non-Dross
ASH-HAM10	0.17	157	558	1.40	Non-Dross
ASH-HAM10	1.17	417	1,150	2.88	Non-Dross
ASH-HAM10	2.17	79	285	0.71	Non-Dross
ASH-HAM11	0.17	183	435	1.09	Non-Dross
ASH-HAM11	1.17	147	219	0.74	Non-Dross
ASH-HAM12	0.17	514	583	2.57	Non-Dross
ASH-HAM12	1.17	67	62	0.34	Non-Dross
ASH-HAM13	0.17	6,820	653	34.10	Non-Dross
ASH-HAM13	1.17	1,310	80	6.55	Non-Dross
ASH-HAM13	2.17	1,280	238	6.40	Non-Dross
ASH-HAM14	0.17	401	225	2.01	Non-Dross
ASH-HAM14	1.17	255	24	1.28	Non-Dross
ASH-HAM14	2.17	164	106	0.82	Non-Dross
ASH-HAN08	0.17	47	129	0.32	Non-Dross

TABLE 3-2
XRF RESULTS FOR SOILS AT THE
HUMBOLDT SMELTER PROPERTY
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Bore	Depth	As	Pb	As_n or Pb_n	Material
ASH-HAN08	1.17	50	160	0.40	Non-Dross
ASH-HAN10	0.17	42	551	1.38	Non-Dross
ASH-HAN10	1.17	36	383	0.96	Non-Dross
ASH-HAO09	0.17	89	187	0.47	DROSS
ASH-HAO09	1.17	123	172	0.62	Non-Dross
ASH-HAO10	0.17	201	539	1.35	DROSS
ASH-HAO10	2.17	39	80	0.20	Non-Dross
ASH-HAO14	0.17	71	484	1.21	DROSS
ASH-HAO14	1.47	113	266	0.67	Non-Dross
ASH-HAO14A	0.17	130	524	1.31	DROSS
ASH-HAO14A	0.67	428	1,070	2.68	Non-Dross
ASH-HAO15	0.17	86	475	1.19	DROSS
ASH-HAO15	1.17	927	1,710	4.64	Non-Dross
ASH-HAO16	0.17	132	447	1.12	Non-Dross
ASH-HAO16	1.67	183	253	0.92	Non-Dross
ASH-HAO17	0.17	144	481	1.20	Non-Dross
ASH-HAO17	1.17	478	1,380	3.45	Non-Dross
ASH-HAO17	2.17	43	58	0.22	Non-Dross
ASH-HAO18	0.17	67	140	0.35	Non-Dross
ASH-HAO18	2.17	44	39	0.22	Non-Dross
ASH-HAO19	0.17	150	1,000	2.50	Non-Dross
ASH-HAO19	1.17	194	930	2.33	Non-Dross
ASH-HAO19	2.17	135	991	2.48	Non-Dross
ASH-HAO20	0.17	64	718	1.80	DROSS
ASH-HAO20	1.17	215	2,040	5.10	Non-Dross
ASH-HAO20	2.67	42	263	0.66	Non-Dross
ASH-HAO21	0.17	68	362	0.91	Non-Dross
ASH-HAO21	2.67	72	232	0.58	Non-Dross
ASH-HAO22	0.17	124	490	1.23	DROSS
ASH-HAO22	2.17	16	41	0.10	Non-Dross
ASH-HAO43	1.17	183	341	0.92	Non-Dross
ASH-HAP12/P12	0.17	29	325	0.81	DROSS
ASH-HAP12/P12	1.17	184	488	1.22	Non-Dross
ASH-HAP12/P12	2.17	78	65	0.35	Non-Dross
ASH-HAP12/P12	2.17	70	65	0.35	Non-Dross
ASH-HAP12/P12	2.17	70	118	0.39	Non-Dross
ASH-HAP12/P12	2.17	78	118	0.39	Non-Dross

TABLE 3-2
XRF RESULTS FOR SOILS AT THE
HUMBOLDT SMELTER PROPERTY
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Bore	Depth	As	Pb	As_n or Pb_n	Material
ASH-HAQ09	0.17	623	2,630	6.58	Non-Dross
ASH-HAQ09	1.17	295	788	1.97	Non-Dross
ASH-HAQ10	0.17	84	556	1.39	Non-Dross
ASH-HAQ10	1.17	103	624	1.56	Non-Dross
ASH-HAQ10	2.17	95	510	1.28	Non-Dross
ASH-HAR08	0.17	336	1,300	3.25	Non-Dross
ASH-HAR08	1.17	63	200	0.50	Non-Dross
ASH-HAR10	0.17	130	668	1.67	Non-Dross
ASH-HAR10	1.17	153	564	1.41	Non-Dross
ASH-HAS09	0.17	126	484	1.21	Non-Dross
ASH-HAS09	1.17	67	263	0.66	Non-Dross
ASH-HAS10	0.17	208	495	1.24	Non-Dross
ASH-HAS10	1.17	48	118	0.30	Non-Dross
ASH-HI78	0.17	25	626	1.57	DROSS
ASH-HI78	1.17	32	570	1.43	Non-Dross
ASH-I11	0.17	15	407	1.02	DROSS
ASH-I11	1.17	19	207	0.52	Non-Dross
ASH-I12	0.17	115	360	0.90	Non-Dross
ASH-I13	0.67	1,220	1,820	6.10	Non-Dross
ASH-IJ10	0.17	19	350	0.88	DROSS
ASH-IJ10	1.17	179	381	0.95	Non-Dross
ASH-J11	0.17	57	210	0.53	Non-Dross
ASH-J12	0.25	39	127	0.32	Non-Dross
ASH-J13	0.17	169	246	0.85	Non-Dross
ASH-K10	0.17	34	445	1.11	DROSS
ASH-K11	0.17	91	404	1.01	DROSS
ASH-KL07	0.17	46	173	0.43	Non-Dross
ASH-L08	0.17	26	298	0.75	DROSS
ASH-L08	1.17	56	173	0.43	Non-Dross
ASH-L10	0.17	45	488	1.22	DROSS
ASH-L10	0.25	14	83	0.21	Non-Dross
ASH-LM67	0.17	80	205	0.51	Non-Dross
ASH-P14B	0.17	47	648	1.62	DROSS
ASH-P14B	1.42	24	119	0.30	Non-Dross
ASH-P14C	0.17	26	461	1.15	DROSS
ASH-P14C	1.42	42	182	0.46	Non-Dross
ASH-P16	0.17	39	351	0.88	DROSS

TABLE 3-2
XRF RESULTS FOR SOILS AT THE
HUMBOLDT SMELTER PROPERTY
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Bore	Depth	As	Pb	As_n or Pb_n	Material
ASH-P16	3.67	22	214	0.54	Non-Dross
ASH-P16	5.67	28	125	0.31	Non-Dross
ASH-SB01/SB01B/E07	0.17	19	369	0.92	DROSS
ASH-SB01/SB01B/E07	2.17	23	339	0.85	Non-Dross
ASH-SB01/SB01B/E07	5.67	17	488	1.22	Non-Dross
ASH-SB01/SB01B/E07	6.67	29	459	1.15	Non-Dross
ASH-SB01/SB01B/E07	7.67	16	37	0.09	Non-Dross
ASH-SB01/SB01B/E07	8.67	18	385	0.96	Non-Dross
ASH-SB01/SB01B/E07	9.17	11	34	0.09	Non-Dross
ASH-SB01/SB01B/E07	9.17	25	34	0.09	Non-Dross
ASH-SB01/SB01B/E07	9.17	11	45	0.13	Non-Dross
ASH-SB01/SB01B/E07	9.17	25	45	0.13	Non-Dross
ASH-SB01/SB01B/E07	11.17	14	41	0.07	Hunc
ASH-SB01/SB01B/E07	11.17	22	41	0.07	Hunc
ASH-SB01/SB01B/E07	11.17	22	24	0.11	Hunc
ASH-SB01/SB01B/E07	11.17	14	24	0.11	Hunc
ASH-SB02/E09	0.17	22	684	1.71	DROSS
ASH-SB02/E09	2.17	32	452	1.13	Non-Dross
ASH-SB02/E09	3.17	266	859	2.15	Non-Dross
ASH-SB02/E09	7.17	269	823	2.06	Non-Dross
ASH-SB02/E09	8.67	48	141	0.35	Non-Dross
ASH-SB03/C10	0.17	52	923	2.31	DROSS
ASH-SB03/C10	4.17	49	539	1.35	DROSS
ASH-SB03/C10	5.17	66	444	1.11	Non-Dross
ASH-SB03/C10	7.67	61	554	1.39	Non-Dross
ASH-SB03/C10	10.17	22	28	0.11	Hunc
ASH-SB04/G09	0.17	27	632	1.58	DROSS
ASH-SB04/G09	2.17	20	339	0.85	DROSS
ASH-SB04/G09	3.67	33	423	1.06	Non-Dross
ASH-SB04/G09	5.17	22	30	0.11	Non-Dross
ASH-SB04/G09	6.67	22	30	0.11	Non-Dross
ASH-SB04/G09	8.17	22	33	0.11	Hunc
ASH-SB05/SB05B/H11	0.17	68	672	1.68	DROSS
ASH-SB05/SB05B/H11	2.17	18	653	1.63	Non-Dross
ASH-SB05/SB05B/H11	4.67	264	633	1.58	Non-Dross
ASH-SB05/SB05B/H11	4.67	333	514	1.58	Non-Dross
ASH-SB05/SB05B/H11	5.17	15	113	0.28	Non-Dross
ASH-SB06/L09	0.17	21	284	0.71	DROSS
ASH-SB06/L09	3.17	16	541	1.35	DROSS
ASH-SB06/L09	5.17	221	756	1.89	DROSS

TABLE 3-2
XRF RESULTS FOR SOILS AT THE
HUMBOLDT SMELTER PROPERTY
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Bore	Depth	As	Pb	As_n or Pb_n	Material
ASH-SB06/L09	6.67	22	24	0.11	Non-Dross
ASH-SB06/L09	7.67	22	30	0.11	Hunc
ASH-SB06/L09	10.17	22	27	0.11	Hunc
ASH-SB06/L09	11.17	22	23	0.11	Hunc
ASH-SB07/P14A	0.10	20	747	1.87	DROSS
ASH-SB07/P14A	3.00	48	427	1.07	DROSS
ASH-SB07/P14A	5.00	27	358	0.90	Non-Dross
ASH-SB07/P14A	6.50	19	36	0.11	Non-Dross
PS-SB01	0.50	66	114	0.33	Non-Dross
PS-SB01	2.00	52	120	0.30	Hunc
PS-SB01	6.00	22	28	0.11	Hunc
PS-SB02	0.50	160	309	0.80	Non-Dross
PS-SB03	0.50	64	203	0.51	Non-Dross
PS-SB03	2.00	14	46	0.12	Hunc
PS-SB03	6.00	22	32	0.11	Hunc
PS-SB04	0.50	37	66	0.19	Non-Dross
PS-SB04	2.00	12	53	0.13	Hunc
PS-SB05	0.00	55	307	0.77	Hunc
PS-SB05	2.00	15	57	0.14	Hunc

As = arsenic; **Pb** = lead, **As_n or Pb_n** = normalized As or Pb soil concentration greater than 1 - exceeds the soil cleanup criteria, **DROSS** = dross material, **Non-dross** = smelter tailings, loam, or fill, **Hunc** = Hickey Formation

Contaminated soils were determined by normalizing As and Pb concentrations to their perspective soil cleanup threshold (As = 200 mg/kg and Pb = 400 mg/kg). e.g., As_n = As/200 mg/kg or Pb_n = Pb/400 mg/kg

A normalized ratio for either Asn or Pbn greater than one (> 1) indicates the soil exceeds the cleanup threshold.

TABLE 3-3
SUMMARY OF SAMPLE ANALYSIS FOR THE HUMBOLDT SMELTER SITE
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Laboratory Analysis/Test	Dross	Plateau Soils	Slag
XRF Field	299	11	---
TAL Metals	37	2	3
SPLP Metals	4	---	3
Acid Base Accounting	4	---	3
Dioxins/Furans	2	---	---
Grain Size	6	4	---
Moisture Content	6	4	---
Atterberg Limits	6	4	---
Specific Gravity	---	---	3

XRF - x-ray fluorescence
TAL - Target analyte List
SPLP - Synthetic Precipitation Leaching Procedure

FIGURES

Base map created using 2010 orthoimagery, proposed sampling plan areas by digitizing.

Map Creation Date: 20 October 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC3_Dross, Plateu& Slag\146_SEC3_Site_Investigation_Area_f3-1

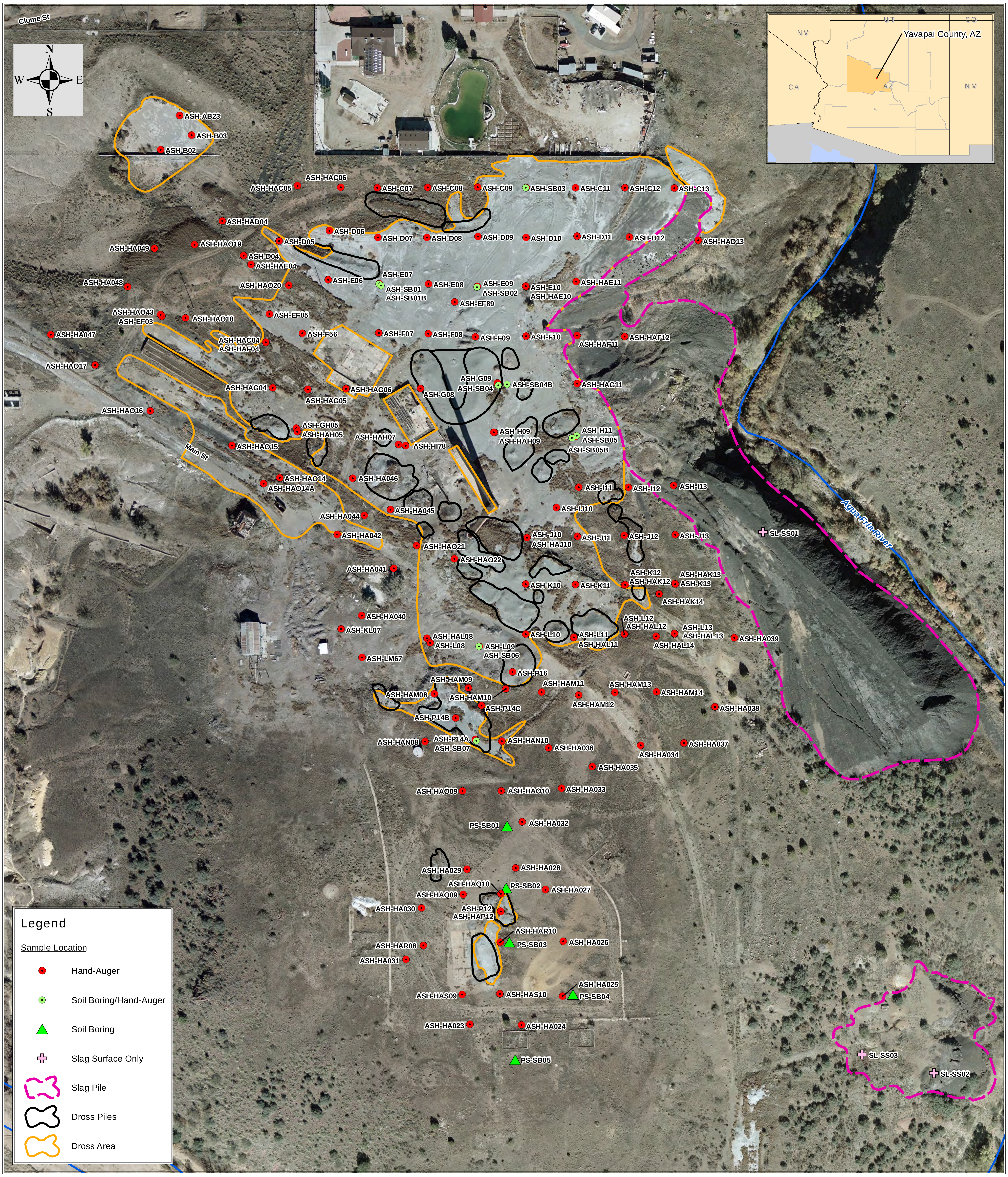
Legend

Area of Interest
- Iron King Mine
- Humboldt Smelter

0 750 1,500 Feet

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 3-1
Site Investigation Area
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery,
sample location data from GPS survey in 2014.

Map Creation Date: 20 Octobert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

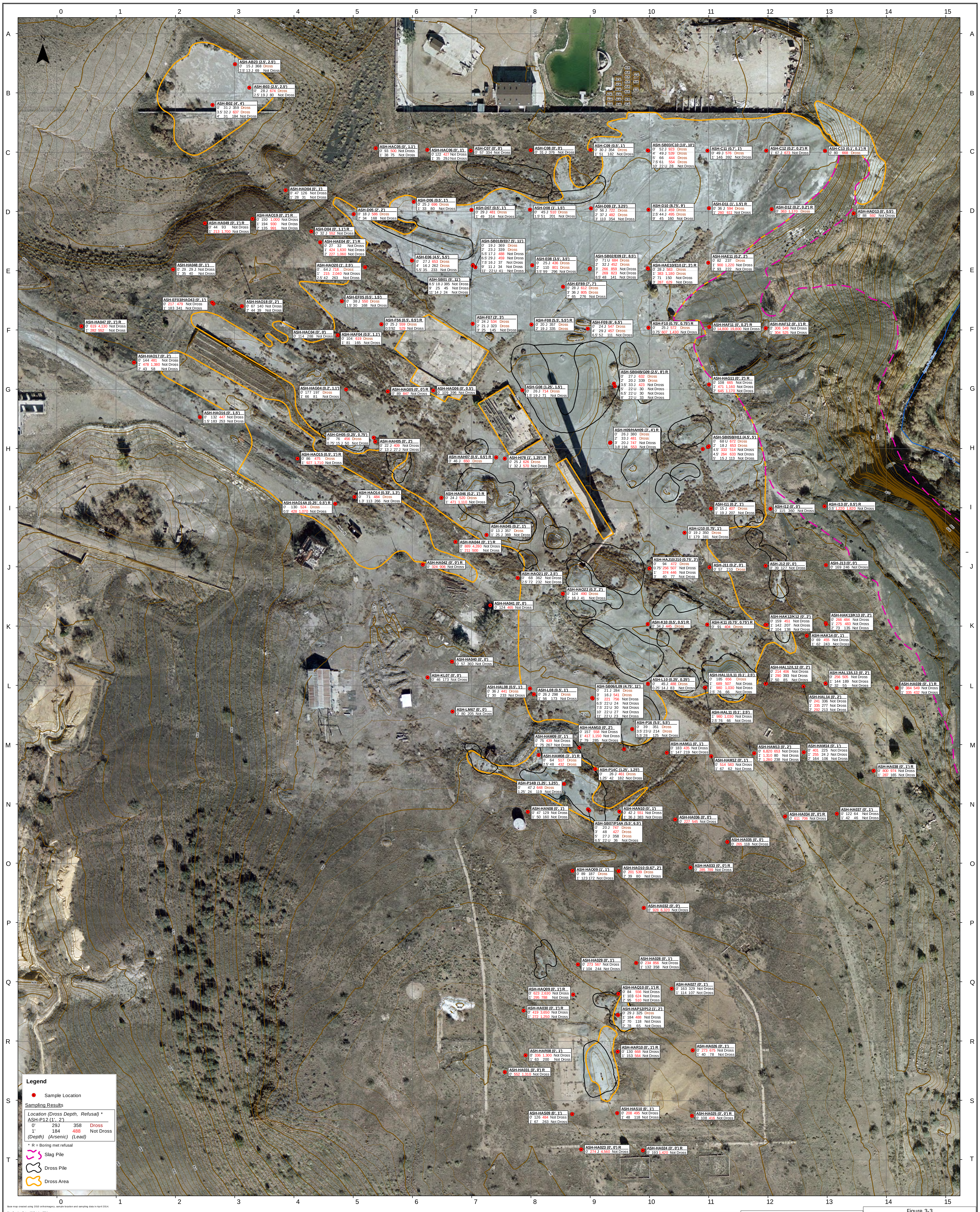
Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC3_Dross, Plateau & Slag/
\146_SEC3_DrossArea_SampleLocation_Csize_f3-2

0 130 260
Feet

D R A F T

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 3-2
Dross Area Sample Location
Iron King Mine Site
Dewey-Humboldt, Arizona



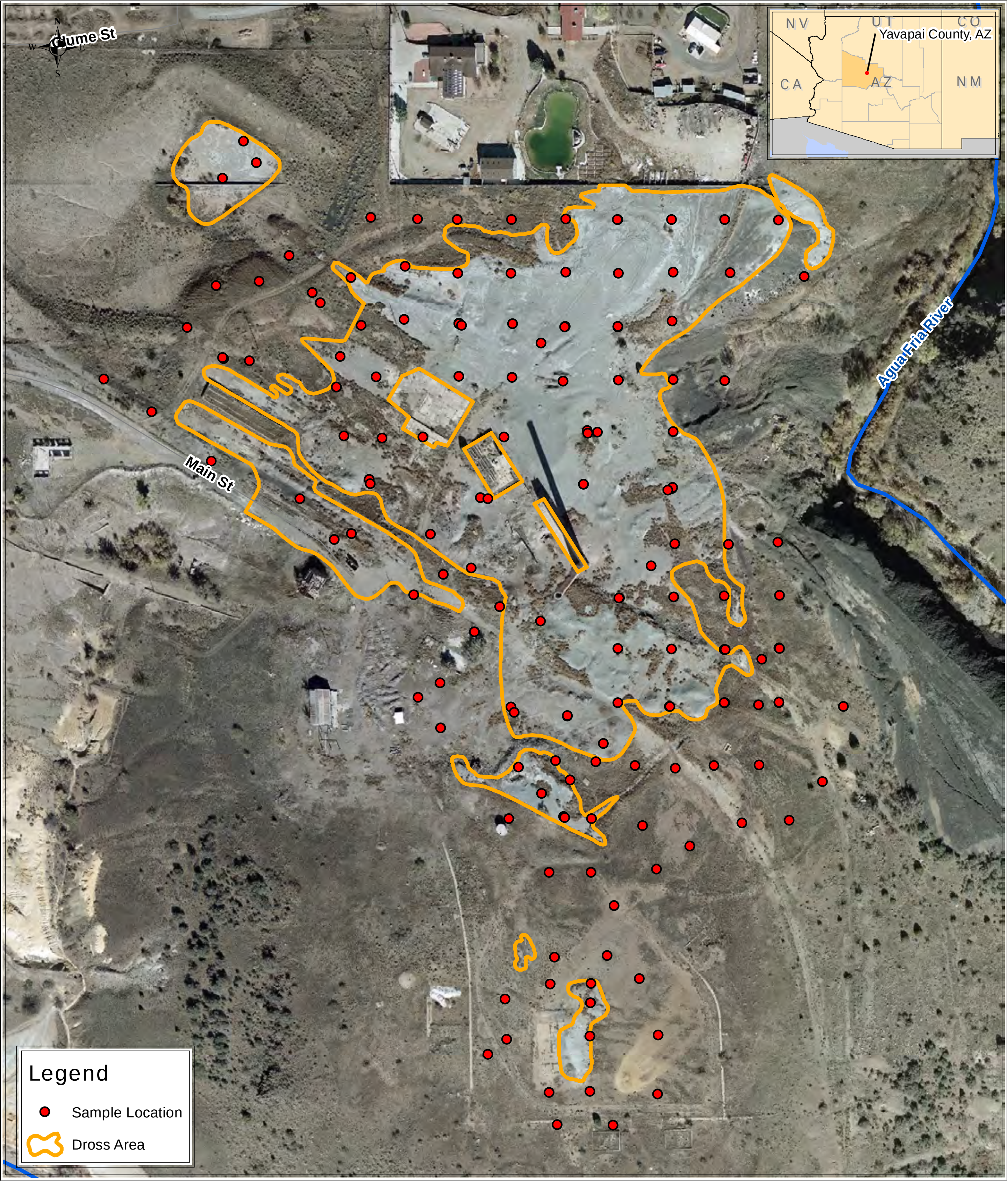
Base map created using 2010 orthoimagery, sample location and sampling data in April 2014.

Map Creation Date: 16 October 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet
Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC3_Dross, Plateau & Slag\146_SEC3_DrossArea_SamplingData_Esize_f3-3.mxd

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 3-3
Dross Area Sampling Data (Arsenic & Lead)
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, data exported from Rockware.

Map Creation Date: 24 October 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

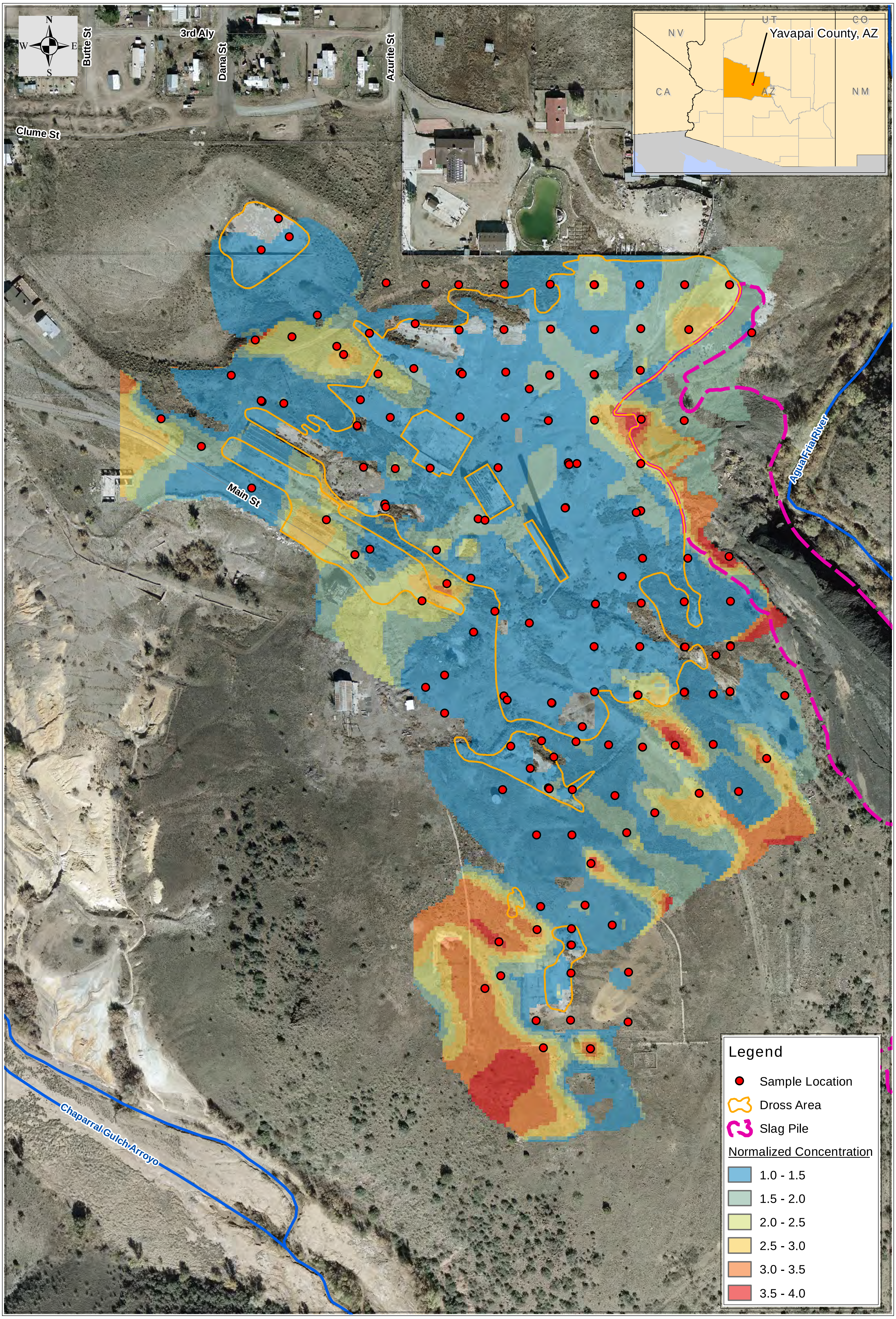
Note:
Hollow Body Volume = 1,272,770 (cubic feet)
Solid Body Volume = 1,273,320 (cubic feet)

0 250 500
Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC3_Dross, Plateau & Slag\146_SEC3_RWdata_DrossArea_f3-4

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 3-4
Dross Area
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, data exported from Rockware.

Map Creation Date: 24 October 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

0 200 400 Feet

Note:
Concentration > 1.0 Exceeds Cleanup Goal for either As or Pb.

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 3-5
Soil Exceeding Cleanup Goal
Iron King Mine Site
Dewey-Humboldt, Arizona

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC3_Dross, Plateau & Slag \146_SEC3_RWdata_Normalize_Concentration_f3-5

APPENDIX 3-A
Sonic Boring Logs
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 3-B

Dross and Contaminated Soil Volume Estimate

Iron King Mine Site

Dewey-Humboldt, Arizona

APPENDIX 3-C
Rockworks
Iron King Mine Site
Dewey-Humboldt, Arizona

SECTION 4 - Main Tailings Pile (MTP) and Waste-Rock Investigation

4.1 INTRODUCTION

The former Iron King Mine (IKM) site is approximately three miles west of the town of Dewey-Humboldt, Arizona. The IKM is situated in the headwaters of Chaparral Gulch, a tributary to the Agua Fria River.

4.2 BACKGROUND

The IKM operated from the late 1890s to 1968, with production peaking in 1963 (ACS, 2008). The ore was composed primarily of zinc (Zn) and lead (Pb) sulfide minerals, with lesser amounts of copper (Cu), silver (Ag) and gold (Au). Total ore production from the IKM was 6,033,912 tons, which was milled and concentrated on site. The Zn-Pb concentrate was shipped offsite for smelting, and the milled waste (tailings) was stockpiled on the mine site, filling a draw at the headwaters of Chaparral Gulch.

The underground workings of the IKM extend 1,600 feet along strike of the ore body and reach a maximum depth of 3,250 feet. The sulfide ore body consisted of three north-northeast trending, *en echelon* lenses that are 'down-stepped' to the southeast. The thickness of the mineralized lenses ranged from 2 to 14 feet. From approximately 1937 to 1962, the ore was extracted by traditional square-set and horizontal cut-and-fill stopping, a technique that stabilized the underground by backfilling the workings with waste-rock. However in the later part of 1962, the extraction technology changed to block-caving, a mining technique that allows a cavern to form by controlled caving. Block-caving technology utilizes a primary tunnel along strike of the ore body that intersects regularly spaced drives that cross-cut the lenses. The cross-cuts were driven into stable, competent bedrock and used as pathways to transport and hoist ore to the surface. The block-caving technique more than doubled the IKM production rate, but it also increased the tonnage of waste-rock that needed to be stockpiled on the surface (ACS, 2008).

By the time mining operations ceased in 1968, the IKM consisted of approximately 40 miles of underground workings. Based on water level measurements from three deep wells (AZDEQ Reg. # 55-904580, 55-904634 and 55-904635), located directly southwest of several abandoned mine shafts in Galena Gulch, the underground workings could be flooded to an approximate depth of 200 feet below ground surface.

The Main Tailings Pile (MTP) on the IKM property covers over 55 acres, is over 100 feet high, and contains over 6,000,000 cubic yards (yd^3) of tailings. A slope failure occurred along the main face of the MTP in 1964 after a period of heavy rainfall. An undetermined amount of tailings were released into Chaparral Gulch, which were ultimately transported further downstream over time. Further slope movements have not been observed since that time and there does not appear to be any immediate risk. However, unless the MTP is stabilized to at least some extent, the potential still exists for future slope failures.

4.2.1 Regional Geology

The geology of the IKM is summarized in Table 4-1, but detailed descriptions of the mine vicinity can be found in:

- Anderson and Blacet, 1972
- Anderson and Creasey, 1958
- Creasey, 1951

- Krieger, 1965
- Kumke and Mille, 1950
- Lindgren, 1926

4.2.2 Lead-Copper (Pb:Cu) Metal Ratios

Ore from IKM is composed primarily of sphalerite (ZnS) and galena (PbS), with lesser amounts of chalcopyrite ($CuFeS_2$) and tennantite ($(Cu,Fe)_{12}As_4S_{13}$). The Zn to Pb (Zn:Pb) ratio for IKM ore ranges from 6.9 to 12.7, averaging 10.4. However more important to this study is the Pb to Cu (Pb:Cu) ratio, which ranges from 2.1 to 3.8, averaging 3.0 (Anderson and Creasey, 1958). The milling process was more efficient at concentrating Zn and Cu sulfides; thereby, increasing the Pb:Cu ratios in the tailings up to 28.8 (refer to sample T1-0 in SCRIBE database [Appendix A]).

4.3 OBJECTIVES

ERT requested Scientific, Engineering, Response and Analytical Services (SERAS) contract personnel to assist with the following tasks:

- Evaluate sediments/soils along the margin of the MTP by completing 11 shallow soil borings.
- Use field portable x-ray fluorescence (XRF) analysis to identify sediments/soils in the shallow borings that exceed the soil cleanup guidelines for either Pb or arsenic (As).
- Complete three deep borings through the MTP into the underlying Hickey Formation.
- Collect samples from deep borings for analysis of Target Analyte List (TAL) metals, metals via synthetic precipitation leaching procedure (SPLP), acid base accounting (ABA) parameters, and geotechnical index and strength properties.
- Assess the hydraulic connectivity between the MTP and underlying Hickey Formation by constructing three monitor wells that terminate near the base of the tailings (above the Hickey Formation).
- Assess waste-rock piles near the former IKM operations area and within Galena Gulch.

4.4 METHODOLOGY

Cascade Drilling (Phoenix, Arizona) completed the drilling activities at the IKM site on two separate events using the sonic drilling method (ASTM D 6914). The 11 shallow soil borings were completed between February 5 and 11, 2014 using a Prosonic/Boart Longyear 200C track-mounted sonic rig. The rig utilized a 4-inch diameter core barrel (for continuous sample retrieval) along with a 6-inch diameter flush-threaded steel over-ride casing (producing a 6-inch diameter borehole). The drilling and installation of the three deep monitor wells was completed between April 2 and 7, 2014, using a Boart Longyear 600T truck-mounted sonic rig. This rig utilized a 6-inch diameter core barrel (for continuous sample retrieval) along with an 8-inch diameter flush-threaded steel over-ride casing (producing an 8-inch diameter borehole).

4.4.1 Shallow Borings

Photographic logs for the shallow soil borings are attached in Appendix 4-A. The borings were logged for lithology, moisture conditions, presence of perched water, and occurrence and depth of the tailings. Sampling depths were determined from field observations (Table 9-2). Samples collected from each boring were placed in small zip-lock plastic bags and analyzed for As, Pb, Zn, Cu, iron (Fe), chromium (Cr) and manganese (Mn) using a field portable XRF (Section 13.2). After soil sampling was completed, the borings were backfilled to grade with hydrated bentonite chips.

Borehole locations are shown on Figure 4-1 (labeled IKM-SB01, SB02, etc.), with survey data and coordinates recorded in the Scribe database. All 11 soil borings were collared and ended in unconsolidated Hickey Formation, with depths ranging up to 24 feet. Tailings were not observed in the shallow borings. Boring logs are attached in Appendix 4-B.

Soil Sampling and Analyses

A total of 49 samples were analyzed by XRF for comparison between colluvium and tailings (Table 4-2). The complete XRF results for soils are recorded in the SCRIBE database, but results for As, Pb, Cu and Zn are summarized on each boring log (Appendix 4-B).

In addition to the XRF analysis, two samples (IKM-SB04-5 and IKM-SB10-5) were collected and analyzed for TAL metals (Table 4-2). Results for these analyses are recorded in the SCRIBE database (Appendix A) and are not discussed further in this document.

4.4.2 Deep Borings and Monitor Well Installation: MTP

Sonic core samples were collected to assess the physical characteristics of both the tailings and underlying Hickey Formation. Three borings were advanced through the tailings and up to 30 feet into the unconsolidated Hickey Formation (Figure 4-1). One boring was drilled on the lower MTP (MTP-SB01) and two on the upper MTP (MTP-SB02 and SB03). A photographic log of the deep borehole cores is attached in Appendix 4-C

The boreholes were backfilled to the base of the tailings and completed as wells to monitor for perched groundwater conditions within in the MTP. The wells were constructed with 4-inch diameter, Schedule 80 PVC riser pipe and 20 feet of 10-slot (0.010 inches) polyvinyl chloride (PVC) screen. The screen interval was positioned near the base of the tailings. Even though the wells MTP-MW01 through MTP-MW03 were dry after installation, pressure transducers (with data logging capability) were installed in all three wells to monitor for groundwater changes (if any) in the MTP over a one-year period. Borehole logs are attached as Appendix 4-D and summarized as follows:

- MTP-SB01 (MTP-MW01) 76.5 feet (base of tailings: 46.5 feet)
- MTP-SB02 (MTP-MW02) 110 feet (base of tailings: 81 feet)
- MTP-SB03 (MTP-MW03) 134 feet (base of tailings: 106 feet)

Tailings Sampling and Analyses

Three to four unconsolidated samples were collected from each borehole for characterization of acid mine drainage (AMD) potential. Samples were collected near the ground surface, in wet intermediate zones within the tailings, near the base of the tailings (MTP-SB02 and MTP-SB03), and the underlying Hickey Formation. Samples were analyzed for TAL metals, ABA parameters (total moisture, saturated paste pH, sulfur species, acid and neutralization potential, and ABA calculation), and the following SPLP-derived (EPA Method 1312) metals: aluminum (Al), As, barium (Ba), cadmium (Cd), chromium (Cr), Cu, iron (Fe), Pb, manganese (Mn), mercury (Hg), selenium (Se), Ag, and Zn. A list of the analytical samples is summarized in Table 4-2.

Geotechnical Properties

During drilling advancement through the MTP, Standard Penetration Tests (SPTs) were conducted at regular intervals in each boring (Table 4-3), in addition to collection of samples for geotechnical testing. A list of the geotechnical tests, sample intervals, and sampling methods is presented in Table 4-4, and summarized as follows.

- Grain size (21 samples) by ASTM D 422
- Specific gravity (21 samples) by ASTM D 854
- Consolidation (3 samples) by ASTM D 2435

- Moisture-density (18 samples) by ASTM D 2937
- Direct shear (3 samples) by ASTM D 3080)
- Plasticity: Atterberg limits (21 samples) by ASTM D 4318
- Permeability (8 samples) by ASTM D 5084 and ASTM D 2434-modified
- Soil-water characteristic curve (3 samples) by ASTM D 6836
- Consolidated-undrained triaxial shear (3 samples) by ASTM D 4767 (*with pore pressure measurements*)

Note the last number in each sample name (#) denotes the depth below grade (in feet) as to where each sample was collected. For example, MTP-SB01-10 indicates the sample was collected from boring MTP-SB01 at 10 feet below ground surface.

Sampling Methods

Sampling methods were split-spoon, Shelby tube or ring, and tailings were submitted for testing as either an undisturbed (Shelby tube or ring) or disturbed (bag) sample. The sampling methods are summarized as follows.

- Split-Spoon (ASTM D 1586): A 30-inch long, 2.0-inch outside diameter hollow tube split-barrel sampler was used to obtain SPT data. The sampler was driven into the ground with a 140-pound (64 kilogram) hammer falling 30 inches. The blow counts (hammer strikes) required to advance the sampler a total of 24 inches were counted and reported. Separate counts were made for each 6 inches of penetration, with the first 6 inches considered as a "seating" drive. The SPT results are summarized in Table 4-3.

- Shelby Tube Sampler (ASTM D 1587): Each Shelby tube consisted of a 3-inch diameter, 30-inch long thin-walled galvanized metal tube with a cutting edge at the toe. A sampler head was used to attach the tubes to the drill rods, which had both a check valve and pressure vents. Generally used in relatively soft cohesive materials, the tubes were advanced into the subsurface, typically 6 inches less than the tube length. The vacuum created by the check valve and cohesion of the sample in the tube cause the sample to be retained when the tube is withdrawn. Material sampled in this manner is considered undisturbed.

- Thick Wall Ring-Lined Sampler (ASTM D 3550): Similar in concept to the SPT sampler, the sampler barrel had a larger diameter and was lined with a series of 2.5-inch diameter, 1-inch long brass rings to contain the sampled material. This type of sampler is generally used in granular materials or harder, cohesive materials, because Shelby tubes cannot effectively be used in these types of materials. Samples from the thick wall sampler are considered somewhat disturbed due to the large area ratio of the sampler; however, it has been established that thick wall samplers (especially when pushed and not driven) can provide adequate or appropriate specimens that can be used directly in laboratory test apparatus without additional trimming or preparation. Applicable geotechnical tests include moisture-density, one-dimensional consolidation, direct shear, and to a lesser extent, permeability (hydraulic conductivity).

4.4.3 Waste-Rock Investigation

A visual survey of waste-rock piles on the IKM site was performed to assess their suitability as construction material for possible use for future site restoration. Waste-rock was stockpiled in the former IKM operations area and Galena Gulch (Figure 4-2).

IKM Area

In April 2014, two waste-rock piles west of the former IKM operations area were visited (Figure 4-2). The boundaries for one relatively large pile, and a smaller pile located further to the west were surveyed using a global positioning system (GPS). In addition, three samples from these piles (WR-SS001 to WR-SS003) were collected and analyzed for TAL metals, SPLP metals, and ABA parameters. Results for these analyses are recorded in the SCRIBE database and are not discussed further in this document.

Galena Gulch Waste Piles

On June 21, 2014, a similar materials survey was performed along Galena Gulch Area (Figure 4-2). While the materials were originally believed to be tailings, upon closer inspection, they were determined to be waste-rock, similar to the materials encountered in the former IKM operations area. The waste pile boundaries were surveyed using a GPS. Samples were not collected, because the material was similar to what was stockpiled in the former IKM area.

4.5 RESULTS AND DISCUSSON

4.5.1 Shallow Borings

A total of 49 sediment samples from the 11 soil borings were analyzed by XRF. The analytical results are recorded in the SCRIBE database and summarized as follows:

- None of the samples observed in the sonic cores could be characterized as tailings.
- Concentrations of As concentrations ranged from 11 to 190 milligrams per kilogram (mg/kg) and averaged 19 mg/kg.
- Concentrations of Pb ranged from 21 to 134 mg/kg and averaged 21 mg/kg.

4.5.2 MTP Investigation

Sonic core samples of the tailings indicated that moisture contents were predominantly damp to moist. However, a few disperse and very narrow saturated zones, less than a half-foot thick, were observed in all three deep borings, which were irregularly spaced with depth. The dispersed zones are believed to result from saturated tailings sludge that was not allowed sufficient time to dry before the next lift was added to the pile.

The contact between the tailings and underlying Hickey Formation was dry in all three borings, and as of August 2014, all three wells were still dry. This condition suggests that groundwater flow along the base of the MTP is minimal (or episodic at best) as well as leakage from the MTP into the underlying Hickey Formation. The dry monitor wells also suggest that water within the few saturated zones is held under tension and essentially locked within the pore spaces of the tailings materials.

4.5.3 Waste-Rock Investigation

Waste-rock is comprised of metasedimentary and metavolcaniclastic rocks (phyllites and rhyolitic to andesitic tuffs) that are believed to be associated with the Precambrian Spud Mountain Volcanics. The phyllites are characterized by a quartz-sericite-chlorite-albite mineral assemblage or 'greenschist facies'. The phyllites have a well-developed foliation and weakly mineralized with pyrite that is both disseminated and hosted in cross-cutting quartz ± carbonate veins. The other rock fragments, averaging approximately 3- to 6-inches in size, appeared to be primarily a meta-andesitic tuff with a siliceous matrix and secondary plagioclase phenocrysts.

Former IKM Area Waste Piles

The former IKM area is comprised of weathered to highly weathered phyllite fragments. A portion of this rock was found to be highly decomposed resulting in a soil-type matrix (Figure 4-2). The hardness was qualitatively assessed in the field, ranging from soft to moderate (at best). Their relatively low density and high porosity (resulting from the minerals present) combined with well-developed foliation surfaces, yields a low strength rock that will weather and disintegrate more rapidly in comparison to harder granites, quartzites, basalts, diabases, and gabbros. The abrasivity of this rock type was determined to be low, meaning it will abrade at a much faster rate compared to highly-competent rocks that are generally not found in the waste piles. The meta-andesitic rocks appeared to be more competent and less weathered than the phyllites. However, this rock type represented only a portion of the total waste-rock, estimated to be no more than 50 %.

Overall, the waste-rock is not considered suitable for riprap or other construction purposes. More suitable rocks (e.g., gabbros and granites) are available from a number of quarries in the IKM site vicinity. Rocks from these quarries have previously been used for a number of restoration activities at the site.

Galena Gulch Waste Piles

Two waste piles were investigated in Galena Gulch: a northern parcel that encompassed a larger area in comparison to a smaller parcel to the south (Figure 4-2). For both areas, waste-rock blanketed what appeared to be bedrock benches and adjoining slopes. However, it could not be determined if the upper, relatively flat benches (especially for the northern area) were naturally occurring or shaped from previous mining activities. Waste-rock appeared to be thickest along the slopes (which could not be measured) and decreased in thickness upslope where a thin veneer covered the upper benches. The northern parcel was determined to be approximately 30 feet in height (from the upper bench to the Galena Gulch channel), while the southern parcel was estimated to be approximately 20 feet.

During the field survey, three abandoned vertical mine shafts and a small horizontal portal (or tunnel) were discovered. Shaft No.1 (Figure 4-2) was filled to within 10 feet or less of surrounding ground surface while shafts No. 2 and No. 3 were open to at least 30 feet or more in depth (based solely on visual observations). The horizontal portal was not investigated and its purpose is unknown at present.

As with the waste-rock near the former operations area, the materials along Galena Gulch are not considered suitable for riprap or other construction purposes.

4.6 REFERENCES

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Lindgren, W., 1926. Ore Deposits of the Jerome and Bradshaw Mountains Quadrangles, Arizona. U.S. Geological Survey Bulletin 782.

Metex Limited, 1985. Iron King Mine Tailings Pond, Yavapai County, Arizona: Recovery of Gold and Silver and Production of Fertilizer and Soil Supplement. May 1985.

TABLES

Table 4-1
Summary of the Regional Geology
Iron King Mine Site
Dewey-Humboldt, Arizona

<table>
<tr>
<td>Tertiary</td>
<td>Hickey Formation</td>
<td colspan="3">

- **<u>Massive to vesicular olivine basalt</u>** flows that may or may not be interbedded with water laid, orange to tan mafic ash and cinder.
- Red to orange **<u>mafic ash, cinders and bombs</u>** that were deposited proximal to a cinder cone.
- Unconsolidated, matrix supported **<u>boulder to pebble conglomerate</u>** with silt to sand matrix that is interbedded with olivine basalt flows.
- Tan to light brown, **<u>boulder to pebble conglomerate</u>** with a **<u>marly</u>** (calcite-rich) matrix that is highly indurated and interbedded with both the unconsolidated conglomerate and olivine basalt flows

</td>
</tr>
<tr>
<td colspan="5">

<u>Angular Unconformity</u>
(Up to 500 feet of pre-existing topographic relief with a well-developed regolith that mantles Precambrian Basement Rocks)

</td>
</tr>
<tr>
<td>Tertiary-Cretaceous</td>
<td>Grano-diorite</td>
<td colspan="3">

<u>Granodiorite</u>. Zoned plagioclase phenocrysts associated with biotite in a medium grain groundmass of plagioclase, quartz, and potassium-feldspar.

</td>
</tr>
<tr>
<td>Precambrain</td>
<td>Metavolcanics and Metasediments
(Iron King and Spud Mountain Volcanincs)</td>
<td>

- **<u>Mafic tuffaceous metasediments</u>** with well-developed foliation and relict bedding surfaces. These rocks are dark grayish-green and contain abundant chlorite. Relict angular fragments of mafic tuff and andesite are common in the groundmass.
- **<u>Amygdaloidal andesite flow</u>** that is interfingered with tuffaceous sediments (smt). These rocks are grayish-green and contain abundant chlorite, sericite, clinozoisite, leucoxene, and sparse quartz and calcite.
- **<u>Pelitic metasediments</u>** that are metamorphosed to muscovite-chlorite-calcite grade and show well-developed crenulated foliation. These rocks dark green phyllites.

</td>
<td>

- **<u>Diorite porphyry</u>** that intrudes the Iron King and Spud Mountain Volcanics (IKV/SMV). Saussuritized plagioclase phenocrysts in a microcrystalline groundmass of plagioclase, quartz, secondary chlorite and epidote.
- **<u>Granodiorite porphyry</u>** that intrudes the IKV/SMV. White plagioclase phenocrysts associated with biotite and hornblende in a medium grain groundmass of plagioclase, quartz, and potassium-feldspar.
- **<u>Quartz diorite</u>**. Plagioclase, biotite and hornblende with potassium-feldspar. Potassium-feldspar has poikilitic texture.
- **<u>Gabbro-Diorite</u>**. Medium grain groundmass, with plagioclase (albite), clinozoisite, chlorite, and/or brown to green amphibole.

</td>
<td>Granitoid Intrusives</td>
</tr>
</table>

TABLE 4-2
Summary of Analytical Methods for Soil Borings
Iron King Mine Site
Dewey-Humboldt, Arizona

Sample #	Sample Date	Analyses
IKM-SB01-0.5	2/5/2014	XRF Metals
IKM-SB01-05	2/5/2014	XRF Metals
IKM-SB01-10	2/5/2014	XRF Metals
IKM-SB01-14	2/5/2014	XRF Metals
IKM-SB01-20	2/5/2014	XRF Metals
IKM-SB01-24	2/5/2014	XRF Metals
IKM-SB02-0	2/5/2014	XRF Metals
IKM-SB02-05	2/5/2014	XRF Metals
IKM-SB02-10	2/5/2014	XRF Metals
IKM-SB02-15	2/5/2014	XRF Metals
IKM-SB03-0.2	2/5/2014	XRF Metals
IKM-SB03-05	2/5/2014	XRF Metals
IKM-SB03-10	2/5/2014	XRF Metals
IKM-SB03-14	2/5/2014	XRF Metals
IKM-SB04-0.5	2/5/2014	XRF Metals
IKM-SB04-05	2/5/2014	TAL Metals & Hg, XRF Metals
IKM-SB04-10	2/5/2014	XRF Metals
IKM-SB04-14	2/5/2014	XRF Metals
IKM-SB05-0.5	2/5/2014	XRF Metals
IKM-SB05-05	2/5/2014	XRF Metals
IKM-SB05-10	2/5/2014	XRF Metals
IKM-SB05-15	2/5/2014	XRF Metals
IKM-SB06-0	2/5/2014	XRF Metals
IKM-SB06-05	2/5/2014	XRF Metals
IKM-SB06-10	2/5/2014	XRF Metals
IKM-SB06-15	2/5/2014	XRF Metals
IKM-SB06-20	2/5/2014	XRF Metals
IKM-SB07-0	2/5/2014	XRF Metals
IKM-SB07-05	2/5/2014	XRF Metals
IKM-SB07-10	2/5/2014	XRF Metals
IKM-SB07-14	2/5/2014	XRF Metals
IKM-SB08-0	2/5/2014	XRF Metals
IKM-SB08-05	2/5/2014	XRF Metals
IKM-SB08-10	2/5/2014	XRF Metals
IKM-SB08-15	2/5/2014	XRF Metals
IKM-SB09-0	2/6/2014	XRF Metals
IKM-SB09-05	2/6/2014	XRF Metals
IKM-SB09-10	2/6/2014	XRF Metals
IKM-SB09-15	2/6/2014	XRF Metals
IKM-SB09-20	2/6/2014	XRF Metals
IKM-SB10-0	2/6/2014	XRF Metals
IKM-SB10-05	2/6/2014	TAL Metals & Hg, XRF Metals
IKM-SB10-10	2/6/2014	XRF Metals
IKM-SB10-15	2/6/2014	XRF Metals
IKM-SB10-20	2/6/2014	XRF Metals
IKM-SB11-0	2/6/2014	XRF Metals
IKM-SB11-05	2/6/2014	XRF Metals
IKM-SB11-10	2/6/2014	XRF Metals
IKM-SB11-15	2/6/2014	XRF Metals
MTP-SB01-05	4/2/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
MTP-SB01-27.5	4/2/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
MTP-SB01-47.5	4/2/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
MTP-SB02-05	4/3/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
MTP-SB02-65	4/4/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
MTP-SB02-81	4/4/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
MTP-SB02-84	4/4/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
MTP-SB03-05	4/7/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
MTP-SB03-63.5	4/7/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
MTP-SB03-106	4/8/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
MTP-SB03-108	4/8/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
WR-SS01-00	4/9/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
WR-SS02-00	4/9/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg
WR-SS03-00	4/9/2014	ABA, SPLP Metals & Hg, TAL Metals & Hg

TABLE 4-3
Standard Penetration Test Results
Iron King Mine Site
Dewey-Humboldt, Arizona

MTP-SB01	
Depth Interval (ft)	blow counts/6-inch drive
0 - 2	3"/50
5 - 7	16/17/23/13
15 - 17	9/8/9/10
25 - 27	13/6/1/35
35 - 37	5/5/5/4
45 - 47	2/3/3/3
MTP-SB02	
Depth Interval (ft)	blow counts/6-inch drive
0 - 2	5/11/8/3
5 - 7	5/7/6/5
15 - 17	4/4/4/5
25 - 27	4/4/3/4
35 - 37	2/2/3/4
45 - 47	1/4/5/5
55 - 57	1/2/2/3
65 - 67	2/1/2/2
75 - 77	WR/1/1/1
MTP-SB03	
Depth Interval (ft)	blow counts/6-inch drive
0 - 2	5/14/8/11
5 -7	5/7/7/6
10 - 12	1/1/3/3
15 - 17	2/2/1/3
20 - 22	5/5/5/5
42.5 - 44.5	4/4/3/4
62.5 - 64.5	6/5/4/6
70 - 72	2/4/4/8
80 - 82	3/4/4/10

WR - weight of rods

TABLE 4- 4
Summary of Geotechnical Test and Sampling Method
Iron King Mine Site
Dewey-Humboldt, Arizona

Sample #	Sample Date	Analyses	Sample Method
MTP-SB01-10	4/2/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB01-11.5	4/2/2014	Moisture - Density	Ring
MTP-SB01-20	4/2/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB01-21.5	4/2/2014	Moisture - Density	Ring
MTP-SB01-30	4/2/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB01-30	4/2/2014	Ksat, Moisture-Density	Shelby tube
MTP-SB01-40	4/2/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB01-47.5	4/2/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB02-10	4/3/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB02-11.5	4/3/2014	Moisture - Density	Ring
MTP-SB02-14	4/3/2014	Moisture - Density	Ring
MTP-SB02-20	4/3/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB02-20	4/3/2014	Moisture - Density	Shelby tube
MTP-SB02-30	4/3/2014	Moisture - Density	Shelby tube
MTP-SB02-34	4/3/2014	Moisture - Density	Ring
MTP-SB02-40	4/4/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB02-41.5	4/4/2014	Ksat, Soil-Water Characteristics	Ring
MTP-SB02-51.5	4/4/2014	Consolidation	Ring
MTP-SB02-52.5	4/4/2014	CU Triaxial Shear, Ksat, Mositure-Density	Shelby tube
MTP-SB02-60	4/4/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB02-61.5	4/4/2014	Direct Shear	Ring
MTP-SB02-70	4/4/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB02-80	4/4/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB02-81	4/4/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB02-81.5	4/4/2014	Moisture - Density	Ring
MTP-SB02-84	4/4/2014	Moisture - Density	Ring
MTP-SB03-05	4/7/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB03-25	4/7/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB03-26.5	4/7/2014	Moisture - Density	Ring
MTP-SB03-31.5	4/7/2014	Moisture - Density	Ring
MTP-SB03-35	4/7/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB03-36.5	4/7/2014	Moisture - Density	Ring
MTP-SB03-46.5	4/7/2014	Direct Shear	Ring
MTP-SB03-48.5	4/7/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB03-51.5	4/7/2014	Consolidation	Ring
MTP-SB03-60	4/7/2014	CU Triaxial Shear, Ksat, Mositure-Density	Shelby tube
MTP-SB03-62.5	4/7/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB03-66.5	4/7/2014	Ksat, Soil-Water Characteristics	Ring
MTP-SB03-75	4/7/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB03-76.5	4/7/2014	Direct Shear	Ring
MTP-SB03-86.5	4/7/2014	Consolidation	Ring
MTP-SB03-91.5	4/8/2014	Ksat, Soil-Water Characteristics	Ring
MTP-SB03-95	4/8/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB03-95	4/8/2014	Ksat, Moisture-Density	Shelby tube
MTP-SB03-100	4/8/2014	CU Triaxial Shear, Ksat, Mositure-Density	Shelby tube
MTP-SB03-105	4/8/2014	Atterberg Limits, grain size, specific gravity	bag
MTP-SB03-106.5	4/8/2014	Moisture - Density	Ring
MTP-SB03-108	4/8/2014	Atterberg Limits, grain size, specific gravity	bag

FIGURES

Base map created using ESRI World Imagery,
well Location and soil boring location from 2014.

Map Creation Date: 06 October 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC4_MTP & Waste Rock
\146_SEC4_Borehole_Well_Locations_f4-1

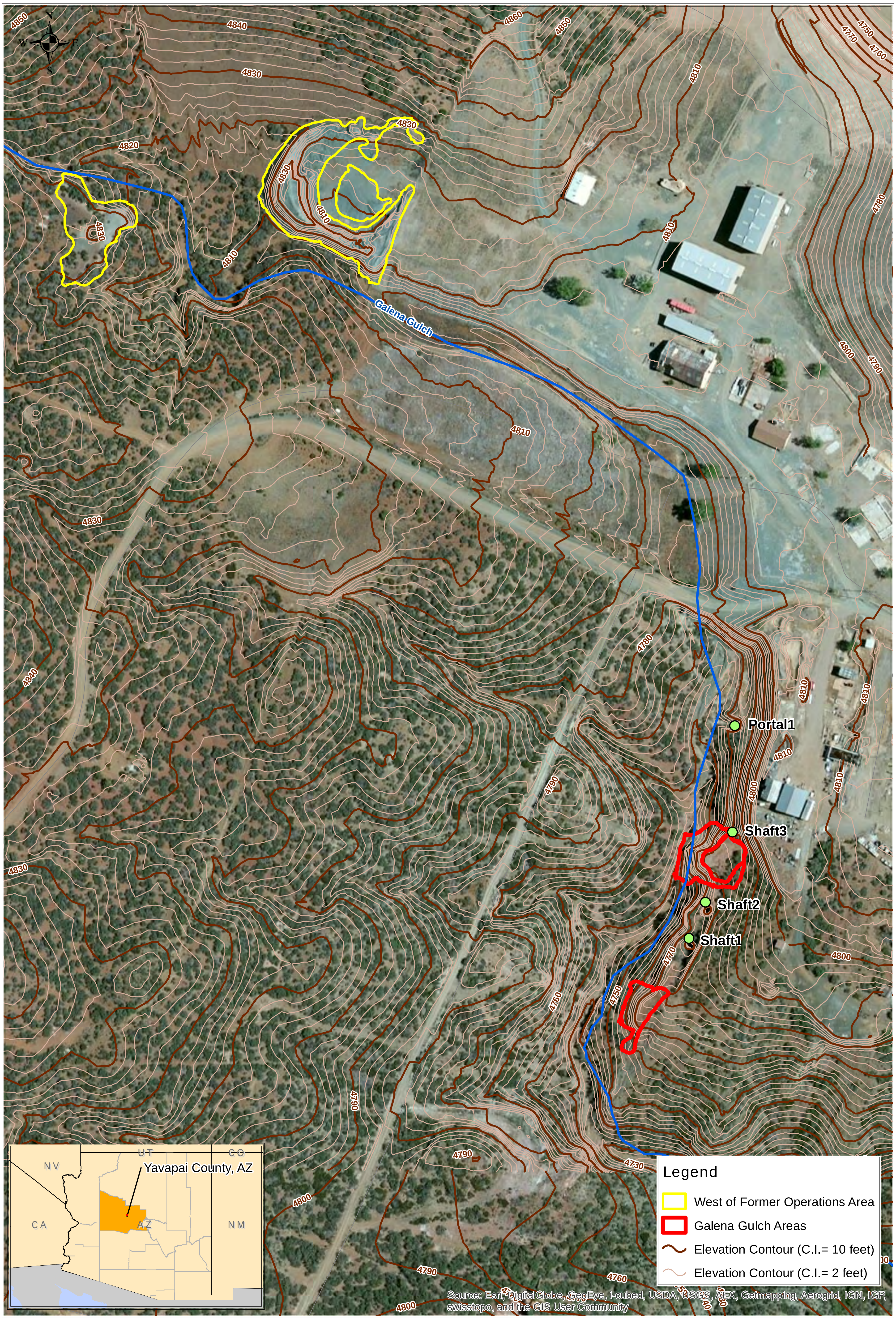
Legend

- Shallow Boring Location
- Deep Boring/Wells

0 300 600
Feet

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 4-1
Borehole/Well Locations
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using ESRI World Imagery,
Vector data from GPS.

Map Creation Date: 29 September 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC4_MTP & Waste Rock \146_SEC4_Waste_Rock_Areas_f4-2

0 150 300
Feet

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 4-2
Waste Rock Areas
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 4-A
Photographs of Shallow Borehole Cores
Iron King Mine Site
Dewey-Humboldt, Arizona

Electronic Copies are Attached

APPENDIX 4-B
Iron King Mine Shallow Soil Boring Logs
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 4-C
Photographs of Deep Main Tailings Pile (MTP) Cores
Iron King Mine Site
Dewey-Humboldt, Arizona

Electronic Copies are Attached

APPENDIX 4-D

Iron King Mine Deep MTP Boring Logs & Well Construction

Iron King Mine Site

Dewey-Humboldt, Arizona

SECTION 5 - Installation of New Site-Wide Monitor Wells

5.1. INTRODUCTION

The Iron King Mine (IKM) Site covers 153 acres in the Upper Agua Fria Watershed, Yavapai County, Arizona (AZ). The IKM is located along the west flank of Spud Mountain in the headwaters of the Chaparral Gulch arroyo (Figure 5-1). Approximately three miles downgradient of the IKM site is the Humboldt Smelter (HS) property. The HS property covers 190 acres, north of the Chaparral Gulch Arroyo, on a bluff overlooking the Agua Fria River. The Chaparral Gulch Arroyo drains into the Agua Fria River.

5.1.1 Background and Regional Hydrogeology

The hydrogeology for the IKM site vicinity (Dewey-Humboldt area) is summarized below, with detailed descriptions of the Upper Agua Fria Watershed discussed in:

- Wilson, 1988
- Nelson, 2002
- Wirt and others, 2004
- Timmons, 2007
- Towne, 2008
- Stitzer and others, 2010

The IKM and HS sites are located in the Chaparral Gulch Subwatershed, a second-order drainage to the Upper Agua Fria Watershed (Figure 5-1). The Upper Agua Fria Watershed is located in the southern portion of Chino-Prescott Valley (aka. Chino-Lonesome Valley), a 28-mile long structural basin that developed during the Tertiary Basin and Range extensional event (Krieger, 1965). The Chino-Prescott basin is filled with a complex sequence of alluvial, volcanoclastic and volcanic deposits (Hickey Formation), making it a highly productive hydrogeologic system (Wirt and others, 2004).

Originally, the Chino-Prescott Valley drained northward into the Verde River, but rapid headwall erosion and downcutting by the south flowing Agua Fria River captured the southern portion of Prescott Valley (historically known as Lonesome Valley). Consequently, the groundwater resource stored in the Chino-Prescott basin is shared by both the Upper Agua Fria Watershed and adjoining Little Chino Watershed, located directly to the north (Krieger, 1965; Wilson, 1988; Corkhill and Mason, 1995). The general location of the groundwater divide parallels Highway 89A east from Prescott to Jerome, Arizona. The groundwater divide is transient, depending on both variations in seasonal precipitation and local groundwater production, because a bedrock divide does not separate the two watersheds (Wirt and others, 2004).

In the Upper Agua Fria Watershed, the southern portion of the Chino-Prescott basin is bound on the west by the northeast trending Spud Fault Zone, and east by the northeast trending Whitney Fault Zone. The Whitney Fault is believed to be a reactivated splay fault of the Precambrian Shylock Fault (Figure 5-1), and an extension of the Tertiary Coyote Fault exposed in the northern portion of the basin (Anderson and Creasey, 1967). The Black Hills are located west of the Spud Fault Zone and Bradshaw Mountains east of the Whitney Fault Zone (Krieger, 1965; Anderson and Blacet, 1972a). The Black Hills and Bradshaw Mountains are the recharge areas for both the Upper Agua Fria and Little Chino Watersheds (Wilson, 1988; Corkhill and Mason, 1995; Timmons, 2007).

The Black Hills and Bradshaw Mountains converge near the Town of Dewey-Humboldt, but are still separated by the Agua Fria River (Anderson and Blacet, 1972b,c; DeWitt *et al*, 2008; Johnson *et al* 2013). The regional groundwater flow is south to southeasterly from the surface divide in Prescott Valley, mimicking the drainage pattern of the Agua Fria River (Wilson, 1988; Corkhill and Mason, 1995; Timmons, 2007). Most reaches of the Agua Fria River are ephemeral, with channel flow only occurring during the monsoon season; however, a short reach through the Town of Dewey-Humboldt has perennial flow (Figure 5-1). Along this stretch, the Agua Fria River has down-cut through the Hickey Formation into the Precambrian basement, allowing baseflow from the lower Hickey Conglomerate to drain into the river (Corkhill and Mason, 1995).

5.1.2 Hydrostratigraphy

The hydrostratigraphy of the IKM vicinity is composed of both unconfined and semiconfined groundwater conditions and separated into five distinct water-bearing units (Figure 5-2). The unconfined aquifer is associated with Quaternary fluvium and the semiconfined aquifers associated with the Tertiary Hickey Formation and Precambrian basement rocks (Creasey, 1951; Anderson and Creasey, 1958). The water-bearing units are defined from top to bottom as (Figure 5-2).

Tailings

Tailings are identified as the uppermost water-bearing unit in the site vicinity and defined as an 'aquitard' because of their very low transmissivity (Figure 5-2). Tailings are stored at two separate locations: the main tailings pile (MTP) on the IKM site and the Chaparral Gulch flood plain on the HS property. Tailings are easily recognized, because they are a very homogenous, clayey-silt with the oxidized material ranging in color from ochre to dark red, and reduced material ranging from dark green to black.

Tailings from the IKM site are lead-rich with a lead to copper (Pb:Cu) ratio greater than (>) 2.1, while the HS tailings are copper-rich with a Pb:Cu less than (<) 0.06. The IKM tailings overlie Hickey Basin Fill (Hunc) deposits on the mine property. The MTP is currently stable, but historically tailings have been released into the Chaparral Gulch Arroyo and presumably reworked with fluvium as the material is transported further downgradient of the mine. (Note: A slope failure occurred in the MTP area in the 1960s after a period of heavy rainfall, indicating the stability of the MTP is likely marginal. Evidence of further slope movements has not been observed since, and there does not appear to be an immediate risk of instability for the current static conditions. Unless the MTP is remediated, the potential for future slope failures still exists.

The HS tailings are stored over lower Hickey Conglomerate (Hcgl) in the swale area south of the smelter and fluvium in Chaparral Gulch, which was dammed for used as a tailings pond. The thickness of the tailings in the Chaparral Gulch 'flood plain' ranges up to 23 feet near the dam.

Hickey Formation

- Upper Tertiary <u>Hickey Basin Fill (Hunc)</u> deposits cover a large portion of the site vicinity (Figure 5-3) and are characterized as a 'semiconfined aquifer' with thick zones (up to 75 feet) of low transmissivity interlayered with narrow zones (< 5 feet) of moderate to very high transmissivity. Basin fill deposits are overlapping alluvial fan deposits (fanglomerates) that develop along the boundaries of tectonically active basins (Figure 5-2). Fanglomerates are characterized as unconsolidated, poorly sorted silt, clay, sand and gravel. The basin fill deposits represent the waning stages of Basin and Range volcanism through post-tectonism. In the site vicinity, the lower portion of the Hickey Basin Fill deposits is believed to be a mudflow and locally interbedded with basalt (Hbslt) flows. The mudflow deposit is highly indurated, with a distinct calcareous (marly) matrix that is white to buff in color.

- Middle to Upper Tertiary Hickey Basalt (Hbslt) crops out south of Chaparral Gulch and on the HS property in the plateau area. The basalt is intersected at depth in monitor wells (MW)-01S, MW-11S and MW-12S/D (discussed later in this report section). The basalt commonly overlies a mafic tuff (ash/cinders) and is characterized as an aquitard, except where the volcanics are fractured/jointed or fluvium was deposited between basalt flows (Figure 5-2). These isolated water-bearing zones are semiconfined and can produce sustainable, albeit low yields in the site vicinity.

- Lower Tertiary Hickey Conglomerate (Hcgl) is intersected at depth in monitor wells MW-02D, MW-07D, MW-09D and MW-10D, and a number of soil borings in the Chaparral Gulch flood plain (Figure 5-3). The conglomerate is poorly sorted, with discontinuous gravel layers dispersed throughout the section. Locally, the lower conglomerate has zones where the matrix is calcareous. In general, the gravel layers are semiconfined zones with poor hydraulic connectivity between isolated water-bearing zones; however, there are isolated high to very high yielding zones, most notably near the unconformity with the underlying Precambrian basement rocks.

Precambrian Basement

- Iron King Volcanics (IKV) crop out along the west side of the Agua Fria River to the IKM site. The IKV are intersected at depth in monitor wells MW-02D, MW-07D, MW-09D and MW-10D, and a few soil borings at the east end of the Chaparral Gulch flood plain. The IKV are characterized by massive andesite flows that are metamorphosed to muscovite-chlorite-calcite greenschist facies (Figure 5-2). The IKV have a well-developed foliation that is oriented north-northeast and dips steeply to the west in the site vicinity.

- Spud Mountain Series (SMS) crop out east of the Agua Fria River and west of the IKM site. The SMS is intersected at depth only in monitor well MW-06D. The SMS is characterized by interbedded pelitic and tuffaceous metasediments, metatuffs and amygdaloidal andesite flows (Figure 5-2). Similar to the IKV, the SMS is metamorphosed to muscovite-chlorite-calcite greenschist facies with a well-developed foliation and relict bedding surfaces.

5.2. OBJECTIVES

The objectives for installing additional site-wide monitor wells (beyond those that existed prior to this investigation) were as follows:

1) Better define groundwater flow directions and gradients in the unconfined and semiconfined aquifers by installing 14 monitor wells in the following areas (Figure 5-3):
   - Main Tailings Pile (MTP-MW01 through MTP-MW03);
   - Quaternary fluvial gravel (CHF-MW01 through CHF-MW03, and STS-MW04-S/I);
   - Tertiary Hickey Formation (MW-10S, MW-11S and MW-12S/D); and
   - Precambrian IKM (MW-02D and MW-10D).
2) Develop a better understanding of the vertical movement of groundwater and dissolved contaminants and further define the lateral and vertical extents of the dissolved contamination.
3) Further define the hydrogeology and hydrostratigraphy such that reliable schematic sections from these wells can be used to identify possible preferential pathways for groundwater flow and contaminant migration pathways by monitoring long-term groundwater trends in the Chaparral Gulch Arroyo and the MTP.
4) Assist in developing a robust conceptual site model (CSM) of groundwater flow and contaminant fate and transport.

Note: The new site-wide wells include MW-02D, MW-10S, MW-10D, MW-11S, MW-12S, and MW-12D. While the other wells are discussed in other report sections, they have also been included in this section to assist with the presentation of results.

5.3. METHODOLOGY

Cascade Drilling of Phoenix, AZ installed a total of 14 monitor wells at the site during three separate events (Figure 5-3). The sonic drilling method was used for the majority of the well installations (ASTM, 2010). However, downhole air hammer drilling was used to reach targeted depths for the deeper wells (MW-02D, MW-10D and MW-12D). The monitor wells were installed in accordance with local and State regulations, and Scientific, Engineering, Response and Analytical Services (SERAS) standard operating procedure (SOP) #2048, *Monitor Well Installation*. The drilling rigs used for each event are summarized as follow:

- February 22 to 28, 2014, a Sonic Prosonic/Boart Longyear 200C track-mounted drilling rig was used to install monitor wells CHF-MW01 through CHF-MW03, and STS-MW04-S/I. Well depths ranged from eight to 28 feet.
- April 2 to 11, 2014, a Sonic Boart Longyear 600T truck-mounted drilling rig was used to install monitor wells MTP-MW01 through MTP-MW03. Well depths ranged from 45 to 106 feet.
- June 11 to July 11, 2014, a Sonic SDC 390-14 track-mounted drilling rig was used to install monitor wells MW-11S and MW-10S, and partial installation of MW-02D. A Gus Pech GP 300RS truck-mounted drilling rig, which had the capability of either sonic or downhole air hammer drilling, was used to complete monitor well MW-02D and install MW-10D and MW-12S/D. Final depths for these six wells ranged from 45 to 356 feet.

Pilot boreholes were advanced to targeted depths by sonic drilling for wells installed in shallow unconsolidated deposits, tailings, and the upper Hickey Formation. The boreholes were continuously cored, sampled, and logged from ground surface to the targeted depths. Wells completed in the Chaparral Gulch flood plain (CHF-MW01 through CHF-MW03 and STS-MW04-S/I) were drilled with a 4-inch diameter sonic core barrel and 6-inch diameter override casing; wells completed in the MTP (MTP-MW01 through MTP-MW03) were drilled with a 6-inch diameter sonic core barrel and 8-inch diameter override casing. Monitor wells MW-10S, MW-11S and MW-12S were constructed in the upper Hickey Formation, within the shallowest groundwater zone encountered at each location. These three wells were continuously cored and sampled using a 7-inch diameter sonic core barrel and 8-inch diameter override casing. The well construction records can be found in Appendix 5-A.

A different method was used for drilling and completion of the deeper wells (MW-02D, MW-10D and MW-12D). Each borehole for the three wells was drilled to some intermediate depth with the sonic method and then completed with a downhole air hammer. The sonic drilling rig was initially tooled with a 7-inch diameter core barrel and 8-inch diameter override casing. The drilling switched from sonic to downhole air hammer when the borehole could not be advanced further (i.e., either all available sonic drill tooling had been used or there was very slow advancement). Prior to switching over to the downhole hammer, an 8-inch diameter sonic core barrel and 9-inch override casing was used to ream and widen each borehole down to the previously drilled depth. An 8-inch diameter air hammer bit was then used to advance each borehole (via open hole drilling) to final, targeted depths. During borehole advancement with the hammer bit, washed drill cuttings were periodically collected for lithologic description. Monitor well MW-12D was constructed in the lower Hickey Formation and MW-02D and MW-10D were constructed in the IKV. The well construction records can be found in Appendix 5-A.

Well Installation

After drilling completion, a single monitor well was installed into each borehole. Monitor wells CHF-MW01 through CHF-MW3 and STS-MW04-S/I were constructed with 2-inch inner diameter (ID), Schedule 40 polyvinyl chloride (PVC) casing and slotted 0.10 well screen. Screen lengths varied from 5 to 15 feet for these monitor wells (Table 5-1). The remaining wells were constructed with 4-inch ID, Schedule 80 PVC casing and 10-slot well screens (Table 5-1). Screen lengths are 20 feet for MTP-MW-1 through MTP0-MW03; 15 feet for the wells installed in the upper Hickey Formation (MW-10S, MW-11S and MW-12S); and 30 to 50 feet for the deeper wells installed in the lower Hickey Formation (MW-12D) or IKV (MW-02D and MW-10D).

All 14 monitor wells were constructed with a 10/20 sieve-size silica sand filter pack that was placed around the well screen. The filter pack was emplaced in lifts up to three feet above the screened interval, as the override casing was removed from the boreholes. A hydrated bentonite pellet seal was placed above the filter pack in each well, and the remainder of the annular space was backfilled with cement-bentonite grout (using a tremie pipe), up to approximately two feet below grade. For deeper installations, a high-solids bentonite grout was placed above the pellet seal, up to approximately 20 feet below grade. After curing, cement-bentonite grout was then used to fill the remainder of the annular space up to approximately two feet below grade. A flush-mounted protective cover or above-ground casing (encased in a concrete pad) was installed over the wellhead at each location.

The construction records for both the existing and SERAS installed monitor wells are summarized in Table 5-1, and locations displayed in Figure 5-3. Well construction diagrams for the SERAS installed wells can be found in Appendix 5-A.

Well Development

The completed monitor wells were developed using a combination of air lifting, surging, and pumping in accordance with SERAS SOP #2044, *Well Development*. The wells were developed no sooner than 48 hours after installation.

Boring Logs

Boring logs for the SERAS installed monitor wells can be found in Appendix 5-A. Boring logs for other important wells that were used to develop a preliminary site hydrostratigraphic model are included in Appendix 5-B.

Two preliminary schematic sections were constructed using the Rockworks16™ three-dimensional visualization software package. The schematic sections were created using the ‘Stratigraphy’ modeling subroutine, and the Yavapai County 2-foot contour map as a surficial boundary condition (i.e., contouring cannot occur above this surface). The model was constructed using the following grid dimensions:

- 100 by 100-foot horizontal grid that delineates a 71,000,000 square foot polygon (100 nodes east by 71 nodes north)
- 2-foot vertical increments from 4,100 to 4,770 feet above sea level (336 elevation nodes)

An Inverse Distance Weighted (IDW) algorithm was used to generate the model, using a:

- Weighting exponent of 2.5,
- Circular search radius of 1,000 feet that is separated into eight 45 degree (º) sectors,
- Minimum of 4 neighbors per 45°sector or 16 neighbors total for the search area,
- Fault boundary displacement interpreted from borehole logs,
- Grid smoothing vertical direction (Filter = 4 and Iterations = 4).

Water Level Monitoring

Depth-to-water measurements were taken and were recorded in each monitor well in July and October in accordance with SOP # 2043, *Water Level Measurements* 2014 (Table 5-2). In addition, long-term water level measurements were collected from select monitor wells (CHF-MW01 through CHF-MWO3, STS-MW04-S/I, and MTP-MW01 through MTP-MW03), using electronic pressure transducers with data-logging capability (Solinst® 3001). The electronic pressure transducers were non-vented and the data were processed by removing barometric pressure influences. Barometric pressures were collected from two locations in the site vicinity. BaroSolinst® transducers were installed above the water table in monitor wells STS-MW04-S (Chaparral Gulch) and MTP-MW02 (IKM site). The BaroSolinsts were synchronized to the transducers.

5.4 RESULTS AND DISCUSSON

5.4.1 Schematic Sections

Two schematic section lines (A-A' and B-B') were constructed across the site vicinity (Figure 5-3). Schematic section A-A' extends 8,200 feet west of Galena Gulch on the IKM site, across the MTP and down the Chaparral Gulch arroyo before terminating at the Agua Fria River (Figure 5-3). Schematic section B-B' begins at the southeast end of the MTP and extends 5,900 feet northeast through the Town of Dewey-Humboldt before terminating at the production wells (ADWR 55-533639) on Old Black Canyon Highway (Figure 5-3).

A-A'

Schematic section A-A' (Figure 5-4) shows the top surface of the Precambrian rocks (IKV and SMS) is reached at lower elevations (greater depths) in boreholes east of the IKM site, cropping out at the surface near the tailings dam at the east end of the Chaparral Gulch flood plain (Figure 5-3). This geologic feature is interpreted as being an asymmetric 'graben' structure that is formed by three east dipping normal faults (Spud Fault Zone) that down-step to the east, and a single west dipping normal fault (Whitney Fault Zone) at the east end of the Chaparral Gulch flood plain (Figure 5-4). The interpretation is supported by previous studies (Krieger, 1965; Wilson, 1988, Timmons, 2007) that propose a structural basin or trough extends southward from the Chino-Prescott Valley into the Dewey-Humboldt area.

The development of the structural basin in the site vicinity is depicted by the depositional history of the Hickey Formation, which filled the basin (Figures 5-2, 5-3 and 5-4). The lower Hickey Conglomerate (Hcgl) was deposited during the onset of the Basin and Range extensional event, prior to volcanism. Crustal thinning resulted in the development of hotspots along the axis of the basin. Eventually some of the hotspots developed into cinder cones that ejected mafic ash and cinder (Hash). As tectonism and volcanic activity approached an apex, some cinder cones evolved into prominent volcanic vents erupting large volumes of mafic lava (Hbslt) into the basin. As volcanic activity waned, erosional processes shaped the terrain as unconsolidated Hickey Basin Fill deposits (Hunc) filled the last vestige of the structural basin (Krieger, 1965).

B-B'

Schematic section B-B' (Figure 5-4) is subparallel to the north-northeast trending axis of the structural basin. The section shows the surface of the Precambrian basement rocks slope to the north with thickening of the overlying unconsolidated Hickey Basin Fill (Hunc) deposits. The interpretation is supported by Krieger (1965), who proposed that Tertiary offset along the Spud and Whitney Fault Zones is at a minimum in the Dewey-Humboldt area and the thickness of the Hickey Formation reaches a maximum in the Chino-Prescott basin, northeast of the Town of Prescott.

5.4.2 Groundwater Elevations

Water levels were measured in 26 monitor wells throughout the site vicinity in mid-June, late-July and late-October 2014 (Table 5-2). The 26 wells are spread over 2.55 square miles and water levels were monitored in five hydrostratigraphic units. The screened intervals in each hydrostratigraphic unit are listed in Tables 5-1 and 5-2. The number of wells installed in each hydrostratigraphic unit is listed from top to bottom as:

- 10 wells monitor the tailings (overburden [OVB]), 5 in Chaparral Gulch flood plain and 5 on the MTP.
- 9 wells monitor the unconsolidated Hickey Basin Fill (Hunc) deposits.
- 3 wells monitor the Hickey Basalt (Hbslt).
- 3 wells monitor the IKV.
- 1 well monitors the SMS.

The composite well spacing (Figure 5-3) is too sparse to provide a clear understanding of the horizontal hydraulic gradients for any of the five hydrostratigraphic units.

5.4.3 Vertical Hydraulic Gradient

Water levels were gaged at six site-wide locations where well pairs are located (Figure 5-3). The well pairs were installed to assess changes in water quality over depth and also, to evaluate vertical hydraulic gradients (Table 5-3). Shallow wells (designated with an "S") were installed in the Hickey Formation and deep wells (designated with a 'D') were installed in either the Hickey Formation or IKV (Table 5-3). The vertical hydraulic gradient (i_v) estimated for each sampling event is listed in Table 5-2 and summarized below:

- The vertical hydraulic gradient ranged from 0.042 to 0.541 with the following caveats:
  - Wells MW-02D and MW-12D were still recovering after their initial well development in late July 2014 and omitted from the final analysis.
  - Wells MW-08S and MW-09D were dry for the late October 2014 sampling event and the vertical hydraulic gradient could not be determined.
  - Depth-to-water measurements for MW-08S and MW-09S for the late July 2014 and October 2012 sampling events are questionable because the measured water depths were below the bottom of the well screens (i.e., depth to water was measured in the 0.3-foot sumps that cap the well bottoms). These data were omitted from the final analysis.
- Under static conditions, the vertical hydraulic gradient increases from 0.042 to 0.541 from southwest to northeast (upgradient of the Agua Fria River), suggesting production from supply wells in the Town of Dewey-Humboldt (Figures 5-3 and 5-4) may be influencing vertical groundwater flow.

5.4.4 Hydrographs

Continuous water level measurements were recorded from June 20 to October 24, 2014 for the tailings deposits in the Chaparral Gulch flood plain and the MTP on the IKM site (Figure 5-3). Hydrographs from the two locations are plotted with rainfall for the same time period. Precipitation records are from the Prescott, AZ Airport, located approximately 17 miles northwest of the Town of Dewey-Humboldt.

Chaparral Gulch Flood Plain

Hydrographs for monitor wells CHF-MW01 through CHF-MW03, and STS-MW04-I (Chaparral Gulch flood plain) are plotted on Figure 5-5. Monitor well STS-MW04-S was omitted because it was dry during the entire monitoring period. Sporadic measurable rain began in early July but the water levels showed a general decline, dropping about three feet from June 20 to mid-August.

In mid-August the monsoon rains began in earnest and the water table in the Chaparral Gulch flood plain responded rapidly, increasing approximately five feet from August 12 to 21 (Figure 5-5). The rains continued and water levels gradually increased approximately three feet in wells CHF-MW02, CHF-MW03 and STS-MW04-I, by October 24. However, during this same time period, the water level in CHF-MW01 peaked then declined into late September, dropping by approximately 2.5 feet. Due to increased rainfall beginning in late September, the water level in CHF-MW01 increased by approximately one foot before the study ended on October 24.

Monitor well CHF-MW01 is located about 200 feet upgradient of the tailings dam, which has a spillway elevation of 4,461 feet above sea level, or two feet below the peak water level elevation that was recorded on August 21 (Figure 5-5). The declining water level in CHF-MW01 correlates with increasing water levels hydraulically upgradient (CHF-MW02, CHF-MW03 and STS-MW04-I), indicating that as the groundwater mound increased, discharge increased near dam. The most likely scenarios are that groundwater may be leaking under the dam and thus recharging into the underlying bedrock and/or surface seepage is spilling over the dam.

MTP

Hydrographs for tailings monitor wells MTP-MW01 through MTP-MW03 are plotted in Figure 5-6. The three wells remained dry during the entire monitoring period; however, the tailings pile could still be a transient groundwater source for local recharge into the underlying Hickey Formation.

5.5 REFERENCES

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TABLES

TABLE 5-1
IRON KING MINE SITE
SUMMARY OF MONITOR WELL CONSTRUCTION
DEWEY-HUMBOLDT, ARIZONA
DECEMBER 2014

Well No.	Longitude	Latitude	Easting (ft)	Northing (ft)	Elevation (ft asl)[1]		Well Diameter	TD (ft)	Screen Depth (ft)		Material
					GS	MP			Top	Bottom	
CHF-MW01	-112.23359157	34.49319799210	604,507.05	1,271,004.24	4464.28	4467.72	2" PVC	26	2	12	Tailings (CGF)
CHF-MW02	-112.23527085	34.49419621960	604,002.21	1,271,369.09	4471.49	4474.60	2" PVC	30	7.5	22.5	Tailings (CGF)
CHF-MW03	-112.23659403	34.49502529670	603,604.48	1,271,672.06	4477.47	4480.62	2" PVC	38	11	21	Tailings (CGF)
STS-MW04-S	-112.23590915	34.49493684110	603,810.74	1,271,639.22	4476.09	4476.10	2" PVC	10	3	8	Tailings (CGF)
STS-MW04-I	-112.23591552	34.49493017180	603,808.81	1,271,636.80	4476.10	4479.01	2" PVC	38	18	28	Tailings (CGF)
MTP-MW01	-112.24798371	34.49893899510	600,177.43	1,273,107.36	4640.83	4643.42	4" PVC	77	25	45	Tailings (MTP)
MTP-MW02	-112.25144433	34.50055367660	599,136.73	1,273,698.39	4747.04	4749.23	4" PVC	110	61	81	Tailings (MTP)
MTP-MW03	-112.25286376	34.49951297770	598,707.82	1,273,321.09	4743.74	4746.67	4" PVC	134	86	106	Tailings (MTP)
MW-1S	-112.23221952	34.49882833900	604,926.85	1,273,051.90	---	4543.59	4" PVC	123	106	121	Hickey Basalt
MW-2S	-112.23663695	34.49646314890	603,593.21	1,272,195.36	---	4516.84	4" PVC	54	37	52	Upper Hickey Fm (Hunc)
MW-2D	-112.23661641	34.49649253110	603,599.43	1,272,206.03	4515.13	4516.31	4" PVC	360	306	356	Iron King Volcanics (IKV)
MW-3S	-112.24806581	34.49772581600	600,151.24	1,272,665.94	---	4607.28	4" PVC	40	23	38	Upper Hickey Fm (Hunc)
MW-4S	-112.24899660	34.50001082430	599,873.54	1,273,498.41	---	4640.68	4" PVC	59	42	57	Upper Hickey Fm (Hunc)
MW-5S	-112.24922548	34.49825224470	599,802.47	1,272,858.67	---	4640.64	4" PVC	59	42	57	Upper Hickey Fm (Hunc)
MW-6D	-112.25604617	34.50333724620	597,753.68	1,274,715.99	---	4760.31	4" PVC	350	315	345	Spud Mountain Series (SMS)
MW-7S	-112.24605852	34.49901469510	600,757.55	1,273,133.01	---	4562.49	4" PVC	34	14	29	Upper Hickey Fm (Hunc)
MW-7D[2]	-112.24583171	34.49901727930	600,825.89	1,273,133.73	---	4561.69	4" PVC	360	325	355	Iron King Volcanics (IKV)
MW-8S	-112.24906291	34.49924766840	599,852.65	1,273,220.75	---	4638.62	2" PVC	33	16	31	Tailings (MTP)
MW-8D	-112.24906216	34.49924861020	599,852.87	1,273,221.09	---	4638.59	2" PVC	62	45	60	Upper Hickey Fm (Hunc)
MW-9S	-112.25338082	34.50132613900	598,554.24	1,273,981.44	---	4751.91	2" PVC	74	52	72	Tailings (MTP)
MW-9D	-112.25337599	34.50131330580	598,555.68	1,273,976.76	---	4751.65	2" PVC	180	158	178	Iron King Volcanics (IKV)
MW-10S	-112.24161947	34.50191699760	602,098.37	1,274,184.87	4530.99	4530.29	4" PVC	51	34	49	Upper Hickey Fm (Hunc)
MW-10D	-112.24160501	34.50190192260	602,102.71	1,274,179.37	4530.77	4530.11	4" PVC	330	294.5	324.5	Iron King Volcanics (IKV)
MW-11S	-112.23800527	34.50011417440	603,185.16	1,273,525.32	4567.29	4566.99	4" PVC	88	62	77	Hickey Basalt
MW-12S	-112.23564932	34.50325408840	603,898.57	1,274,665.73	4512.54	4511.87	4" PVC	49	30	45	Upper Hickey Fm (Hunc)
MW-12D	-112.23563223	34.50325482000	603,903.72	1,274,665.98	4512.30	4511.83	4" PVC	219	135	175	Hickey Volcanics (Hash)

MP - measuring point elevation or top-of-PVC (feet above mean sea level)
TD - total depth below ground surface (feet)
DTW - average depth to water below ground surface (feet)
Scr-Top - top of screen below ground surface
Scr-Bot - bottom of screen below ground surface
Mat'l - material screened

1. Elevation datum NAVD88
2. Alternate log shows a TD of 354 feet and a screen interval of 319 to 349 feet (?)

TABLE 5-2
IRON KING MINE SITE
HISTORICAL WATER LEVELS FROM MONITOR WELLS
DEWEY-HUMBOLDT, ARIZONA
DECEMBER 2014

Well No.	Easting (ft)	Northing (ft)	MP[1] (ft asl)	TD (ft)	Date	DTW (ft)	GW Elev. (ft asl)	Mat'l
CHF-MW01	604,507.05	1,271,004.24	4,467.72	26	10/20/14	4.66	4463.06	Tailings (CHF)
					07/28/14	5.69	4462.03	
					06/10/14	6.13	4461.59	
CHF-MW02	604,002.21	1,271,369.09	4,474.60	30	10/20/14	8.33	4,466.27	Tailings (CHF)
					07/28/14	10.90	4,463.70	
					06/10/14	10.70	4,463.90	
CHF-MW03	603,604.48	1,271,672.06	4,480.62	38	10/20/14	13.44	4,467.18	Tailings (CHF)
					07/28/14	16.13	4,464.49	
					06/10/14	16.39	4,464.23	
STS-MW04S	603,810.74	1,271,639.22	4,476.10	10	10/20/14	DRY	DRY	Tailings (CHF)
					07/28/14	DRY	DRY	
					06/10/14	DRY	DRY	
STS-MW04I	603,808.81	1,271,636.80	4,479.01	38	10/20/14	12.32	4,466.69	Tailings (CHF)
					07/28/14	8.89	4,470.12	
					06/10/14	14.90	4,464.11	
MTP-MW01	600,177.43	1,273,107.36	4,643.42	77	10/20/14	DRY	DRY	Tailings (MTP)
					07/28/14	DRY	DRY	
					06/10/14	DRY	DRY	
MTP-MW02	599,136.73	1,273,698.39	4,749.23	110	10/20/14	DRY	DRY	Tailings (MTP)
					07/28/14	DRY	DRY	
					06/10/14	DRY	DRY	
MTP-MW03	598,707.82	1,273,321.09	4,746.67	134	10/20/14	DRY	DRY	Tailings (MTP)
					07/28/14	DRY	DRY	
					06/10/14	DRY	DRY	
MW-01S	604,926.85	1,273,051.90	4,543.59	123	10/20/14	95.55	4,448.04	Hickey Basalt (Hbslt)
					07/29/14	115.81	4,427.78	
					06/10/14	105.08	4,438.51	
					10/17/12	102.57	4,441.02	
					05/04/10	85.63	4,457.96	
					04/29/09	96.44	4,447.15	
MW-02S	603,593.21	1,272,195.36	4,516.84	54	10/20/14	41.53	4,475.31	Upper Hickey Fm (Hunc)
					07/29/29	43.81	4,473.03	
					06/10/14	43.16	4,473.68	
					10/17/12	42.00	4,474.84	
					05/03/10	34.05	4,482.79	
					04/29/09	40.19	4,476.65	
MW-02D	603,599.43	1,272,206.03	4,516.31	360	10/20/14	111.79	4,404.52	Iron King Volcanics (IKV)
					07/30/14	334.17	4,182.14	
MW-03S	600,151.24	1,272,665.94	4,607.28	40	10/20/14	27.80	4,579.48	Upper Hickey Fm (Hunc)
					07/29/14	30.64	4,576.64	
					06/10/14	29.05	4,578.23	
					10/15/12	26.12	4,584.59	
					05/03/10	22.47	4,584.81	
					04/27/09	22.69	4,581.16	
MW-04S	599,873.54	1,273,498.41	4,640.68	59	10/20/14	47.40	4,593.28	Upper Hickey Fm (Hunc)
					07/29/14	48.41	4,592.27	
					06/10/14	47.97	4,592.71	
					10/16/12	46.09	4,594.59	
					05/05/10	44.53	4,596.15	
					04/28/09	45.13	4,595.55	

TABLE 5-2
IRON KING MINE SITE
HISTORICAL WATER LEVELS FROM MONITOR WELLS
DEWEY-HUMBOLDT, ARIZONA
DECEMBER 2014

Well No.	Easting (ft)	Northing (ft)	MP[1] (ft asl)	TD (ft)	Date	DTW (ft)	GW Elev. (ft asl)	Mat'l
MW-05S	599,802.47	1,272,858.67	4,640.64	59	10/20/14	45.03	4,595.61	Upper Hickey Fm (Hunc)
					07/29/14	47.02	4,593.62	
					06/10/14	46.01	4,594.63	
					10/17/12	42.14	4,598.50	
					05/04/10	39.50	4,601.14	
					04/28/09	41.69	4,598.95	
MW-06D	597,753.68	1,274,715.99	4,760.31	350	10/20/14	210.00	4,550.31	Spud Mountain Series (SMS)
					07/02/14	210.25	4,550.06	
					06/10/14	212.40	4,547.91	
					10/17/12	227.02	4,533.29	
					05/05/10	253.31	4,507.00	
					04/30/09	266.33	4,493.98	
					10/13/08	275.08	4,485.23	
MW-07S	600,757.55	1,273,133.01	4,562.49	34	10/24/14	8.79	4,553.70	Upper Hickey Fm (Hunc)
					07/30/14	11.10	4,551.39	
					06/10/14	6.69	4,555.80	
					10/16/12	7.67	4,554.82	
MW-07D[2]	600,825.89	1,273,133.73	4,561.69	360	10/20/14	22.16	4,539.53	Iron King Volcanics (IKV)
					07/30/14	29.20	4,532.49	
					06/10/14	31.67	4,530.02	
					10/16/12	42.05	4,519.64	
MW-08S	599,852.65	1,273,220.75	4,638.62	33	10/20/14	DRY	DRY	Tailings (MTP)
					07/29/14	31.06	4,607.56	
					06/10/14	33.20	4,605.42	
					10/15/12	31.12	4,607.50	
MW-08D	599,852.87	1,273,221.09	4,638.59	62	10/20/14	37.52	4,601.07	Upper Hickey Fm (Hunc)
					07/29/14	41.42	4,597.17	
					06/10/14	40.39	4,598.20	
					10/15/12	34.90	4,603.69	
MW-9S	598,554.24	1,273,981.44	4,751.91	74	10/20/14	DRY	DRY	Tailings (MTP)
					07/29/14	72.25	4,679.66	
					06/10/14	72.12	4,679.79	
					10/15/12	71.27	4,680.64	
MW-9D	598,555.68	1,273,976.76	4,751.65	180	10/20/14	94.30	4,657.35	Upper Hickey Fm (Hunc)
					07/28/14	94.35	4,657.30	
					06/10/14	93.90	4,657.75	
					10/15/12	92.56	4,659.09	
MW-10S	602,098.37	1,274,184.87	4,530.29	51	10/20/14	20.03	4,510.26	Upper Hickey Fm (Hunc)
					07/29/14	21.27	4,509.02	
MW-10D	602,102.71	1,274,179.37	4,530.11	330	10/20/14	78.91	4,451.20	Iron King Volcanics (IKV)
					07/29/14	96.73	4,433.38	
MW-11S	603,185.16	1,273,525.32	4,566.99	88	10/20/14	76.17	4,490.82	Hickey Basalt (Hbslt)
					07/29/14	75.50	4,491.49	
MW-12S	603,898.57	1,274,665.73	4,511.87	49	10/20/14	20.57	4,491.30	Upper Hickey Fm (Hunc)
					07/30/14	22.31	4,489.56	
MW-12D	603,903.72	1,274,665.98	4,511.83	219	10/20/14	63.50	4,448.33	Hickey Basalt (Hbslt)
					07/30/14	85.92	4,425.91	

MP - measuring point elevation or top-of-PVC (feet above sea level)
TD - total depth below ground surface (feet)
DTW - average depth to water below ground surface (feet)
Scr-Top - top of screen below ground surface
Scr-Bot - bottom of screen below ground surface
Mat'l - material screened

1. Elevation datum NAVD88
2. Alternate log shows a TD of 354 feet and a screen interval of 319 to 349 feet

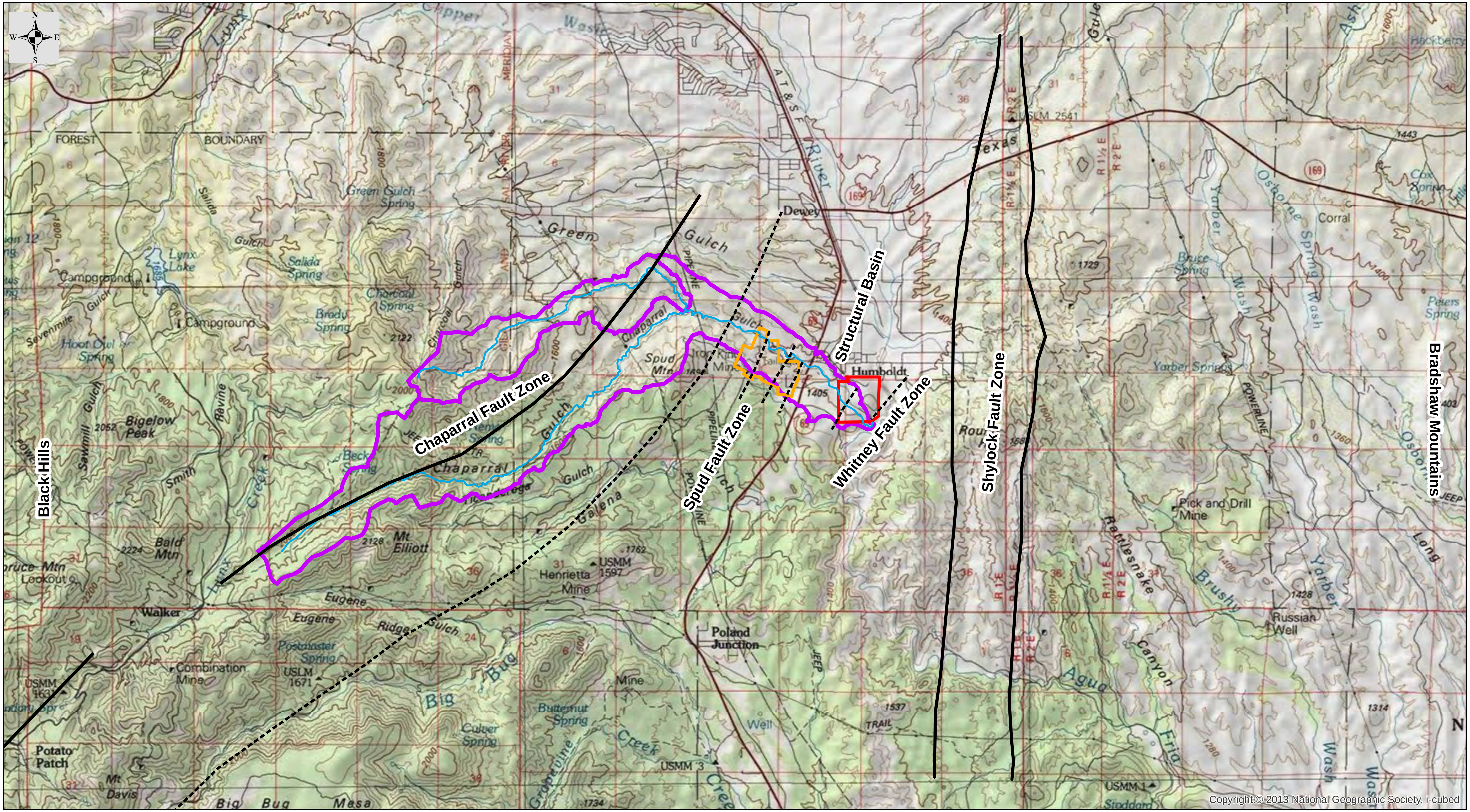
TABLE 5-3
IRON KING MINE SITE
SUMMARY OF VERTICAL HYDRAULIC GRADIENT
DEWEY-HUMBOLDT, ARIZONA
DECEMBER 2014

Well No.	Easting (ft)	Northing (ft)	MP (ft-asl)	TD (ft)	Screen Depth (ft) Top	Screen Depth (ft) Bottom	Date	DTW (ft)	Vertical Gradient (i_v)
MW-02S	603,593.21	1,272,195.36	4,516.84	54	37	52	10/20/14	41.53	---
							07/29/14	43.81	---
MW-02D	603,599.43	1,272,206.03	4,516.31	360	306	356	10/20/14	111.79	**0.245**
							7/30/14[2]	334.17	**1.013**
MW-07S	600,757.55	1,273,133.01	4,562.49	34	14	29	10/24/14	8.79	---
							07/30/14	11.10	---
							06/10/14	6.69	---
MW-07D[1]	600,825.89	1,273,133.73	4,561.69	360	325	355	10/20/14	22.16	**0.042**
							07/30/14	29.20	**0.057**
							06/10/14	31.67	**0.078**
MW-8S	599,852.65	1,273,220.75	4,638.62	33	16	31	10/20/14	**DRY**	---
							7/29/14[3]	31.06	---
							6/10/14[3]	31.05	---
							10/15/12[3]	31.12	---
MW-8D	599,852.87	1,273,221.09	4,638.59	62	45	60	10/20/14	37.52	**DRY**
							07/29/14	41.42	**0.357**
							06/10/14	40.39	**0.322**
							10/15/12	34.90	**0.130**
MW-9S	598,554.24	1,273,981.44	4,751.91	74	52	72	10/20/14	**DRY**	---
							7/29/14[3]	72.25	---
							6/10/14[3]	72.17	---
							10/15/12[3]	71.27	---
MW-9D	598,555.68	1,273,976.76	4,751.65	180	158	178	10/20/14	94.30	**DRY**
							07/28/14	94.35	**0.208**
							06/10/14	93.90	**0.205**
							10/15/12	92.56	**0.201**
MW-10S	602,098.37	1,274,184.87	4,530.29	51	34	49	10/20/14	20.03	---
							07/29/14	21.27	---
MW-10D	602,102.71	1,274,179.37	4,530.11	330	294.5	324.5	10/20/14	78.91	**0.220**
							07/29/14	96.73	**0.282**
MW-12S	603,898.57	1,274,665.73	4,511.87	49	30	45	10/20/14	20.57	---
							07/30/14	22.31	---
MW-12D	603,903.72	1,274,665.98	4,511.83	219	135	175	10/20/14	63.50	**0.365**
							7/30/14[2]	85.92	**0.541**

MP - measuring point elevation or top-of-PVC (feet above mean sea level)
TD - total depth below ground surface (feet)
DTW - average depth to water below ground surface (feet)
Scr-Top - top of screen below ground surface
Scr-Bot - bottom of screen below ground surface

(1) Alternate log shows a TD of 354 feet and a screen interval of 319 to 349 feet (?)
(2) Well still recovering from late-July well development action.
(3) Depth to water is greater than bottom of screen elevation (i.e., water has collected in the 0.3-foot sump, capping the bottom of the well).

FIGURES



Base map created using ESRI USA Topo Maps data, geologic faults data from USGS, watershed created from DEM data.

Map Creation Date: 01 December 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC5_Site Wide MWs\146_SEC5_Site_Location_f5-1

Note:
The upper Agua Fria River watershed overlies the Tertiary Chino-Prescott basin.

Legend

Fault (Precambrian)
Fault (Tertiary)
Chaparral Gulch Subwatershed

Area of Interest
Iron King Mine
Humboldt Smelter

0 6,000 12,000
Feet

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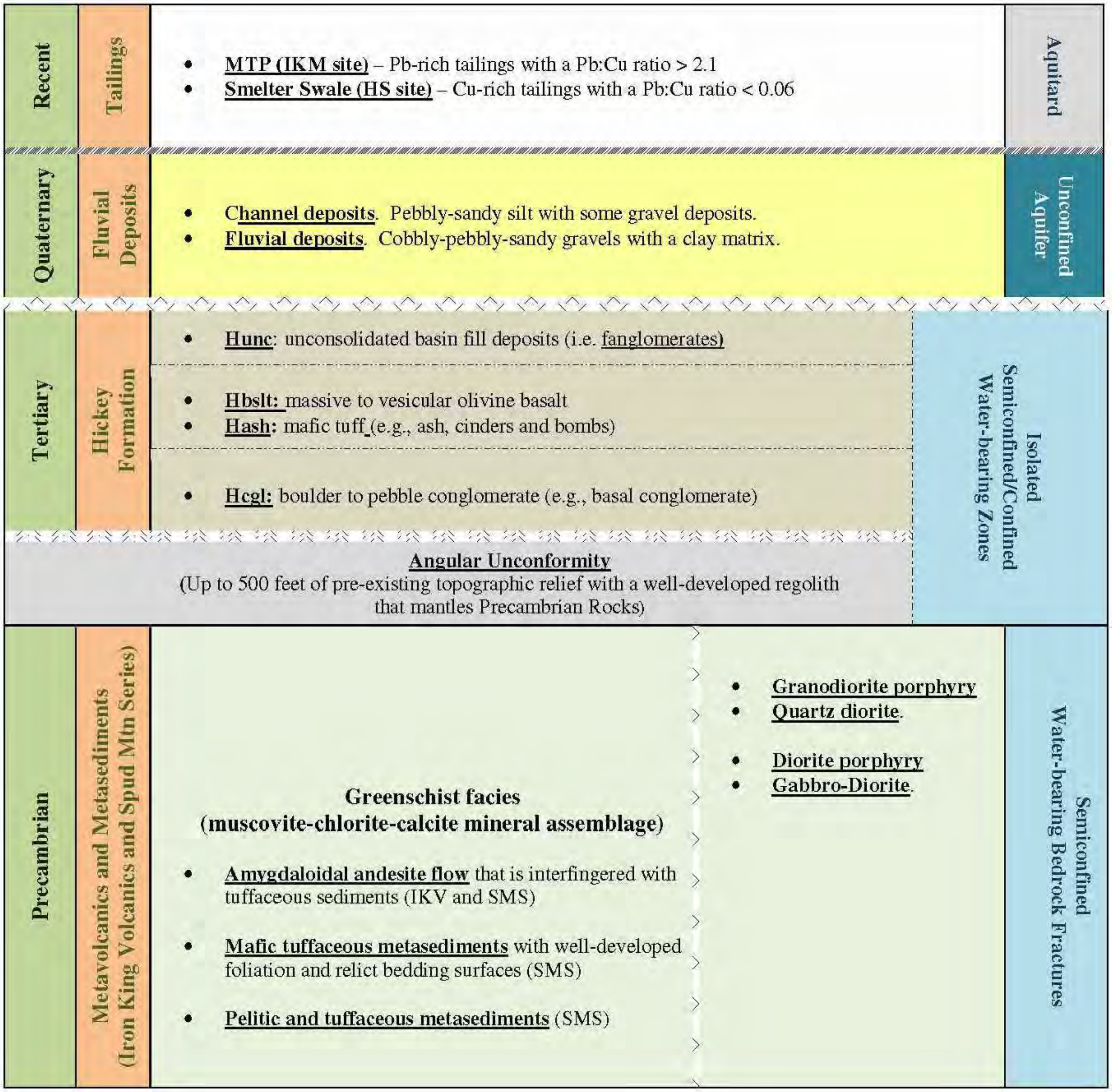
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 5-1
Site Location
Iron King Mine Site
Dewey-Humboldt, Arizona



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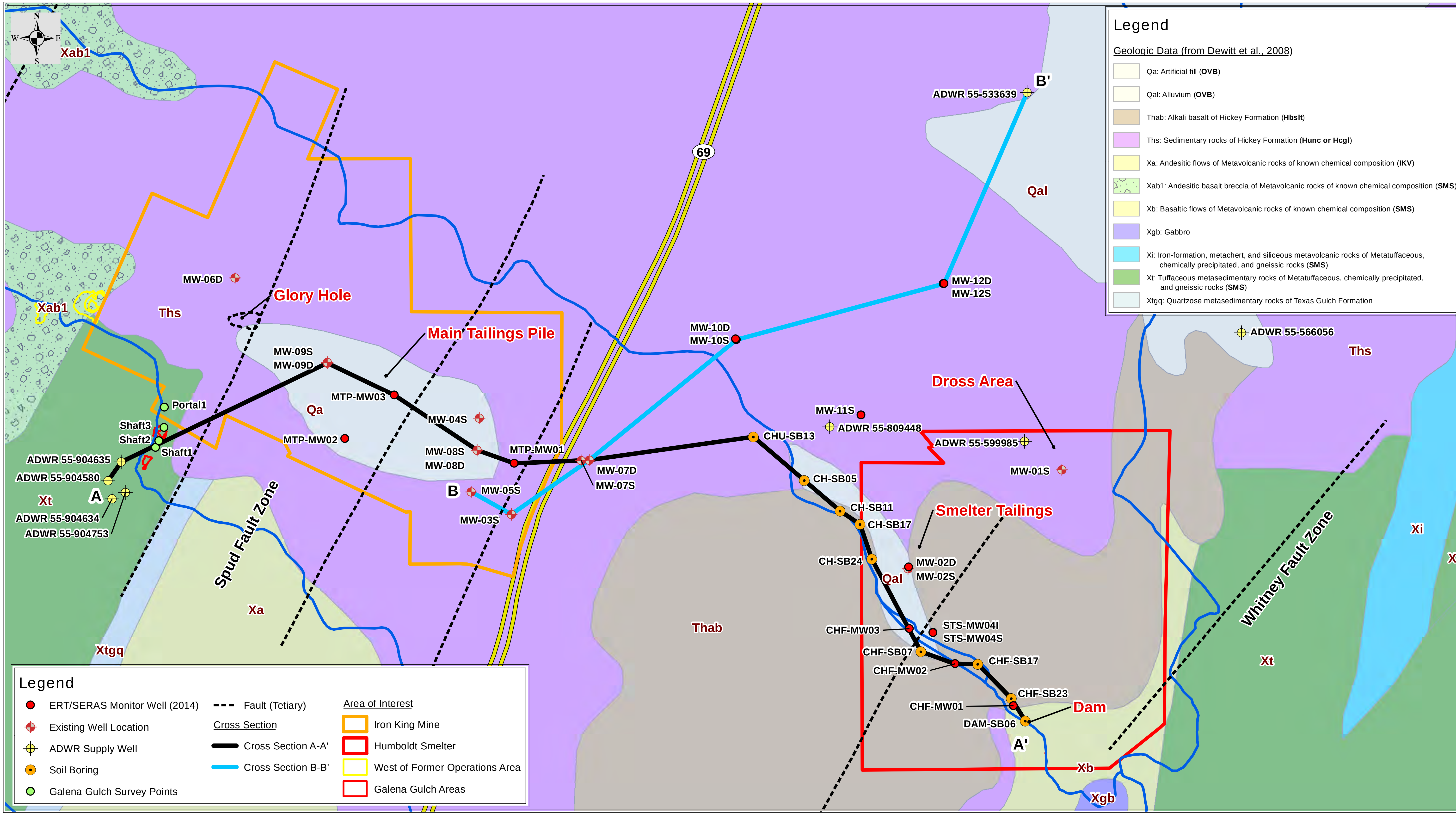
EP-W-09-031
W.A.# 0 - 146

Figure 5-2
Schematic Hydrostratigraphic Section
Iron King Mine Site
Dewey-Humboldt, Arizona

J;/SERAS01 Projects/ACAD_2013/00-146/DEdgerton_Projects/SEC5_146_Schem_Hydro_Section.dwg



Base map created using Geologic Data from USGS, existing well location, ERT/SERAS well location and soil boring location.

Map Creation Date: 01 December 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC5_Site Wide MWs\\146_SEC5_Site_GeologicMap_xsAABB_f5-3

Note: Tertiary faults inferred from boring logs.

Geologic data information:
Geologic Map of Prescott National Forest and the Headwaters of the Verde River, Yavapai and Coconino Counties, Arizona.
2008, DeWitt, Ed; Langenheim, Victoria; Force, Eric; Vance, R.K.; Lindberg, P.A.; Driscoll, R.L.
USGS Scientific Investigations Map: 2996
This 1:100,000-scale digital geologic map details the complex Early Proterozoic metavolcanic and plutonic basement of north-central Arizona

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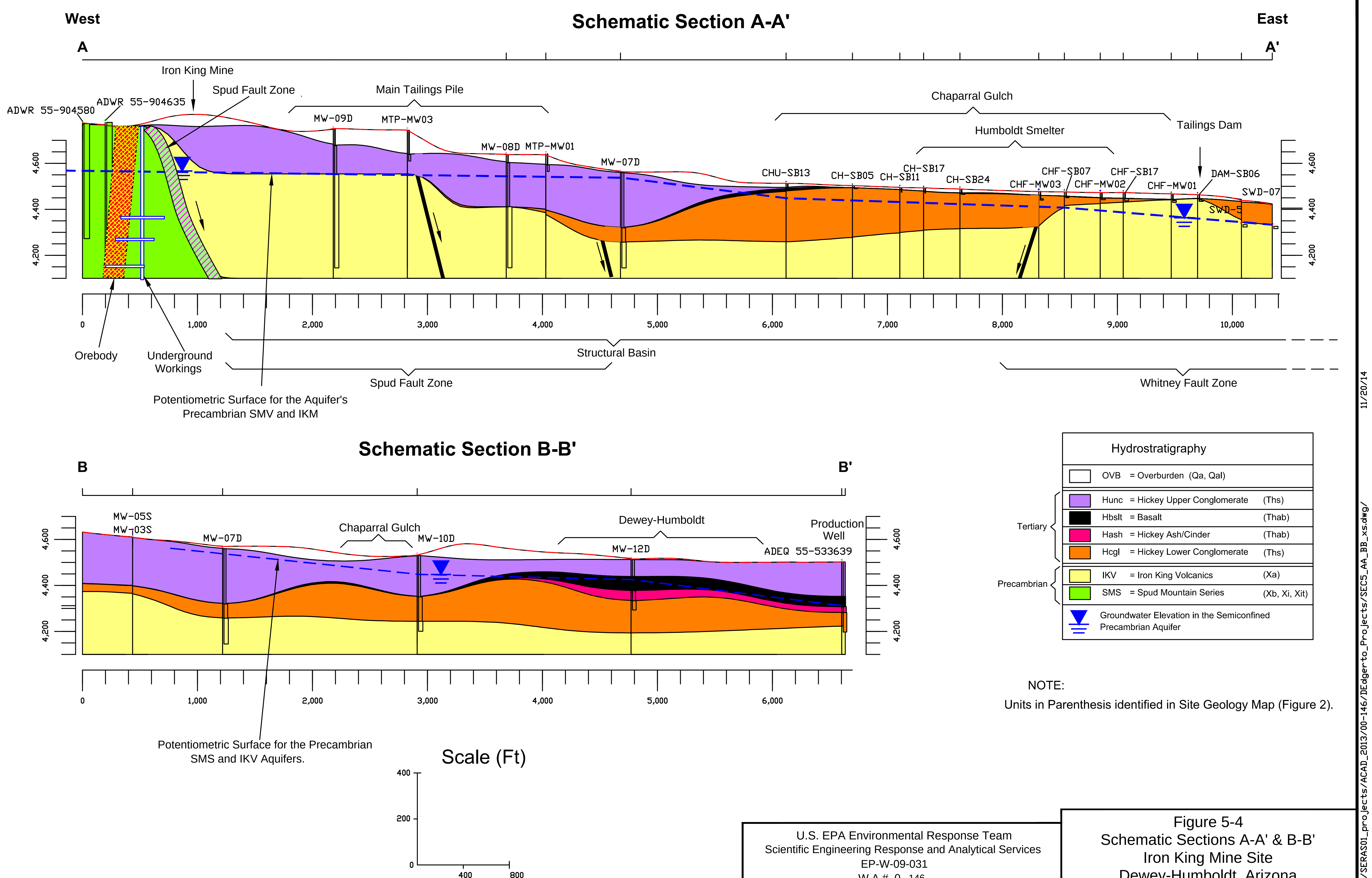
W.A.# 0-146

Figure 5-3
Site Geologic Map
Iron King Mine Site
Dewey-Humboldt, Arizona



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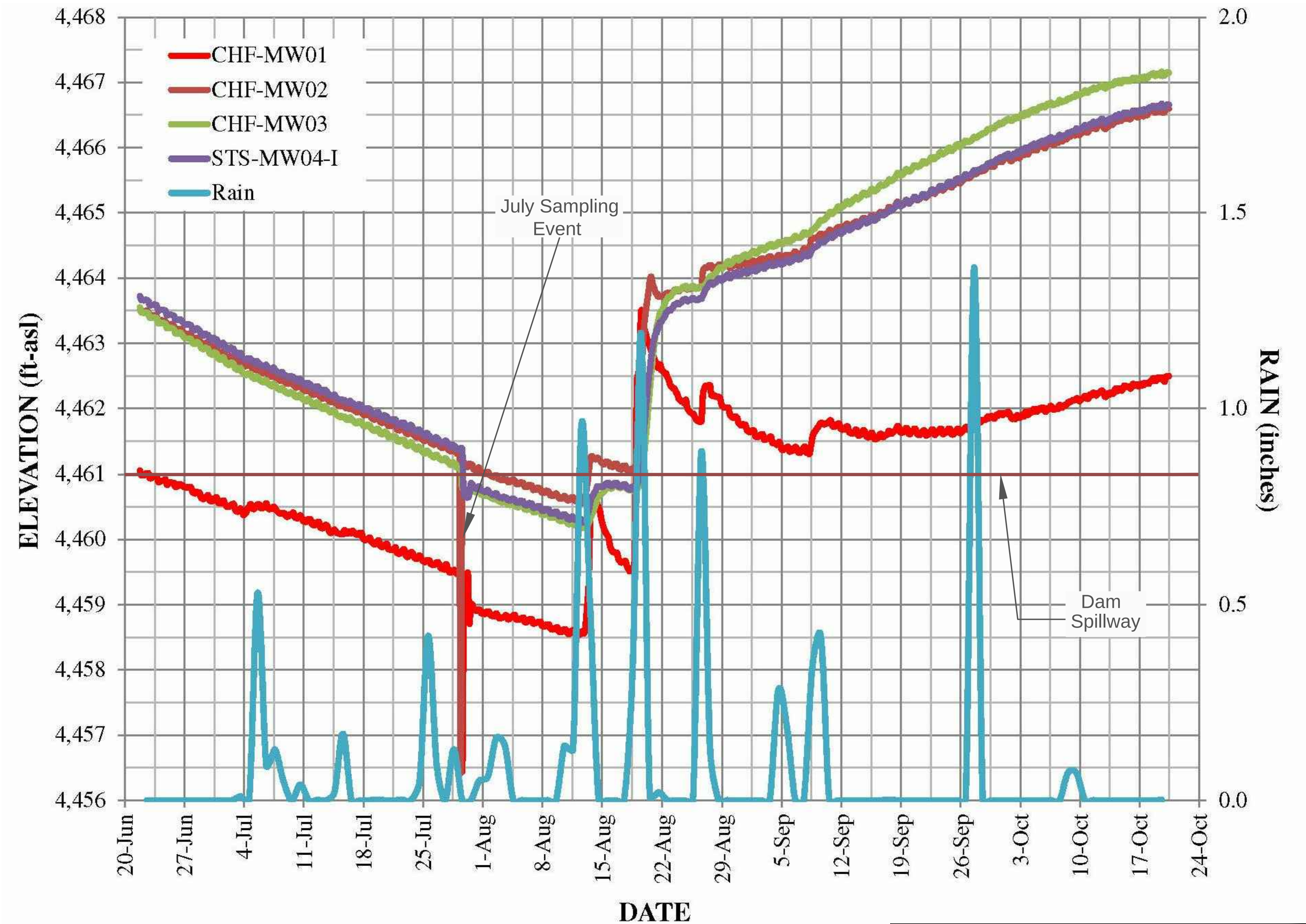
W.A.# 0 -146

Figure 5-4
Schematic Sections A-A' & B-B'
Iron King Mine Site
Dewey-Humboldt, Arizona



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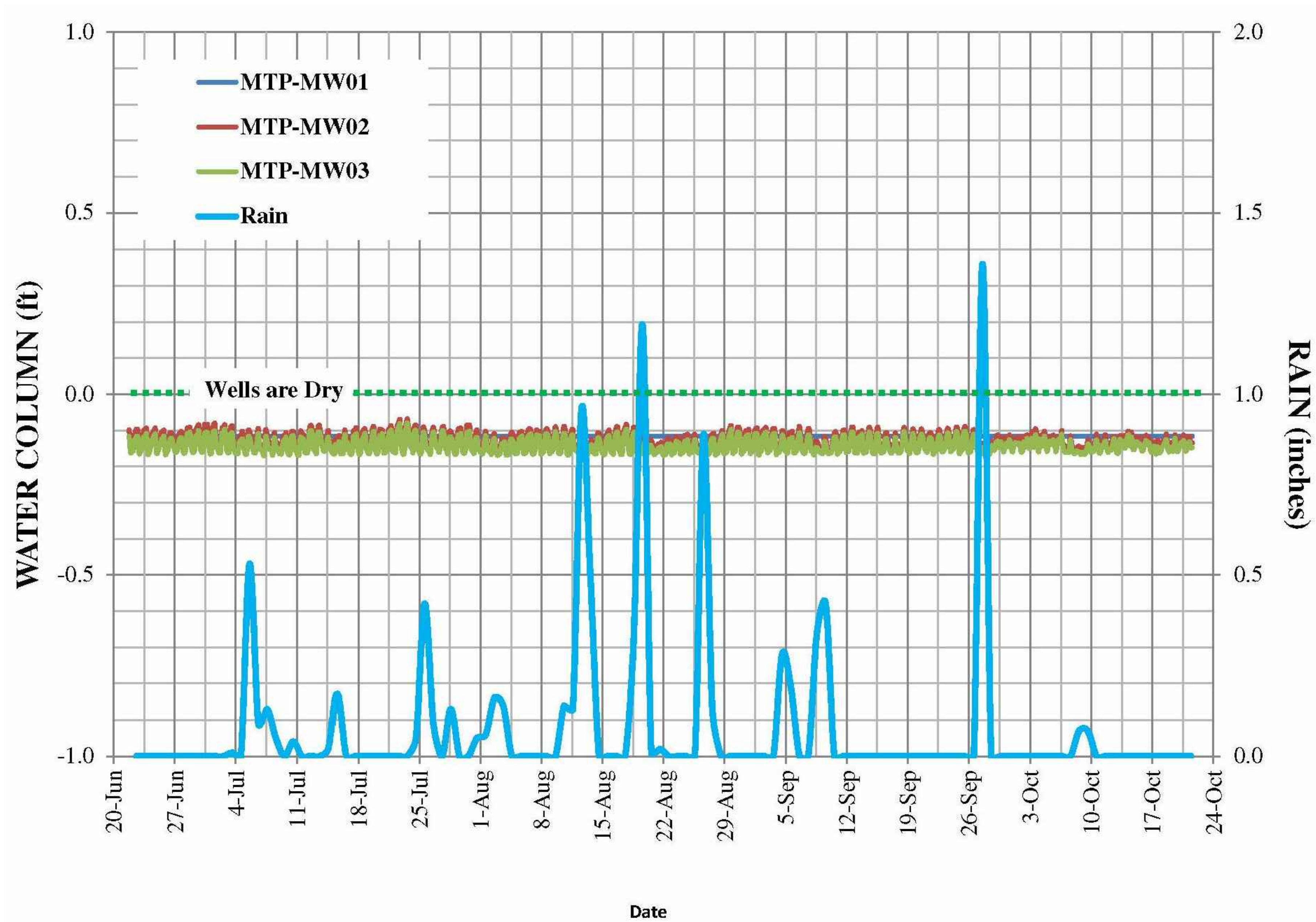
W.A.# 0 -146

Figure 5-5
Chaparral Gulch Flood Plain Hydrographs
Iron King Mine Site
Dewey-Humboldt, Arizona

J:/SERAS01_Projects/ACAD_2013/00-146/DEdgerton_Projects/146_SEC5_Chaparral_Gulch_comp.dwg



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W.A.# 0 - 146

Figure 5-6
Main Tailings Pile Hydrographs
Iron King Mine Site
Dewey-Humboldt, Arizona

J;/SERAS01_Projects/ACAD_2013/00-146/DEdgerton_Projects/SEC5_146_Main_Tailing_Pile_comp.dwg

APPENDIX 5-A

Boring Logs and Construction Records for SERAS Wells

Iron King Mine Site

Dewey-Humboldt, Arizona

APPENDIX 5-B
Important Boring Logs Used in the Schematic Sections
Iron King Mine Site
Dewey-Humboldt, Arizona

SECTION 6 - Geologic Model

6.1 INTRODUCTION

The lower drainage of the Chaparral Gulch Arroyo covers 252 acres from Third Street (Town of Dewey-Humboldt, Arizona) to the confluence of the Agua Fria River and includes the Humboldt Smelter (HS) property (Figure 6-1). The HS, operated from the early 1900s to 1937, processing high grade copper (Cu) ore from the Big Bug Mining District (Lindgren, 1926; Anderson and Creasey, 1958). The smelting operation included the utilization of the Arroyo as an impoundment to store tailings, which required the construction of a dam (i.e., Chaparral Gulch Dam) across the Arroyo, approximately 1,500 feet (ft) upgradient of the Agua Fria River.

The HS property is approximately one mile east of the Iron King Mine (IKM). The most intensive mining operations at the IKM occurred between 1939 and 1968 and focused on a high-grade zinc (Zn) and lead (Pb) orebody. The near proximities of the HS and IKM suggest a relation exists between the two operations; however, this is not the case (ACS, 2008).

A detailed background of the Site history and references for the regional geology can be found in Sections 1, 3, 4 and 5.

6.2 OBJECTIVE

A preliminary conceptual site model (CSM) and three-dimensional (3D) visualization model of the Chaparral Gulch Arroyo was developed to:

- Evaluate the extents of HS tailings by delineating the vertical and horizontal extents, volume and the primary contaminant(s),
- Determine the volume of HS tailings in the flood plain that exceed the soil cleanup thresholds for either Pb (greater than [>] 400 milligrams per kilogram [mg/kg]) or arsenic (As) (> 200 mg/kg),
- Delineate the vertical and horizontal extents and total volume of soil exceeding the soil cleanup thresholds for Pb and/or As, and
- Constrain the hydrostratigraphy by:
    - Separating the major hydrostratigraphic units within the Arroyo,
    - Delineating important water-bearing zones, and
    - Assessing the groundwater flow pattern upgradient of the dam.

6.3 METHODOLOGY

Borehole lithology, x-ray fluorescence (XRF) field results, and borehole water level measurements were incorporated into a 3D model that was used to develop a hydrostratigraphic CSM of the Chaparral Gulch Arroyo. A discussion of the shallow exploratory borehole investigation is presented in Section 1.

6.3.1 Hydrostratigraphy of Chaparral Gulch Arroyo

The basis of the CSM is the hydrostratigraphy of the Chaparral Gulch Arroyo (Figure 6-2). The hydrostratigraphy was developed from the logs of 115 exploratory borings that were completed in or adjacent to the Arroyo. There are four distinct stratigraphic marker units in the Arroyo: HS tailings, Brown Clay, Principle Fluvial Gravels (PFG) and the bedrock contact. Interbedded with the HS tailings are channel deposits consisting of reworked fluvium and tailings. The channel deposits are separated into three distinct units based on their proximity within the Arroyo, stratigraphic superposition, and Pb to Cu ratios (Pb:Cu). These units are the Uppermost Channel Deposit (UCD), Humboldt Smelter Channel Deposit (HSCD) and Lowermost Channel Deposit (LCD).

The proposed hydrostratigraphy of the Chaparral Gulch Arroyo is displayed in Figure 6-2, and summarized from top to bottom (i.e., bedrock) as follows.

Uppermost Channel Deposit (UCD)

The UCD is brown to light brown clayey silt to fine sand with occasional pebbles. The pebbles are subangular to subrounded Precambrian metavolcanics and granitoids with some Hickey Basalt. The unit has dark red iron-oxide laminae dispersed throughout. The Pb:Cu is characteristically > 2.1, suggesting a fraction of the detrital material is derived from reworked IKM tailings. (Note: tailings from the IKM Main Tailings Pile (MTP) are not found as a unique hydrostratigraphic unit in the Chaparral Gulch Arroyo proper.) The UCD has a stratigraphic thickness ranging up to 13 ft.

Humboldt Smelter (HS) Tailings

The HS tailings are comprised of very homogeneous silty clay material, with well-developed layering classified as either laminae (less than [<] 0.02 ft) or beds (up to 2 ft). The HS tailings are exposed on the surface in the HS swale, but subcrop within the Chaparral Gulch 'flood plain'. The stratigraphic thickness of HS tailings ranges up to 23.5 ft and is characterized by Pb:Cu < 0.1.

The HS tailings are further separated into oxidized and reduced zones, with the redox boundary representing the transition from the unsaturated to the saturated zone. Oxidized tailings (unsaturated zone) are composed of iron oxide minerals (e.g., goethite and limonite) and individual layers range from orange to dark red to brown in color. The reduced tailings (saturated zone) are composed predominantly of iron sulfides (e.g., pyrite and marcasite) with individual layers ranging from dark green to gray to black.

Humboldt Smelter Channel Deposit (HSCD)

The HSCD is always interbedded with the HS tailings, found proximal to the HS swale within the Chaparral Gulch flood plain, which 'pinches out' or thins over short distances. The HSCD is mottled dark red to brown and comprised of silt to coarse sand with some pebbles. The pebbles are predominantly subangular to subrounded Precambrian metavolcanics and granitoids. The HSCD has a stratigraphic thickness < 5 ft thick and is characterized by a Pb:Cu < 0.1. The HSCD may coalesce with the LCD situated downgradient of the HS swale.

Lowermost Channel Deposit (LCD)

The LCD occurs only at depth (i.e., below grade) and overlies either the Brown Clay along the margins of the gulch, or the PFG along the bedrock channel. The LCD is mottled, with colors ranging from brown to dark green to dark gray, and consists primarily of pebbly sand with occasional cobbles. The cobbles are subangular to rounded Precambrian metavolcanics and granitoids. The LCD is massive with a stratigraphic thickness ranging up to 8 ft.

Brown Clay (Quaternary)

The Brown Clay crops out in the HS swale, but also found at depth (sub crops) throughout the Arroyo. The Brown Clay is best developed along the margins of the Arroyo. The Brown Clay more commonly overlies bedrock, but was observed overlying thin sections of the PFG. The clay is dark brown with very weakly developed laminae. The Brown Clay has a stratigraphic thickness ranging up to 8 ft.

Principle Fluvial Gravel (Quaternary)

The PFG is found at depth within the bedrock channel. The PFG is mottled brown to dark green and is comprised of poorly sorted clayey-silty gravels with some pebbles and cobbles. The pebbles and cobbles are rounded Precambrian metavolcanics and granitiods. Pebbles are imbricated and the deposit is water-bearing from Third Street to the tailings dam. The PFG has a stratigraphic thickness ranging up to 14 ft (i.e., at CHU-SB06).

6.3.2 XRF Results and Metal Ratios

Analytical results for the shallow borings are discussed in Section 1, but important to the development of the CSM are XRF results for As, Pb and Cu and the resulting Pb:Cu for each sample location. A total of 509 samples were collected from the 115 borings (Table 6-1; Figure 6-1). Data were processed to assess contaminated and non-contaminated deposits by normalizing ratios of As_n and/or Pb_n concentrations to their respective soil cleanup threshold. Normalized ratios greater than one (either As_n or Pb_n >1) indicate the presence of contaminated deposits. The larger ratio of the two (for any given sample) was then used to map the horizontal extent of contaminated deposits throughout the gulch by plotting and contouring the data on site aerial imagery at 5-foot depth intervals (ranging from 0 to 15 ft below grade).

The Pb:Cu for contaminated deposits (As_n or Pb_n >1) was evaluated to assess the potential source of contamination. The Pb:Cu for ore from IKM ranges from 2.1 to 3.8 (Anderson and Creasey, 1958), but increases up to 450 in the MTP due to the milling process (refer to Section 4, borings MTP-SB01 through MTP-SB03). The HS was designed to process Cu ore from the Big Bug Mining District (BBMD), which has a Pb:Cu ranging from 0.01 to 0.06 (Lindgren, 1926). Analytical results for HS tailings collected from the swale had a Pb:Cu < 1.0, suggesting the smelting process was more efficient at extracting Cu than Pb from the BBMD ore.

6.3.3 Depth to Groundwater

Upon drilling completion, each borehole was left open for up to 12 hours to allow the groundwater level to stabilize before a depth-to-water (DTW) measurement was collected (Table 6-2). The DTW measurements were used to develop a schematic groundwater elevation contour map.

6.3.4 Development of the 3D Visualization Model

The 3D modeling software, Rockworks16™, was used to construct a *solid-body* model of the hydrogeology and extent of contaminated deposits within the Chaparral Gulch Arroyo. The hydrostratigraphy was semi-quantified from the 115 borehole logs and the extent of contamination was defined from XRF results for As and/or Pb from the 509 borehole samples (Table 6-1; Figure 6-1). The details of the modeling method and the approach used for the hydrostratigraphic superposition and volume estimates are attached in Appendix 6-A.

6.3.5 Survey of the Tailings Swale Area

Granite Basin Engineering, Inc. (Prescott, Arizona) surveyed the extent of HS tailings in the swale area, south of the smelter stack (Figure 6-1). (Refer to Section 14, Survey Report.) The top surfaces of both the HS tailings and Quaternary Brown Clay unit (Figure 6-2) were surveyed as an independent method to determine the volume of HS tailings (upslope or upgradient of a breached tailings berm) within the highly eroded and gullied swale area (Figure 6-1). The results of the survey indicated that approximately 13,000 cubic yards (yd^3) of tailings are currently present in the swale (above the berm).

An independent volume assessment of the HS tailings was completed using Granite Basin's survey data and the Rockworks16 modeling software. The assessment provided slightly higher (or more conservative) results, with a volume estimate of approximately 14,090 yd^3. The results of this independent assessment were implemented into the 3D model and presented as part of the HS tailings assessment. The methodology of the volume estimate is provided in Appendix 6-B.

6.4. RESULTS AND DISCUSSION

6.4.1 Volume Estimates

A 3D model of the Chaparral Gulch Arroyo was developed for a preliminary assessment of environmental changes (e.g., increased sedimentation and depositional contamination) to the Arroyo from Site predevelopment (prior to smelting and mining activities) to the present. Assuming the top of the Quaternary deposits (PFG or Brown Clay) represents the 'pristine' Arroyo, all overlying channel fill deposits can be attributed to either smelting (HS tailings, HSCD and LCD) and/or mining (UCD) activities. The modeling results suggest:

- 349,150 yd^3 of channel deposits (UCD, HS Tailings, HSCD and LCD) have filled the Arroyo after smelting and mining activities began.
- The volume of HS tailings is estimated to be 187,380 yd^3, where approximately 68 percent (%) are oxidized (unsaturated zone) and 32% reduced (saturated zone).
- The volume of channel fill that exceeds the soil cleanup threshold for either Pb and/or As is estimated to be 280,610 yd^3, with 97% of the contaminated deposits located between ground surface and 10 ft in depth.
- Based on observed depths to the top of the PFG, channel fill deposits have changed (or lowered) the hydraulic gradient from an estimated 0.028 foot per foot (ft/ft) to the existing 0.012 ft/ft (average) in the flood plain area.
- The change in the hydraulic gradient has produced a groundwater mound behind the tailings dam.

6.4.2 Hydrostratigraphic Sections

Two schematic sections (A-A' and B-B') were constructed along the axis of the Chaparral Gulch Arroyo (Figure 6-1). The schematic sections include all boreholes within 25 ft of the projected section lines. In addition, eight 1,000-foot profile sections, spaced 400 ft apart, were constructed across the Arroyo (Figure 6-1). Each profile includes boreholes within 50 ft of the projected cross-lines.

The schematic and profile sections provide insight into the evolution of the Arroyo during the Quaternary (i.e., predevelopment) and development period (i.e., 1900 to the present). For simplicity, only the development period involving smelting and mining activities are discussed in relation to the deposition of the UCD, HS tailings, HSCD and LCD.

Schematic Sections A-A' and B-B'

Sections A-A' and B-B' are shown in Figure 6-3 and discussed in unison. Section A-A' extends 3,700 ft from Third Street (CHU-SB07) to the tailings dam (DAM-SB03). Section B-B' extends 2,300 ft from the upper reach of the HS swale (STS-SB01) to the tailings dam (DAM-SB06).

The UCD is thickest (13 ft) downgradient of Third Street, but thins to about 5 ft before reaching the HS swale (Section A-A'). Downgradient of the HS swale, the UCD occurs in the flood plain as a surface veneer that is locally discontinuous. The thinning of the UCD (at CH-SB30), upgradient of the HS swale, is coincident with the appearance of the HS tailings (CH-SB31), which appears to have encroached upgradient of the swale, into the Arroyo (Section A-A'). The progradation of the HS tailings pile eventually filled the Arroyo (Sections A-A' and B-B') within the flood plain area.

In the flood plain, the combined thickness of the HS tailings, HSCD and LCD increases from 2 to 25 ft from the swale to the tailings dam (Sections A-A' and B-B'). The thickness of the oxidized HS tailings decreases from 10 to 3 ft downgradient of the swale, but the thickness of the reduced HS tailings increases to approximately 15 ft. The increased thickness of the reduced HS tailings coincides with a shallowing of the water table toward the dam. The HSCD is locally important near the HS swale, but pinches out over a short distance from the swale. This suggests the HSCD represents either a temporary cessation of smelting activities, which allowed the HS tailings to be redistributed into the Arroyo, or the expansion of the HS tailings pile as it prograded into the Arroyo. The relative abundance and continuous nature of the LCD from the swale to the tailings dam suggests that management of the HS tailings was not a concern during the early stages of smelter operations, and that HS tailings were readily redistributed within the flood plain.

Profile Sections C-C' through F-F'

Profile Sections C-C' through FF' in the upper Chaparral Gulch Arroyo are displayed in Figure 6-4a and discussed in unison. Profile C-C' shows the UCD is absent in the Arroyo but present in a side gully, suggesting that IKM tailings (from the 1964 MTP slope failure) may have flowed through that gully (Figure 6-1). Profiles C-C' through F-F' show the thickness of the UCD ranges from up to 13 ft, reaching the maximum thickness around 950 ft downgradient of Third Street before thinning to around 5 ft at the HS swale (approximately 1,450 ft downgradient of Third Street).

Profile Sections G-G' through J-J'

Profile Sections G-G' through J-J' in the Chaparral Gulch flood plain are displayed in Figure 6-4b and discussed in unison. Profile G-G' shows the complex relationship among the channel fill deposits. A thin veneer of HS tailings in the upper reaches of the swale depicts a relict tailings stockpile. Downslope, the HS tailings pile progrades from the swale, over the LCD and into the flood plain, in a process similar to the building of alluvial fans or a shallow water deltaic system. The LCD overlies the PFG in the main channel of the flood plain, and increases in thickness downgradient of the HS swale.

Profiles G-G' through J-J' show the thickness of the HS tailings increasing downgradient of the swale, but the rate of thickening appears to depend on the narrowing of the gulch. Profiles H-H' and I-I' show a relatively constant tailings thickness of 13 ft (CHF-SB35 and CHF-SB36), which increases to 23.5 ft where the channel width is narrowest (Profile J-J').

6.4.3 Humboldt Smelter Tailings

An isopach model of the HS tailings was developed using borehole logs and survey data (provided by Granite Basin Engineering). The solid-body volume estimate of HS tailings in the swale and Chaparral Gulch flood plain was determined to be approximately 187,380 yd^3, which is distributed as follows (Figure 6-5):

- 14,090 yd^3 of oxidized tailings reside in the HS swale,
- 113,985 yd^3 of oxidized tailings reside in the flood plain (unsaturated zone), and
- 59,305 yd^3 of reduced tailings reside in the flood plain (saturated zone).

The fraction of tailings that exceed the soil cleanup threshold for either Pb or As was defined by XRF sample results. Each borehole sample concentration was normalized (Pb_n and As_n) to their respective soil cleanup concentration, with the higher of the two ratios tabulated (Table 6-1). Results suggest that 61% (114,390 yd^3) of the HS tailings that are distributed throughout the study area exceed the soil cleanup threshold (i.e., for either Pb or As).

6.4.4 Contaminated Channel Fill Deposits

A solid-body estimate of the total volume of contaminated channel fill (LCD, HS tailings, HSCD and LCD) was performed for the Chaparral Gulch Arroyo. Contaminated deposits were defined by normalized Pb_n or As_n that exceeded the soil cleanup threshold (Table 6-1, explained above). Normalized ratios greater than one (either As_n or Pb_n >1) indicate the presence of contaminated deposits. The larger ratio of the two (for any given sample) was then used to illustrate the horizontal extent of contaminated deposits throughout the gulch by plotting and contouring the data on site aerial imagery at 5-foot depth intervals, ranging from 0 to 15 ft below grade (Figures 6-6a through 6-6c).

Based on the model, the volume of contaminated deposits in the Chaparral Gulch Arroyo and HS swale was estimated to be approximately 280,610 cu. yds. The model shows the vast majority of contaminated deposits occur at depths less than 15 ft below grade. In addition, the 114,390 yd^3 of HS tailings (from above) represents only 41% of the total volume of contaminated deposits, suggesting the UCD accounts for the remaining volume. Over depth, the volume of contaminated deposits is distributed as follows:

- 0 to 5 ft below grade: 179,560 yd^3. (Figure 6-6a)
- 5 to 10 ft below grade: 91,650 yd^3. (Figure 6-6b)
- 10 to 15 ft below grade: 9,400 yd^3. (Figure 6-6c)
- 99% of the contaminated volume resides between ground surface and 10 ft in depth.

6.4.5 Origin of Contamination

An evaluation of contaminant "sources" was performed using the following assumptions:

- Both Pb and Cu minerals are assumed to be inert (i.e., insoluble),
- Pb:Cu > 2.1 represents IKM tailings,
- Pb:Cu > 1.0 and < 2.1 represents mixed IKM and HS tailings, and
- Pb:Cu < 0.1 represents HS tailings.

General Pb:Cu Trends

A review of Pb to Cu ratios for contaminated deposits suggest two general trends: 1) Pb and As are the driving contaminants associated with IKM tailings, and 2) As is the driving contaminant associated with HS tailings (Table 6-1). Contaminated deposits associated with mixed IKM and HS tailings are driven by Pb and/or As contaminants, but are also characterized by elevated Cu concentrations.

Contamination in the UCD is driven by 1) As plus or minus (±) Pb concentrations that exceed the soil cleanup threshold, and 2) Pb:Cu > 2.1. This trend is very consistent upgradient of the HS swale where contaminated deposits were identified at depths down to 13 ft (CH-SB17). Downgradient of the HS swale, the trend is still relatively consistent, but the Pb:Cu are occasionally < 2.0. The decreasing Pb:Cu ratio suggests the UCD 'reworked' shallow deposits of the Cu-rich HS tailings and then redistributed the material into the flood plain.

The HS tailings are visually distinguishable from the overlying UCD. A significant volume (39%) of the HS tailings does not exceed the soil cleanup threshold but in general, this portion of the HS tailings is either exposed in the HS swale (STS-SB01 through STS-SB08) or at depths greater than 15 ft below grade. Only HS tailings at depths shallower than 15 ft below grade are found to 'potentially' exceed the soil cleanup threshold. HS tailings at depths greater than 10 ft below grade are driven by As contamination and a Pb:Cu < 0.6 (STS-SB01 through STS-SB15/15B), suggesting shallow HS tailings are reworked and deeper HS tailings in the flood plain are 'undisturbed'. The undisturbed HS tailings may represent the 'floor' of the former tailings pond at the cessation of smelting activities.

Reworked HS tailings at depths shallower than 10 ft below grade are more complex, with Pb:Cu ranging from 0.05 to 13 (CHF-SB21, CHF-SB31, DAM-SB03 and DAM-SB06). The wide range of Pb to Cu ratios in the reworked HS tailings suggest that IKM tailings (from the MTP) may have flowed through the flood plain, remobilizing, reworking and redepositing HS tailings further downstream, in proximity to the dam. Assuming the Pb to Cu ratios represent the origin of the tailings, up to 15 ft of 'freeboard' may have existed between the floor of the tailings pond and the dam spillway at the cessation of smelting activities in 1937. The 15 ft of freeboard was eventually filled with reworked HS tailings that are characterized by Pb:Cu > 1.0, Pb and/or As that exceed the soil cleanup threshold, and elevated Cu concentrations.

6.4.6 Groundwater Depths and Elevations

DTW measurements in boreholes are listed in Table 6-2. The contoured data are illustrated in Figure 6-7, and shows the DTW decreases from 20 to 12 ft below grade from Third Street to the HS swale (over a distance of approximately 2,300 ft) then abruptly decreases from 12 to 2 ft from the HS swale to before the tailings dam (a distance of approximately 1,000 ft). Water levels become slightly deeper near the tailings dam (4 to 6 ft below grade), suggesting groundwater leakage beneath the structure.

Groundwater elevations were additionally derived using the DTW measurements and borehole elevations (Table 6-2). The contoured data (Figure 6-8) show a moderately gentle hydraulic gradient (0.016 ft/ft) from Third Street to the HS swale. However, between the HS swale and dam, a series of groundwater mounds occur. Closer to the dam, the hydraulic gradient steepens rapidly, suggesting that groundwater is leaking beneath the structure.

6.5 CONCEPTUAL SITE MODEL OF THE CHAPARRAL GULCH ARROYO

The hydrostratigraphy of Chaparral Gulch Arroyo is summarized in Figure 6-2 and a CSM of the hydrogeologic development of the gulch is summarized below:

6.5.1 Quaternary Geology

- The topography of the Site and surrounding areas prior to Basin and Range uplift (Early Tertiary) was characterized by moderate relief (up to 500 ft) and a very well developed regolith that mantled the Precambrian Iron King Volcanics (IKV).
- The Basin and Range event began in the Middle Tertiary with gentle uplift and warping, as characterized by the deposition of the basal Hickey Conglomerate over the Precambrian IKV.
- Increased tectonism during the middle Tertiary (Miocene) resulted in emergent faulting (uplift) and volcanism, as characterized by interbedded Hickey conglomerate and volcanics (mafic ash, cinder and flows).
- Development of fluvial systems during the Late Miocene was dynamic and changing, as drainage systems constantly responded to volcanic eruptions, episodic uplift and increased erosion.
- The Basin and Range event ended (in the Pliocene) and the Chaparral Gulch drainage system developed. The PFG was deposited in a bedrock channel that down-cut through the basal Hickey Conglomerate, across an unconformity and into the IKV in the Chaparral Gulch flood plain.

6.5.2 Recent Geology

- Full-scale smelting activities began at the HS property in 1904, with construction of the tailings dam (i.e., Chaparral Gulch Dam) and stockpiling of Cu-rich tailings (Pb:Cu < 0.1) in the Arroyo flood plain. Channel fill deposits (HSCD and LCD) were also introduced into the flood plain at this time.
- Smelting activities ceased around 1937, with an estimated 187,380 cu. yds. of HS tailings occupying the swale and flood plain area. However, based solely on Pb to Cu ratios from borehole samples, as much as 15 ft of freeboard between the floor of the tailings pond and dam spillway may have existed at the cessation of smelting activities.
- Full-scale mining commenced at the IKM around 1939. Poor management of IKM tailings was probably ongoing from the beginning of mining operations, but reached an apex in 1964 when a slope failure along the main face of the MTP. The slope failure resulted in the release of Pb-rich tailings (Pb:Cu > 2.1) slurry into the headwaters of Chaparral Gulch that over time, mixed with channel deposits (UCD) along the Arroyo, extending up to and probably beyond the dam.

- Primary mining activities ceased at the IKM in 1968; areas of the site (including the MTP) remained as *sources* or *potential sources* of contamination.
- Over time (beyond 1937), a mixture of fluvium and tailings (from both the IKM and HS) continued to fill in the flood plain area until reaching the top elevation of the dam spillway.

6.6 REFERENCES

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TABLES

TABLE 6-1

Summary of XRF Results

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
UPPER CHAPARRAL GULCH ARROYO	CHU-SB01	0	160	242	100	0.80	2.4	UCD
	CHU-SB02	0	135	180	72	0.68	2.5	UCD
		3	775	374	70	3.88	5.3	UCD
		4	35	29	97	0.18	0.3	Brown Clay
		9	29	32	120	0.15	0.3	PFG
		13.5	20	36	417	0.10	0.1	PFG
	CHU-SB03	0	76	92	31	0.38	3.0	UCD
		2.5	30	35	86	0.15	0.4	UCD
		5	27	22	205	0.14	0.1	Brown Clay
		8	25	29	173	0.13	0.2	Brown Clay
		9	16	27	170	0.08	0.2	Hickey Cgl
		13	11	22	57	0.06	0.4	Hickey Cgl
	CHU-SB04	0	254	458	69	1.27	6.6	UCD
		5	484	40	59	2.42	0.7	Brown Clay
		9	13	28	457	0.07	0.1	Brown Clay
		11.5	12	35	63	0.09	0.6	Hickey Cgl
	CHU-SB05	0	85	94	47	0.43	2.0	UCD
		4	171	160	50	0.86	3.2	UCD
		9	16	34	31	0.09	1.1	PFG
		13.5	16	36	55	0.09	0.7	Hickey Cgl
	CHU-SB06	0	109	130	44	0.55	3.0	UCD
		5	18	25	40	0.09	0.6	Brown Clay
		9.5	14	30	56	0.08	0.5	Brown Clay
		14	15	30	52	0.08	0.6	PFG
		18	15	27	37	0.08	0.7	PFG
	CHU-SB07	0	332	622	93	1.66	6.7	UCD
		5	15	29	51	0.08	0.6	Brown Clay
		9	12	29	41	0.07	0.7	Brown Clay
		14	11	28	18	0.07	1.6	PFG
		17	17	26	43	0.09	0.6	PFG
	CHU-SB08	0	27	86	65	0.22	1.3	UCD
		5	22	26	39	0.11	0.7	Brown Clay
		10	22	28	22	0.11	1.3	Brown Clay
		15	23	16	24	0.12	0.7	PFG
		17.5	15	29	36	0.08	0.8	PFG
		19	12	30	40	0.08	0.8	PFG
	CHU-SB09	0	63	373	102	0.93	3.7	UCD
		5	12	28	51	0.07	0.5	Brown Clay
		10	24	22	46	0.12	0.5	PFG
		15	12	28	36	0.07	0.8	Hickey Cgl

TABLE 6-1
Summary of XRF Results
Chaparral Gulch Arroyo
Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
UPPER CHAPARRAL GULCH ARROYO	CHU-SB10	0	152	192	69	0.76	2.8	UCD
		5	14	27	42	0.07	0.6	Brown Clay
		8.5	18	27	45	0.09	0.6	Brown Clay
		15	16	20	38	0.08	0.5	Brown Clay
		20	20	28	52	0.10	0.5	PFG
	CHU-SB11	0	392	694	79	1.96	8.8	UCD
		5	19	37	26	0.10	1.4	PFG
		8	18	35	41	0.09	0.9	PFG
		10	33	23	47	0.17	0.5	PFG
		14	19	28	42	0.10	0.7	PFG
	CHU-SB12	0	185	205	61	0.93	3.4	UCD
		5	203	316	61	1.02	5.2	PFG
		10	16	24	20	0.08	1.2	PFG
		14.5	17	31	47	0.09	0.7	PFG
	CHU-SB13	0	181	189	50	0.91	3.8	UCD
		2.5	35	82	55	0.21	1.5	UCD
		5	15	24	45	0.08	0.5	Brown Clay
		10	15	23	35	0.08	0.7	PFG
		15	30	43	46	0.15	0.9	PFG
	CHU-SB14	0	54	271	188	0.68	1.4	UCD
		3.5	24	58	46	0.15	1.3	PFG
		5	18	31	37	0.09	0.8	PFG
		10	13	28	34	0.07	0.8	PFG
	CHU-SB15	0	158	300	93	0.79	3.2	UCD
		2	15	28	43	0.08	0.7	Hickey Cgl
CHAPARRAL GULCH (3RD STREET TO HS SWALE)	CH-SB01	0	468	458	95	2.34	4.8	UCD
		4	3,050	3,180	233	15.25	13.6	UCD
		6	36	31	102	0.18	0.3	UCD
		7.5	17	22	189	0.09	0.1	UCD
		8.5	1,400	1,550	143	7.00	10.8	UCD
		10	28	21	140	0.14	0.2	PFG
		12	447	356	109	2.24	3.3	PFG
		13	25	28	193	0.13	0.1	PFG
	CH-SB02	0	142	217	58	0.71	3.7	UCD
		4	447	854	115	2.24	7.4	UCD
		4.5	65	133	56	0.33	2.4	PFG
	CH-SB03	0	125	236	78	0.63	3.0	UCD
		4.5	1,340	784	92	6.70	8.5	UCD
		6	841	60	56	4.21	1.1	UCD
		8	135	32	76	0.68	0.4	PFG
		11	18	22	44	0.09	0.5	PFG

TABLE 6-1

Summary of XRF Results

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
CHAPARRAL GULCH (3RD STREET TO HS SWALE)	CH-SB04	0	165	234	58	0.83	4.0	UCD
		4	1,520	877	102	7.60	8.6	UCD
		6	246	249	225	1.23	1.1	UCD
		8	17	27	864	0.09	0.0	UCD
	CH-SB05	0	117	160	64	0.59	2.5	UCD
		4	159	221	38	0.80	5.8	UCD
		10	11	27	68	0.07	0.4	Hickey Cgl
	CH-SB06	0	52	112	66	0.28	1.7	UCD
	CH-SB07	0	172	212	47	0.86	4.5	UCD
		6	459	194	64	2.30	3.0	UCD
		7	22	40	130	0.11	0.3	Hickey Cgl
	CH-SB08	0	183	264	67	0.92	3.9	UCD
		5	40	75	58	0.20	1.3	PFG
	CH-SB09	0	134	199	62	0.67	3.2	UCD
		5	13	38	58	0.10	0.7	PFG
		8.5	55	110	68	0.28	1.6	PFG
	CH-SB10	0	131	201	90	0.66	2.2	UCD
		4	11	31	38	0.08	0.8	UCD
	CH-SB11	0	273	407	71	1.37	5.7	UCD
		5	75	78	42	0.38	1.9	UCD
		7	3,030	4,850	174	15.15	27.9	LCD
		11	403	243	73	2.02	3.3	LCD
		12	91	47	300	0.46	0.2	LCD
	CH-SB12	0	151	225	69	0.76	3.3	UCD
		5	208	166	83	1.04	2.0	UCD
		7	708	2,070	130	5.18	15.9	UCD
		10	22	24	280	0.11	0.1	LCD
		11	189	295	89	0.95	3.3	LCD
	CH-SB13	0	101	135	58	0.51	2.3	UCD
		5.5	26	64	188	0.16	0.3	UCD
		10.5	16	26	50	0.08	0.5	PFG
	CH-SB14/14B	0	20	56	108	0.14	0.5	UCD
		0	163	383	211	0.96	1.8	UCD
		4	22	30	49	0.11	0.6	UCD
	CH-SB15	0	45	113	319	0.28	0.4	UCD
		4	11	26	49	0.07	0.5	UCD
	CH-SB16	0	170	230	42	0.85	5.5	UCD
		4.5	150	102	45	0.75	2.3	UCD
		10	36	78	336	0.20	0.2	UCD

TABLE 6-1

Summary of XRF Results

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
CHAPARRAL GULCH (3RD STREET TO HUMBOLDT SMELTER SWALE)	CH-SB17	0	223	287	66	1.12	4.3	UCD
		4.5	71	71	33	0.36	2.2	UCD
		8.5	1,970	1,920	101	9.85	19.0	UCD
		10	162	213	73	0.81	2.9	UCD
		13	653	147	81	3.27	1.8	UCD
		15	20	38	902	0.10	0.0	UCD
	CH-SB18	0	117	121	43	0.59	2.8	UCD
		5	20	28	42	0.10	0.7	UCD
		10	16	23	39	0.08	0.6	PFG
		16	35	31	239	0.18	0.1	PFG
	CH-SB19	0	360	621	87	1.80	7.1	UCD
		5	24	27	73	0.12	0.4	Brown Clay
		9	15	31	48	0.08	0.6	Brown Clay
	CH-SB20	0	163	228	44	0.82	5.2	UCD
		5	81	102	39	0.41	2.6	UCD
		8.5	790	217	43	3.95	5.0	UCD
		11	99	145	65	0.50	2.2	UCD
	CH-SB21	0	382	618	74	1.91	8.4	UCD
		2.5	82	113	45	0.41	2.5	UCD
		5	34	47	86	0.17	0.5	Brown Clay
		7.5	15	29	33	0.08	0.9	PFG
	CH-SB22	0	273	599	234	1.50	2.6	UCD
		5	24	38	102	0.12	0.4	Brown Clay
	CH-SB23	0	214	311	70	1.07	4.4	UCD
		5	32	47	34	0.16	1.4	UCD
		10	211	105	96	1.06	1.1	UCD
		15	30	27	218	0.15	0.1	PFG
	CH-SB24	0	535	1,120	93	2.80	12.0	UCD
		5	47	53	54	0.24	1.0	UCD
		8.5	961	275	65	4.81	4.2	UCD
		10	107	67	52	0.54	1.3	UCD
		15	17	28	170	0.09	0.2	PFG
	CH-SB25	0	325	642	104	1.63	6.2	UCD
		5	53	60	45	0.27	1.3	Brown Clay
		10	26	28	242	0.13	0.1	PFG
	CH-SB26	0	283	390	85	1.42	4.6	UCD
		4.5	13	29	34	0.07	0.9	Hickey Cgl
		10	22	30	52	0.11	0.6	Hickey Cgl
	CH-SB27	0	90	205	155	0.51	1.3	UCD
		5	11	25	56	0.06	0.4	Brown Clay
		10	16	22	55	0.08	0.4	Hickey Cgl

TABLE 6-1

Summary of XRF Results

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
CHAPARRAL GULCH FLOOD PLAIN	CH-SB28	0	193	282	72	0.97	3.9	UCD
		5	17	26	42	0.09	0.6	PFG
	CH-SB29	0	363	650	83	1.82	7.8	UCD
		4	25	59	169	0.15	0.3	UCD
		8.5	18	24	42	0.09	0.6	Brown Clay
		13	11	26	56	0.07	0.5	PFG
		18.5	21	20	79	0.11	0.3	PFG
	CH-SB30	0	310	625	81	1.56	7.7	UCD
		5	71	88	39	0.36	2.3	UCD
		9	409	270	61	2.05	4.4	UCD
	CH-SB31	0	263	435	110	1.32	4.0	HS Tailings (reworked)
		5	228	134	53	1.14	2.5	LCD
		10	115	52	471	0.58	0.1	PFG
		11.5	42	31	408	0.21	0.1	PFG
		13	21	27	184	0.11	0.1	Hickey Cgl
	CHF-SB01	0	261	447	143	1.31	3.1	HS Tailings (reworked)
		4	88	233	270	0.58	0.9	HS Tailings (undisturbed)
		7.5	106	370	9,210	0.93	0.0	HS Tailings (undisturbed)
		9	88	124	427	0.44	0.3	HS Tailings (undisturbed)
		10.5	121	245	347	0.61	0.7	LCD
		11.5	53	105	153	0.27	0.7	PFG
		13	11	21	51	0.06	0.4	Hickey Cgl
	CHF-SB02	0	251	300	90	1.26	3.3	HS Tailings (reworked)
		3.5	741	985	122	3.71	8.1	HS Tailings (reworked)
		5	126	268	496	0.67	0.5	HS Tailings (undisturbed)
		7.5	110	217	4,300	0.55	0.1	HS Tailings (undisturbed)
		11	19	39	511	0.10	0.1	LCD
		13	23	27	151	0.12	0.2	PFG
	CHF-SB03	0	146	218	79	0.73	2.8	UCD
		5	222	469	72	1.17	6.5	HS Tailings (reworked)
		7	548	85	79	2.74	1.1	HS Tailings (reworked)
		10	55	90	139	0.28	0.6	LCD
		15	20	29	200	0.10	0.1	LCD
	CHF-SB04	0	196	209	44	0.98	4.8	UCD
		5	490	371	50	2.45	7.4	HS Tailings (reworked)
		7.5	329	450	206	1.65	2.2	HS Tailings (reworked)
		10	50	94	85	0.25	1.1	LCD
		11	50	231	1,560	0.58	0.1	LCD
		12	32	82	343	0.21	0.2	PFG
		15	14	29	50	0.07	0.6	PFG

TABLE 6-1

Summary of XRF Results

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
CHAPARRAL GULCH FLOOD PLAIN	CHF-SB05	0	245	419	75	1.23	5.6	UCD
		3	391	320	76	1.96	4.2	HS Tailings (reworked)
		4	575	722	120	2.88	6.0	HS Tailings (reworked)
	CHF-SB06	0	460	760	93	2.30	8.2	HS Tailings (reworked)
		5	1,620	1,350	83	8.10	16.3	HS Tailings (reworked)
		9	85	147	66	0.43	2.2	HS Tailings (reworked)
		12.5	46	52	60	0.23	0.9	PFG
		15	33	37	81	0.17	0.5	Hickey Ash/Cinder
	CHF-SB07	0	280	529	79	1.40	6.7	UCD
		5	437	342	30	2.19	11.4	HS Tailings (reworked)
		7.5	563	540	317	2.82	1.7	HS Tailings (reworked)
		10	41	78	205	0.21	0.4	PFG
		13	63	124	432	0.32	0.3	PFG
	CHF-SB08	0	583	520	128	2.92	4.1	UCD
		2.5	1,500	2,410	77	7.50	31.3	HS Tailings (reworked)
		5	1,420	1,920	439	7.10	4.4	LCD
		10	49	71	387	0.25	0.2	LCD
		12	90	111	463	0.45	0.2	PFG
	CHF-SB09	0	172	243	86	0.86	2.8	UCD
		5	945	164	304	4.73	0.5	HS Tailings (undisturbed)
		8	143	50	324	0.72	0.2	HS Tailings (undisturbed)
		10	27	23	1,930	0.14	0.0	Brown Clay
		19	24	32	418	0.12	0.1	Brown Clay
		21.5	18	19	151	0.09	0.1	PFG
	CHF-SB10	0	542	1,180	111	2.95	10.6	UCD
		5	1,020	1,170	272	5.10	4.3	HS Tailings (reworked)
		9	700	1,140	225	3.50	5.1	HS Tailings (reworked)
	CHF-SB11	0	312	670	145	1.68	4.6	UCD
		2.5	69	122	476	0.35	0.3	Brown Clay
	CHF-SB12	0	418	739	105	2.09	7.0	HS Tailings (reworked)
		5	2,360	1,910	846	11.80	2.3	HS Tailings (reworked)
		8	74	137	371	0.37	0.4	HS Tailings (undisturbed)
		14	118	203	2,110	0.59	0.1	LCD
		22.5	22	22	64	0.11	0.3	PFG
	CHF-SB13	0	165	205	207	0.83	1.0	HS Tailings (undisturbed)
		2.5	102	90	133	0.51	0.7	HS Tailings (undisturbed)
		5	73	256	1,160	0.64	0.2	HS Tailings (undisturbed)
		9	434	341	425	2.17	0.8	LCD
		13.5	152	153	291	0.76	0.5	Brown Clay

TABLE 6-1

Summary of XRF Results

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
CHAPARRAL GULCH FLOOD PLAIN	CHF-SB14	0	142	172	793	0.71	0.2	HS Tailings (undisturbed)
		2.5	147	196	359	0.74	0.5	HS Tailings (undisturbed)
		4	372	308	480	1.86	0.6	HS Tailings (undisturbed)
		5	15	17	9,250	0.08	0.0	HS Tailings (undisturbed)
		10	17	15	214	0.09	0.1	Brown Clay
		15	26	30	86	0.13	0.3	Hickey Ash/Cinder
	CHF-SB15	0	194	200	410	0.97	0.5	UCD
		2.5	1,100	2,150	145	5.50	14.8	HS Tailings (reworked)
		5	1,350	1,650	1,730	6.75	1.0	HS Tailings (reworked)
		9	372	495	881	1.86	0.6	HS Tailings (undisturbed)
		14	115	136	899	0.58	0.2	LCD
		15	148	144	1,800	0.74	0.1	LCD
		19	282	269	2,140	1.41	0.1	PFG
	CHF-SB16	0	354	579	911	1.77	0.6	UCD
		2.5	214	304	416	1.07	0.7	HS Tailings (undisturbed)
		6	384	629	1,720	1.92	0.4	HS Tailings (undisturbed)
		6.5	481	652	885	2.41	0.7	HS Tailings (undisturbed)
		13.5	15	30	52	0.08	0.6	Brown Clay
		15.5	20	30	42	0.10	0.7	Hickey Ash/Cinder
	CHF-SB17	0	118	102	277	0.59	0.4	UCD
		5	376	410	320	1.88	1.3	HS Tailings (reworked)
		9.5	119	182	1,320	0.60	0.1	HS Tailings (undisturbed)
		15	22	30	49	0.11	0.6	HS Tailings (undisturbed)
		17.5	26	30	32	0.13	0.9	Brown Clay
	CHF-SB18	0	583	1,060	131	2.92	8.1	UCD
		5	2,970	3,000	270	14.85	11.1	HS Tailings (reworked)
		9.5	96	142	559	0.48	0.3	HS Tailings (undisturbed)
		12.5	68	107	106	0.34	1.0	PFG
	CHF-SB19	0	549	516	292	2.75	1.8	UCD
		2.5	1,990	5,760	159	14.40	36.2	HS Tailings (reworked)
		4.5	358	237	362	1.79	0.7	HS Tailings (undisturbed)
		6	53	109	63	0.27	1.7	Brown Clay
		16	29	33	67	0.15	0.5	Hickey Cgl
	CHF-SB20	0	594	438	340	2.97	1.3	UCD
		5	355	337	451	1.78	0.7	HS Tailings (undisturbed)
		10	102	170	563	0.51	0.3	HS Tailings (undisturbed)
		19	54	64	172	0.27	0.4	HS Tailings (undisturbed)
		23.5	178	248	1,720	0.89	0.1	LCD
		25.5	14	28	47	0.07	0.6	PFG

TABLE 6-1

Summary of XRF Results

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
CHAPARRAL GULCH FLOOD PLAIN	CHF-SB21	0	202	324	501	1.01	0.6	UCD
		4.5	488	603	480	2.44	1.3	HS Tailings (reworked)
		6	1,890	1,990	622	9.45	3.2	HS Tailings (reworked)
		10	662	909	867	3.31	1.0	HS Tailings (reworked)
		12.5	259	400	1,370	1.30	0.3	LCD
		19	22	26	37	0.11	0.7	PFG
	CHF-SB22	0	246	506	1,020	1.27	0.5	HS Tailings (undisturbed)
		5	244	290	374	1.22	0.8	HS Tailings (undisturbed)
		9	83	229	1,220	0.57	0.2	HS Tailings (undisturbed)
		15	192	193	1,430	0.96	0.1	HS Tailings (undisturbed)
		17.5	13	32	78	0.08	0.4	Brown Clay
	CHF-SB23	0	538	388	552	2.69	0.7	UCD
		4	1,040	1,320	1,270	5.20	1.0	HS Tailings (reworked)
		5	76	133	344	0.38	0.4	HSCD
		7.5	56	96	195	0.28	0.5	HS Tailings (undisturbed)
		13	104	272	873	0.68	0.3	LCD
		19	82	215	860	0.54	0.3	LCD
		24.5	79	142	1,240	0.40	0.1	PFG
	CHF-SB24	0	216	353	680	1.08	0.5	UCD
		5	199	309	319	1.00	1.0	HS Tailings (reworked)
		9	114	302	260	0.76	1.2	HS Tailings (reworked)
		12.5	110	408	1,850	1.02	0.2	HS Tailings (undisturbed)
	CHF-SB25	0	370	307	1,640	1.85	0.2	UCD
		5	148	241	355	0.74	0.7	HS Tailings (undisturbed)
		7.5	274	384	6,880	1.37	0.1	HS Tailings (undisturbed)
	CHF-SB26	0	304	138	434	1.52	0.3	UCD
		2.5	1,340	2,500	240	6.70	10.4	HS Tailings (reworked)
		5	178	418	1,300	1.05	0.3	HS Tailings (undisturbed)
		8	111	255	1,750	0.64	0.1	HS Tailings (undisturbed)
	CHF-SB27	0	457	703	248	2.29	2.8	UCD
		5	2,040	3,160	721	10.20	4.4	HS Tailings (reworked)
		10	325	541	1,270	1.63	0.4	HS Tailings (undisturbed)
		15	17	33	69	0.09	0.5	LCD
		18.5	135	202	356	0.68	0.6	LCD
	CHF-SB28	0	210	344	598	1.05	0.6	UCD
		5	336	458	640	1.68	0.7	HS Tailings (undisturbed)
		10	59	87	106	0.30	0.8	HS Tailings (undisturbed)
		15	74	143	179	0.37	0.8	HS Tailings (undisturbed)
		20	66	156	1,260	0.39	0.1	LCD

TABLE 6-1

Summary of XRF Results

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
CHAPARRAL GULCH FLOOD PLAIN	CHF-SB29	0	169	302	647	0.85	0.5	UCD
		5	222	256	351	1.11	0.7	HS Tailings (undisturbed)
		10	97	207	1,170	0.52	0.2	HS Tailings (undisturbed)
		15	65	128	662	0.33	0.2	HS Tailings (undisturbed)
		19.5	109	260	1,350	0.65	0.2	HS Tailings (undisturbed)
		25	104	167	1,520	0.52	0.1	PFG
	CHF-SB30	0	173	322	774	0.87	0.4	HS Tailings (undisturbed)
		5	185	282	502	0.93	0.6	HSCD
		10	96	202	1,300	0.51	0.2	HS Tailings (undisturbed)
		13	20	19	44	0.10	0.4	Brown Clay
		20	18	29	48	0.09	0.6	Brown Clay
	CHF-SB31	0	107	185	444	0.54	0.4	UCD
		5	475	159	550	2.38	0.3	HS Tailings (undisturbed)
		10	191	250	1,770	0.96	0.1	HS Tailings (undisturbed)
		15	223	225	1,330	1.12	0.2	HS Tailings (undisturbed)
		20	33	45	81	0.17	0.6	Brown Clay
	CHF-SB32	0	187	295	532	0.94	0.6	UCD
		5	327	332	241	1.64	1.4	HS Tailings (reworked)
		10	80	180	172	0.45	1.0	HS Tailings (reworked)
		15	78	159	515	0.40	0.3	HS Tailings (undisturbed)
		19.5	69	120	1,050	0.35	0.1	PFG
	CHF-SB33	0	293	538	162	1.47	3.3	UCD
		5	172	241	342	0.86	0.7	HS Tailings (undisturbed)
		10	35	63	142	0.18	0.4	HS Tailings (undisturbed)
		15	40	76	410	0.20	0.2	HS Tailings (undisturbed)
		19	138	93	761	0.69	0.1	LCD
	CHF-SB34	0	357	793	96	1.98	8.3	UCD
		4	629	1,170	90	3.15	13.0	HS Tailings (reworked)
		5	274	329	369	1.37	0.9	Brown Clay
		7.5	22	36	60	0.11	0.6	Brown Clay
		11	11	30	39	0.08	0.8	Brown Clay
		13.5	120	189	39	0.60	4.8	PFG
	CHF-SB35	0	259	330	247	1.30	1.3	HS Tailings (reworked)
		5	751	1,050	716	3.76	1.5	HS Tailings (reworked)
		10	147	217	1,620	0.74	0.1	HS Tailings (undisturbed)
		15	18	23	53	0.09	0.4	LCD
		19.5	17	24	67	0.09	0.4	PFG

TABLE 6-1

Summary of XRF Results

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
CHAPARRAL GULCH FLOOD PLAIN	CHF-SB36	0	253	245	116	1.27	2.1	UCD
		5	326	354	100	1.63	3.5	HS Tailings (reworked)
		10	110	138	817	0.55	0.2	HSCD
		12.5	62	317	2,350	0.79	0.1	HS Tailings (undisturbed)
		15	22	27	105	0.11	0.3	PFG
		20	22	28	32	0.11	0.9	PFG
	CHF-SB37	0	197	190	86	0.99	2.2	UCD
		5	1,810	1,130	97	9.05	11.6	HS Tailings (reworked)
		10	53	113	61	0.28	1.9	LCD
		15	101	115	214	0.51	0.5	PFG
	CHF-SB38	0	312	505	132	1.56	3.8	HS Tailings (reworked)
		5	404	198	69	2.02	2.9	HSCD
		10	63	294	2,400	0.74	0.1	HS Tailings (undisturbed)
		12.5	12	32	124	0.08	0.3	LCD
	CHF-SB39	0	430	235	199	2.15	1.2	UCD
		5	701	172	353	3.51	0.5	HS Tailings (undisturbed)
		7.5	91	682	4,200	1.71	0.2	HS Tailings (undisturbed)
		10	21	43	2,340	0.11	0.0	LCD
		15	18	31	483	0.09	0.1	PFG
	CHF-SB40	0	161	205	311	0.81	0.7	UCD
		5	788	252	2,110	3.94	0.1	HS Tailings (undisturbed)
		5.5	213	1,740	28,200	4.35	0.1	LCD
		10	16	26	66	0.08	0.4	Hickey Ash/Cinder
	CHF-SB41	0	234	438	132	1.17	3.3	UCD
		5	240	352	267	1.20	1.3	LCD
		7	1,790	2,250	187	8.95	12.0	LCD
		12.5	75	165	73	0.41	2.3	LCD
		17	21	33	98	0.11	0.3	PFG
		20	22	30	73	0.11	0.4	PFG
	CHF-SB42	0	117	159	71	0.59	2.2	UCD
		5	392	796	72	1.99	11.1	LCD
		10	53	35	69	0.27	0.5	LCD
		13	46	90	155	0.23	0.6	LCD
		15	26	29	156	0.13	0.2	PFG
		18	15	31	203	0.08	0.2	PFG
	CHF-SB43	0	399	693	121	2.00	5.7	UCD
		5	684	2,190	133	5.48	16.5	HS Tailings (reworked)
		7.5	634	267	534	3.17	0.5	LCD
		8.5	49	115	230	0.29	0.5	LCD
		10	67	89	179	0.34	0.5	PFG
		11.5	143	182	176	0.72	1.0	PFG
		15	20	22	118	0.10	0.2	PFG

TABLE 6-1

Summary of XRF Results

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
CHAPARRAL GULCH FLOOD PLAIN	CHF-SB44	0	142	170	199	0.71	0.9	UCD
		4	298	258	289	1.49	0.9	HS Tailings (undisturbed)
		5	31	78	20,000	0.20	0.0	HS Tailings (undisturbed)
		8	19	30	56	0.10	0.5	HS Tailings (undisturbed)
		10	36	56	84	0.18	0.7	Brown Clay
		14.5	63	93	176	0.32	0.5	Brown Clay
	CHF-SB45	0	415	914	108	2.29	8.5	UCD
		5	1,090	2,600	340	6.50	7.6	HS Tailings (reworked)
		7.5	70	71	45	0.35	1.6	HS Tailings (reworked)
		10	44	44	79	0.22	0.6	LCD
		12	55	86	302	0.28	0.3	PFG
		17	57	92	363	0.29	0.3	PFG
	CHF-SB46	0	306	612	96	1.53	6.4	UCD
		5	423	317	369	2.12	0.9	HS Tailings (undisturbed)
		7.5	448	873	1,070	2.24	0.8	HS Tailings (undisturbed)
		10	107	237	143	0.59	1.7	HS Tailings (undisturbed)
		15	50	138	468	0.35	0.3	LCD
		19	48	73	215	0.24	0.3	PFG
	CHF-SB47	0	143	176	399	0.72	0.4	UCD
		5	194	296	1,540	0.97	0.2	HS Tailings (undisturbed)
		10	23	28	68	0.12	0.4	Brown Clay
		15	22	26	52	0.11	0.5	PFG
		20	18	26	39	0.09	0.7	PFG
TAILINGS DAM	DAM-SB01	0	172	193	561	0.86	0.3	UCD
		5	397	536	1,140	1.99	0.5	UCD
		10	3,020	17,000	2,390	42.50	7.1	HS Tailings (reworked)
	DAM-SB02	0	100	125	326	0.50	0.4	UCD
		6	370	638	769	1.85	0.8	HS Tailings (undisturbed)
		11	122	247	968	0.62	0.3	HS Tailings (undisturbed)
		12.5	199	568	4,310	1.42	0.1	HS Tailings (undisturbed)
	DAM-SB03	0	102	116	657	0.51	0.2	UCD
		5	199	242	1,780	1.00	0.1	UCD
		13.5	696	1,520	729	3.80	2.1	HS Tailings (reworked)
		20	422	798	806	2.11	1.0	HS Tailings (reworked)
		27	35	100	572	0.25	0.2	LCD
	DAM-SB04	0	947	2,630	326	6.58	8.1	UCD
		5	697	314	163	3.49	1.9	HS Tailings (reworked)
		6	1,090	1,470	382	5.45	3.8	HS Tailings (reworked)
		10	116	161	737	0.58	0.2	HS Tailings (undisturbed)
		15	351	334	2,840	1.76	0.1	HS Tailings (undisturbed)

TABLE 6-1

Summary of XRF Results

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
TAILINGS DAM	DAM-SB05	0	195	346	925	0.98	0.4	UCD
		5	1,060	1,720	321	5.30	5.4	HS Tailings (reworked)
		7.5	1,730	2,800	271	8.65	10.3	HS Tailings (reworked)
		10	892	2,770	884	6.93	3.1	HS Tailings (reworked)
		12.5	119	146	598	0.60	0.2	HS Tailings (undisturbed)
	DAM-SB06	0	130	179	412	0.65	0.4	HS Tailings (undisturbed)
		5	119	146	337	0.60	0.4	HS Tailings (undisturbed)
		10	322	593	640	1.61	0.9	HS Tailings (undisturbed)
		15	423	953	358	2.38	2.7	HS Tailings (undisturbed)
		18.5	133	196	710	0.67	0.3	HS Tailings (undisturbed)
		23	218	478	4,150	1.20	0.1	HS Tailings (undisturbed)
		26	21	61	302	0.15	0.2	HS Tailings (undisturbed)
HUMBOLDT SMELTER SWALE	STS-SB01	0	213	500	1,230	1.25	0.4	HS Tailings (undisturbed)
		5	13	30	116	0.08	0.3	Brown Clay
		10	16	31	30	0.08	1.0	Hickey Cgl
	STS-SB02	0	137	295	898	0.74	0.3	HS Tailings (undisturbed)
		4	13	29	134	0.07	0.2	Brown Clay
		10	22	32	44	0.11	0.7	Hickey Cgl
	STS-SB03	0	195	232	801	0.98	0.3	HS Tailings (undisturbed)
		4	22	43	1,580	0.11	0.0	HS Tailings (undisturbed)
		10	11	26	41	0.07	0.6	---
	STS-SB04	0	144	268	704	0.72	0.4	HS Tailings (undisturbed)
		5	181	195	15,800	0.91	0.0	Brown Clay
		12	22	25	41	0.11	0.6	Hickey Cgl
	STS-SB05	0	99	207	1,060	0.52	0.2	HS Tailings (undisturbed)
		3	283	282	3,070	1.42	0.1	HS Tailings (undisturbed)
		5	22	39	10,000	0.11	0.0	HS Tailings (undisturbed)
		6	19	37	233	0.10	0.2	Brown Clay
		10	22	34	59	0.11	0.6	Hickey Cgl
	STS-SB06	0	177	327	753	0.89	0.4	HS Tailings (undisturbed)
		5	22	36	40	0.11	0.9	Hickey Cgl
		10	17	20	43	0.09	0.5	Hickey Cgl
	STS-SB07	0	130	218	448	0.65	0.5	HS Tailings (undisturbed)
		1	45	77	9,590	0.23	0.0	HS Tailings (undisturbed)
		3	22	22	81	0.11	0.3	Brown Clay
		5	22	29	41	0.11	0.7	Hickey Cgl
		10	11	33	32	0.08	1.0	Hickey Cgl
	STS-SB08	0	168	265	579	0.84	0.5	HS Tailings (undisturbed)
		5	77	161	602	0.40	0.3	HS Tailings (undisturbed)
		9	96	227	3,700	0.57	0.1	HS Tailings (undisturbed)
		10.5	22	27	51	0.11	0.5	Hickey Cgl

TABLE 6-1

Summary of XRF Results

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location	Boring	Depth (feet)	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	As_n *or* Pb_n [1] [-]	Pb:Cu[2] [-]	Hydrostratigraphic Unit[3]
HUMBOLDT SMELTER SWALE	STS-SB09	0	111	221	1,350	0.56	0.2	HS Tailings (undisturbed)
		2.5	22	26	41	0.11	0.6	HS Tailings (undisturbed)
	STS-SB09B	0	167	233	686	0.84	0.3	HS Tailings (undisturbed)
	STS-SB10	0	148	270	631	0.74	0.4	HS Tailings (undisturbed)
		4.5	13	31	72	0.08	0.4	Brown Clay
		7	14	33	55	0.08	0.6	PFG
		10	23	20	35	0.12	0.6	PFG
		12	12	22	58	0.06	0.4	Hickey Cgl
	STS-SB11	0	82	98	1,890	0.41	0.1	HS Tailings (undisturbed)
		2	22	24	57	0.11	0.4	Hickey Cgl
		5	11	25	45	0.06	0.6	Hickey Cgl
	STS-SB12	0	233	371	612	1.17	0.6	HSCD
		1	377	33	1,220	1.89	0.0	HSCD
		5.5	404	341	698	2.02	0.5	HS Tailings (undisturbed)
		9	16	35	119	0.09	0.3	Brown Clay
		16	17	33	60	0.09	0.6	LCD
	STS-SB13	0	141	304	229	0.76	1.3	HS Tailings (undisturbed)
		3	372	158	370	1.86	0.4	HS Tailings (undisturbed)
		4.5	342	36	734	1.71	0.0	HS Tailings (undisturbed)
		9	22	33	1,820	0.11	0.0	HS Tailings (undisturbed)
	STS-SB14	0	16	24	54	0.08	0.4	Brown Clay
	STS-SB15	0	267	345	890	1.34	0.4	HS Tailings (undisturbed)
		5	12	43	5,490	0.11	0.0	HS Tailings (undisturbed)
		6	574	235	1,670	2.87	0.1	HSCD
		10	16	25	10,200	0.08	0.0	HS Tailings (undisturbed)
		15	26	43	452	0.13	0.1	HS Tailings (undisturbed)
		20	77	42	307	0.39	0.1	HS Tailings (undisturbed)
		25	39	25	72	0.20	0.3	PFG
	STS-SB15B	0	653	298	949	3.27	0.3	HS Tailings (undisturbed)
		8	599	318	1,540	3.00	0.2	HSCD
		10	14	34	265	0.09	0.1	HS Tailings (undisturbed)

As = arsenic; **Pb** = lead, **UCD** = Uppermost Channel Deposit, **HS Tailings** = Humboldt Smelter Tailings (oxidized or reduced), **HSCD** = Humboldt Smelter Channel Deposit, **LCD** = Lowermost Channel Deposit, **Brown Clay**, **PFG** = Principle Fluvial Gravel **Hickey Cgl** = Hickey Conglomerate (bedrock), **Hickey Ash/Cinder** = Hickey Mafic Tuffs

= Soil concentration exceeds the cleanup threshold for either As or Pb (**As_n or Pb_n > 1**)

1. As_n or Pb_n = normalized As (As/200 mg/kg) or Pb (Pb/400 mg.kg) soil concentrations that are > 1 exceed the soil cleanup threshold for either As (200 mg.kg) or Pb (400 mg/kg) and identify contaminated soil
2. Pb:Cu = lead to copper ratios are used to determine the potential source of metal contamination. Pb:Cu > 2.1 are characteristic of Iron King Mine tailings while Pb:Cu <2.1 are more indicative of Humboldt Smelter tailings.
3. Descriptions of hydrostratigraphic units are summarized in Figure 6-2.

TABLE 6-2

Water Level Measurements[1]

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location		East (feet)	North (feet)	Elevation (ft-asl)	Depth (feet)	Date	DTW (feet)	WL (ft-asl)	Hydrostratigrpahic Unit2
UPPER CHAPARRAL GULCH	CHU-SB01	602,291.4	1,272,966.2	4,509.9	1.5	2/25/14	Dry	---	
	CHU-SB02	602,174.9	1,273,011.1	4,513.3	14.5	2/25/14	Dry	---	
	CHU-SB03	602,108.0	1,272,994.3	4,513.6	13.5	2/25/14	Dry	---	
	CHU-SB04	602,010.8	1,272,971.9	4,515.3	11.5	2/25/14	Dry	---	
	CHU-SB05	602,562.0	1,273,337.0	4,509.2	13.5	2/25/14	Dry	---	
	CHU-SB06	602,450.7	1,273,453.4	4,511.7	25.0	2/26/14	Dry	---	
	CHU-SB07	602,390.2	1,273,519.8	4,512.7	19.0	2/26/14	17.5	4495.2	PFG
	CHU-SB08	602,578.0	1,273,494.9	4,513.5	23.0	2/26/14	Dry	---	
	CHU-SB09	602,609.2	1,273,365.5	4,510.2	17.0	2/26/14	Dry	---	
	CHU-SB10	602,457.5	1,273,277.1	4,509.0	25.0	2/26/14	17.0	4492.0	PFG
	CHU-SB11	602,366.8	1,273,351.1	4,511.4	17.5	2/26/14	Dry	---	
	CHU-SB12	602,302.0	1,273,399.8	4,513.4	19.5	2/26/14	19.0	4494.4	PFG
	CHU-SB13	602,251.6	1,273,335.6	4,512.0	25.0	2/28/15	20.5	4491.5	PFG
	CHU-SB14	602,321.0	1,273,273.0	4,512.0	12.0	2/28/15	Dry	---	
	CHU-SB15	602,405.2	1,273,234.8	4,510.1	8.0	2/28/15	Dry	---	
CHAPARRAL GULCH (3RD STREET TO HS SWALE)	CH-SB01	602,498.3	1,273,043.0	4,504.5	18.0	2/27/14	Dry	---	
	CH-SB02	602,521.5	1,273,094.5	4,505.0	15.0	2/8/14	Dry	---	
	CH-SB03	602,561.7	1,273,137.3	4,505.0	15.0	2/8/14	Dry	---	
	CH-SB04	602,625.4	1,272,902.4	4,501.4	15.0	2/8/14	Dry	---	
	CH-SB05	602,691.0	1,272,960.1	4,500.3	10.5	2/8/14	Dry	---	
	CH-SB06	602,555.7	1,272,857.9	4,502.0	5.0	2/9/14	Dry	---	
	CH-SB07	602,765.1	1,272,770.2	4,498.0	10.0	2/9/14	Dry	---	
	CH-SB08	602,823.3	1,272,797.5	4,498.2	10.0	2/9/14	Dry	---	
	CH-SB09	602,863.6	1,272,852.2	4,498.0	10.0	2/9/14	Dry	---	
	CH-SB10	602,963.9	1,272,623.5	4,494.6	15.0	2/9/14	Dry	---	
	CH-SB11	603,003.1	1,272,691.6	4,494.3	20.0	2/9/14	15.0	4479.3	PFG
	CH-SB12	603,027.5	1,272,716.8	4,495.0	20.0	2/9/14	15.0	4480.0	PFG
	CH-SB13	603,054.9	1,272,762.8	4,496.0	11.5	2/9/14	Dry	---	
	CH-SB14B	603,052.8	1,272,801.5	4,496.9	6.0	2/9/14	Dry	---	
	CH-SB15	603,183.9	1,272,713.5	4,496.0	5.5	2/9/14	Dry	---	
	CH-SB16	603,154.8	1,272,654.5	4,492.7	20.0	2/10/14	14.5	4478.2	PFG
	CH-SB17	603,174.5	1,272,576.4	4,490.7	20.0	2/10/14	17.0	4473.7	PFG
	CH-SB18	603,108.3	1,272,525.7	4,492.0	22.5	2/10/14	Dry	---	
	CH-SB19	603,099.7	1,272,457.3	4,489.8	20.0	2/10/14	Dry	---	
	CH-SB20	603,233.3	1,272,491.3	4,490.1	25.0	2/10/14	16.0	4474.1	PFG
	CH-SB21	603,177.8	1,272,440.0	4,490.1	20.0	2/10/14	16.0	4474.1	PFG
	CH-SB22	603,365.1	1,272,374.2	4,489.9	12.5	2/10/14	Dry	---	
	CH-SB23	603,300.6	1,272,313.0	4,488.0	20.3	2/10/14	18.0	4470.0	PFG
	CH-SB24	603,276.6	1,272,277.2	4,487.5	22.5	2/10/14	18.0	4469.5	PFG
	CH-SB25	603,224.9	1,272,207.4	4,486.0	20.0	2/11/14	17.0	4469.0	PFG
	CH-SB26	603,065.2	1,272,450.6	4,491.9	17.5	2/11/14	Dry	---	
	CH-SB27	603,100.5	1,272,331.2	4,490.2	15.0	2/11/14	Dry	---	
	CH-SB28	603,124.6	1,272,137.7	4,486.8	15.0	2/11/14	Dry	---	
	CH-SB29	603,242.3	1,271,836.3	4,483.2	22.5	2/24/14	Dry	---	
	CH-SB30	603,314.8	1,271,909.9	4,482.9	22.5	2/25/14	17.5	4465.4	PFG
	CH-SB31	603,416.9	1,272,024.4	4,482.3	15.0	2/25/14	Dry	---	

TABLE 6-2

Water Level Measurements[1]

Chaparral Gulch Arroyo

Dewey-Humboldt, Arizona

Location		East (feet)	North (feet)	Elevation (ft-asl)	Depth (feet)	Date	DTW (feet)	WL (ft-asl)	Hydrostratigrpahic Unit2
CHAPARRAL GULCH FLOOD PLANE	CHF-SB01	603,495.7	1,271,872.9	4,479.7	20.0	2/11/14	Dry	---	
	CHF-SB02	603,500.5	1,271,772.7	4,479.0	20.0	2/12/14	Dry	---	
	CHF-SB03	603,504.3	1,271,671.9	4,477.3	25.0	2/12/14	18.0	4459.3	LCD/PFG
	CHF-SB04	603,499.9	1,271,573.4	4,477.6	25.0	2/12/14	16.5	4461.1	PFG
	CHF-SB05	603,537.1	1,271,476.7	4,476.5	6.0	2/12/14	Dry	---	
	CHF-SB06	603,713.0	1,271,380.4	4,475.6	25.0	2/12/14	Dry	---	
	CHF-SB07	603,702.6	1,271,474.9	4,475.0	25.0	2/12/14	16.0	4459.0	PFG
	CHF-SB08	603,795.6	1,271,481.4	4,473.9	28.0	2/12/14	13.0	4460.9	PFG
	CHF-SB09	603,792.1	1,271,553.1	4,475.1	27.0	2/12/14	16.0	4459.1	PFG
	CHF-SB10	603,828.3	1,271,293.0	4,473.3	20.0	2/13/14	11.0	4462.3	LCD/PFG
	CHF-SB11	603,780.8	1,271,243.3	4,473.8	19.0	2/13/14	Dry	---	
	CHF-SB12	603,905.2	1,271,374.1	4,473.0	25.0	2/13/14	11.0	4462.0	LCD/PFG
	CHF-SB13	603,996.1	1,271,463.6	4,473.4	38.5	2/13/14	13.5	4459.9	LCD/PFG
	CHF-SB14	604,055.6	1,271,528.4	4,474.0	23.0	2/13/14	Dry	---	
	CHF-SB15	604,094.9	1,271,272.6	4,470.8	28.5	2/13/14	11.0	4459.8	LCD/PFG
	CHF-SB16	604,287.0	1,271,358.0	4,471.3	21.5	2/18/14	10.0	4461.3	Brown Clay/PFG
	CHF-SB17	604,196.7	1,271,365.3	4,471.2	35.0	2/18/14	14.0	4457.2	Brown Clay/PFG
	CHF-SB18	603,999.0	1,271,175.1	4,471.3	23.0	2/18/14	11.0	4460.3	PFG
	CHF-SB19	604,269.5	1,271,069.5	4,467.7	21.0	2/18/14	10.0	4457.7	PFG
	CHF-SB20	604,299.2	1,271,156.5	4,468.6	29.5	2/18/14	10.0	4458.6	LCD/PFG
	CHF-SB21	604,381.8	1,271,253.0	4,469.5	30.0	2/18/14	11.0	4458.5	LCD/PFG
	CHF-SB22	604,500.3	1,271,170.7	4,467.5	32.5	2/19/14	6.0	4461.5	HS-Tlgs
	CHF-SB23	604,488.8	1,271,068.9	4,465.0	35.0	2/19/14	7.0	4458.0	HS-Tlgs/PFG
	CHF-SB24	604,597.1	1,270,964.6	4,463.4	16.0	2/19/14	3.0	4460.4	HS-Tlgs
	CHF-SB25	604,495.9	1,270,903.7	4,464.2	11.5	2/19/14	8.0	4456.2	HS-Tlgs
	CHF-SB26	604,338.5	1,271,026.6	4,465.3	15.0	2/20/14	2.5	4462.8	HS-Tlgs
	CHF-SB27	604,380.9	1,271,059.3	4,466.2	28.0	2/20/14	3.2	4463.0	HS-Tlgs/PFG
	CHF-SB28	604,504.6	1,271,000.5	4,464.1	26.0	2/20/14	5.5	4458.6	HS-Tlgs/PFG
	CHF-SB29	604,395.0	1,271,169.8	4,468.3	30.0	2/21/14	6.0	4462.3	HS-Tlgs/PFG
	CHF-SB30	604,308.9	1,271,265.1	4,468.8	30.0	2/21/14	5.5	4463.3	HS-Tlgs/PFG
	CHF-SB31	604,209.1	1,271,296.1	4,470.6	30.0	2/21/14	7.0	4463.6	HS-Tlgs/PFG
	CHF-SB32	604,189.0	1,271,170.5	4,469.7	27.5	2/21/14	5.4	4464.3	HS-Tlgs/PFG
	CHF-SB33	604,110.6	1,271,172.9	4,470.5	24.0	2/21/14	5.5	4465.0	HS-Tlgs/PFG
	CHF-SB34	603,903.8	1,271,199.3	4,472.4	18.5	2/21/14	9.0	4463.4	Brown Clay/PFG
	CHF-SB35	603,995.9	1,271,368.9	4,471.7	30.0	2/22/14	13.0	4458.7	HS-Tlgs/PFG
	CHF-SB36	603,698.1	1,271,569.2	4,475.5	30.0	2/22/14	11.0	4464.5	HS-Tlgs/PFG
	CHF-SB37	603,600.8	1,271,569.9	4,476.2	25.0	2/22/14	11.5	4464.7	PFG
	CHF-SB38	603,599.5	1,271,672.2	4,477.4	37.5	2/22/14	17.0	4460.4	LCD/PFG
	CHF-SB39	603,691.5	1,271,663.5	4,474.7	27.5	2/22/14	12.5	4462.2	PFG
	CHF-SB40	603,598.1	1,271,768.7	4,476.7	15.0	2/22/14	Dry	---	
	CHF-SB41	603,402.0	1,271,673.3	4,479.8	26.0	2/22/14	18.0	4461.8	PFG
	CHF-SB42	603,394.0	1,271,768.3	4,481.2	24.5	2/22/14	20.0	4461.2	PFG
	CHF-SB43	603,431.3	1,271,944.2	4,481.9	22.0	2/25/14	Dry	---	
	CHF-SB44	603,903.7	1,271,479.6	4,473.6	25.0	2/25/14	10.0	4463.6	Brown Clay/PFG
	CHF-SB45	603,908.6	1,271,271.8	4,472.6	23.0	2/25/14	9.0	4463.6	HS-Tlgs/PFG
	CHF-SB46	603,995.9	1,271,272.1	4,472.5	26.0	2/25/14	9.0	4463.5	HS-Tlgs/PFG
	CHF-SB47	604,098.8	1,271,370.1	4,472.0	30.0	2/25/14	9.0	4463.0	HS-Tlgs/PFG

TABLE 6-2
Water Level Measurements[1]
Chaparral Gulch Arroyo
Dewey-Humboldt, Arizona

Location		East (feet)	North (feet)	Elevation (ft-asl)	Depth (feet)	Date	DTW (feet)	WL (ft-asl)	Hydrostratigrpahic Unit2
DAM	DAM-SB01	604,625.8	1,270,888.3	4,461.6	15.0	2/19/14	7.5	4454.1	UCD/PFG
	DAM-SB02	604,609.1	1,270,906.1	4,461.7	14.0	2/19/14	3.1	4458.6	UCD/PFG
	DAM-SB03	604,609.4	1,270,854.0	4,461.1	27.5	2/19/14	2.5	4458.6	UCD/PFG
	DAM-SB04	604,590.1	1,270,829.4	4,461.9	16.0	2/20/14	4.0	4457.9	UCD/PFG
	DAM-SB05	604,577.5	1,270,839.9	4,462.3	22.0	2/20/14	5.5	4456.8	UCD/PFG
	DAM-SB06	604,610.3	1,270,873.7	4,462.5	29.0	2/25/14	2.5	4460.0	UCD/PFG
HS SWALE	STS-SB01	603,601.4	1,272,671.4	4,518.5	18.0	2/6/14	Dry	---	
	STS-SB02	603,606.7	1,272,365.8	4,512.0	10.0	2/6/14	Dry	---	
	STS-SB03	603,628.8	1,272,277.2	4,510.8	10.0	2/6/14	Dry	---	
	STS-SB04	603,704.7	1,272,105.7	4,499.4	15.0	2/6/14	Dry	---	
	STS-SB05	603,925.2	1,272,371.5	4,514.4	15.0	2/7/14	Dry	---	
	STS-SB06	603,791.5	1,272,277.1	4,513.2	15.0	2/7/14	Dry	---	
	STS-SB07	603,798.5	1,272,164.5	4,499.9	15.0	2/7/14	Dry	---	
	STS-SB08	603,858.1	1,271,988.9	4,506.0	28.0	2/7/14	Dry	---	
	STS-SB09	603,606.0	1,272,068.2	4,503.1	6.0	2/7/14	Dry	---	
	STS-SB09B	603,606.3	1,272,035.9	4,499.3	18.5	2/7/14	Dry	---	
	STS-SB10	603,508.2	1,271,970.8	4,482.1	15.0	2/7/14	Dry	---	
	STS-SB11	603,800.0	1,271,901.7	4,493.9	12.5	2/8/14	Dry	---	
	STS-SB12	603,808.1	1,271,666.6	4,476.9	28.0	2/8/14	14.0	4462.9	LCD/PFG
	STS-SB13	603,997.8	1,271,574.6	4,473.8	15.0	2/8/14	Dry	---	
	STS-SB14	603,799.7	1,271,817.4	4,481.9	12.0	2/24/14	Dry	---	
	STS-SB15	603,803.9	1,271,638.5	4,476.1	37.5	2/24/14	9.0	4467.1	LCD/PFG

UCD/PFG = Uppermost Channel Deposit to Principle Fluvial Gravel, HS-Tlgs = Humboldt Smelter Tailings
HS-Tlgs/PFG = Humboldt Smelter Tailings to Principle Fluvial Gravels, **Brown Clay/PFG** = Brown Clay to Principle Fluvial Gravels, **PFG** = Principle Fluvial Gravel, **LCD/PFG** = Lowermost Channel Deposit to Principle Fluvial Gravel,

1. Water level measurements were collected from open boreholes 3 to 12 hours after the boring was completed.
2. The primary producing unit in the Chaparral Gulch arroyo is the Principle Fluvial Gravels. Water levels stabilizing above the top of the gravel unit are assumed to represent semiconfined aquifer conditions.

FIGURES

Base map created using 2010 orthoimagery,
sample location from GPS survey in 2014.

Map Creation Date: DEcember 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC6_Chaparral_Gulch Models/146_SEC6_Site_Location&Pr_Sec_Lines_F6-1

0 240 480
Feet

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EP-W-09-031
W.A.# 0-146

Figure 6-1
Soil Boring Locations and
Profile Section Lines
Iron King Mine Site
Dewey-Humboldt, Arizona

Age	Unit	Description	Hydrostratigraphic Unit
Recent	Tailings or Mixed Fluvium-Tailings	▪ **MTP Tailings (IKM site)** – stockpiled in the headwaters of Chaparral Gulch on the IKM site. The tailings are Pb-rich with a Pb:Cu ratio > 2.1 (Note: MTP Tailings are not found in the Chaparral Gulch flood plain).	Unsaturated Zone
		▪ **Uppermost Channel Deposit (UCD)** is reworked fluvium-IKM tailings. Material is light brown to brown with mottle iron-oxide staining, consisting of pebbly-sandy silt with some cobbles. The unit ranges **up to 13 feet thick**. The Pb:Cu is characteristically > 2.1, suggesting MTP tailings are a source of detritus.	
		▪ **HS Tailings (HS site)** – occurs only in the tailings swale and flood plain downgradient of the swale. Undisturbed HS tailings are Cu-rich with a Pb:Cu ratio < 0.6.	Aquitard
		▪ **Humboldt Smelter Channel Deposit (HSCD)** is reworked fluvium-HS tailings. The unit is found only in the flood plain downgradient of the HS swale and always interbedded with HS tailings. Material is light brown to orange, consisting of pebbly-sandy silt with some cobbles. The unit is **< 5 feet thick**, with a Pb:Cu < 1.0.	Semiconfined Aquifer
		▪ **Lowermost Channel Deposit (LCD)** is found in the lower Chaparral Gulch (flood plain). Material is mottled brown, green and tan, consisting of pebbly-sandy gravel with cobbles. The unit ranges **up to 8 feet thick**, and overlies either the principle fluvial gravels or bedrock.	
Quaternary	Fluvial Deposits	▪ **Brown Clay** is occurs along the channel margins, most commonly overlies bedrock and less commonly overlies the principal Fluvial Gravels (PFG). The clay is dark brown with weakly developed laminae to massive. The deposit ranges **up to 6** feet thick.	Aquitard
		▪ **Principle Fluvial Gravel (PFG)l** directly overlies bedrock and defines the bedrock channel. The unit is mottled brown-dark green-tan, poorly sorted, cobbly-pebbly-sandy gravel with a clay matrix. Pebbles/cobbles are subrounded to rounded Precambrian volcanics and granitoids. The deposit ranges **up to 14** feet thick	Unconfined Aquifer
Tertiary	Hickey Formation	• **Basin Fill Deposits**: unconsolidated basin fill deposits (i.e. fanglomerates)	Aquitard (Shallow Bedrock Interval Underlying Fluvium is Dry)
		• **Basalt:** massive to vesicular olivine basalt • **Mafic tuff:** ash, cinders and bombs	
		• **Lower Conglomerate:** boulder to pebble conglomerate (e.g., basal conglomerate)	
		Angular Unconformity	
Precambrian	Iron King Volcanics	**Amygdaloidal Andesite Flow** • Greenschist facies (muscovite-chlorite-calcite mineral assemblage) • Well-developed foliation oriented 020-050° with subvertical dip • **Granodiorite porphyry** • **Quartz diorite**. • **Diorite porphyry** • **Gabbro-Diorite**.	

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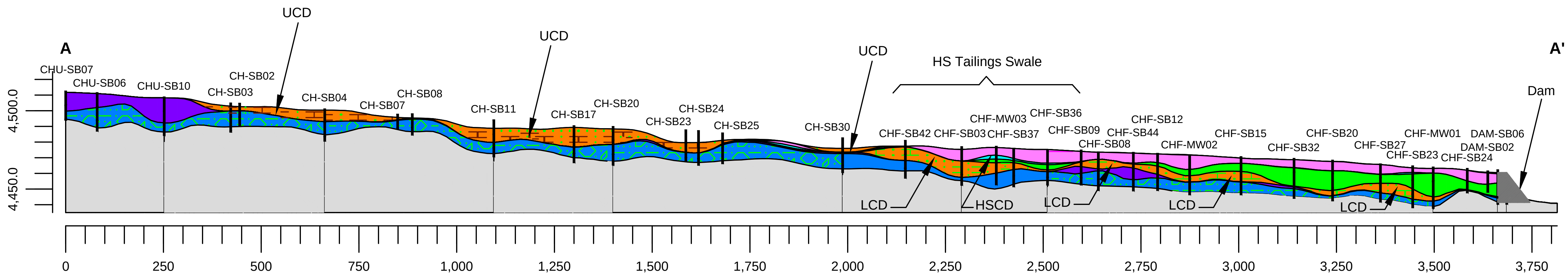
EP-W-09-031
W.A.# 0 - 146

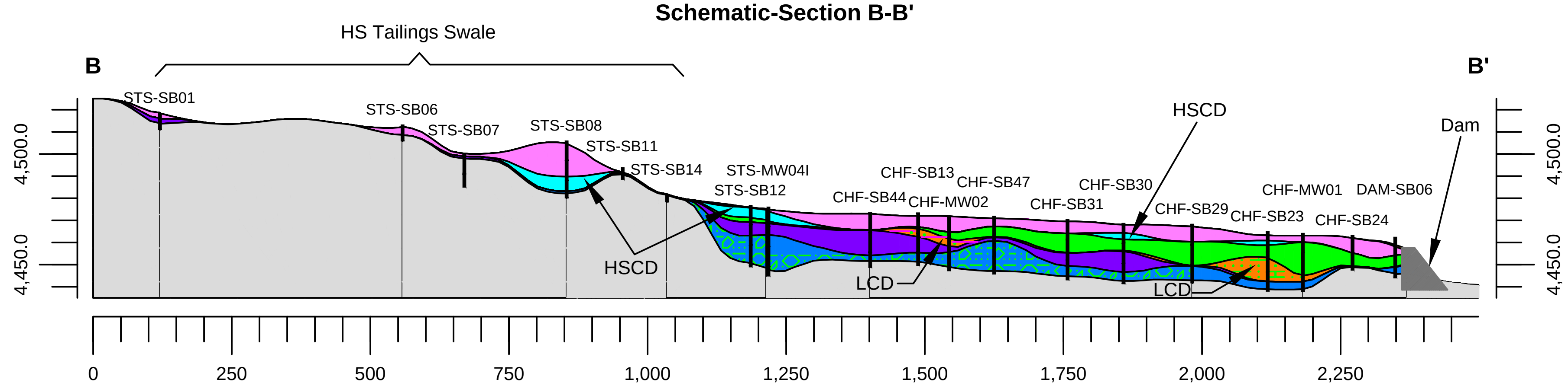
Figure 6-2
Hydrostratigraphy of Chaparral Gulch
Iron King Mine Site
Dewey-Humboldt, Arizona

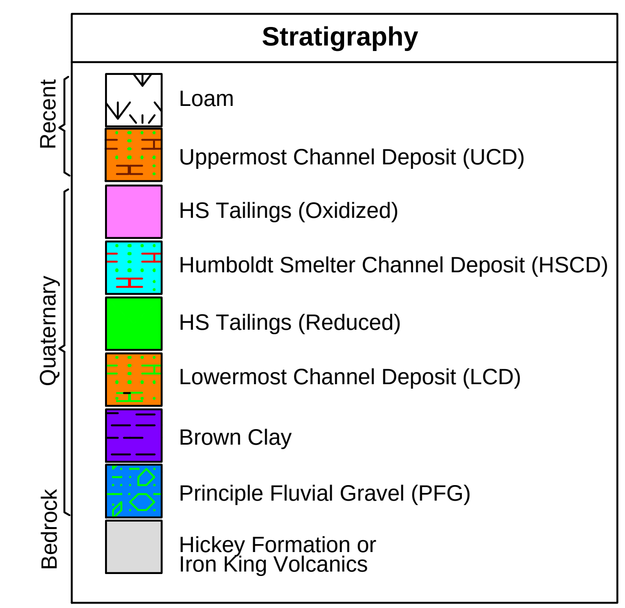
J:/SERAS01_projects/ACAD 2013/00-146/DEdgerton_Projects/SEC6_Hydrostratigraphy_F6-2.dwg

Schematic-Section A-A'



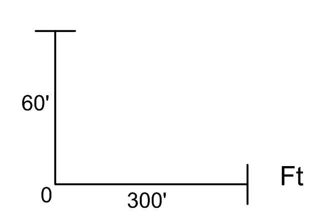
Schematic-Section B-B'





Note: Summary of Hydrostratigraphy is displayed in Figure 6-2.

Scale:



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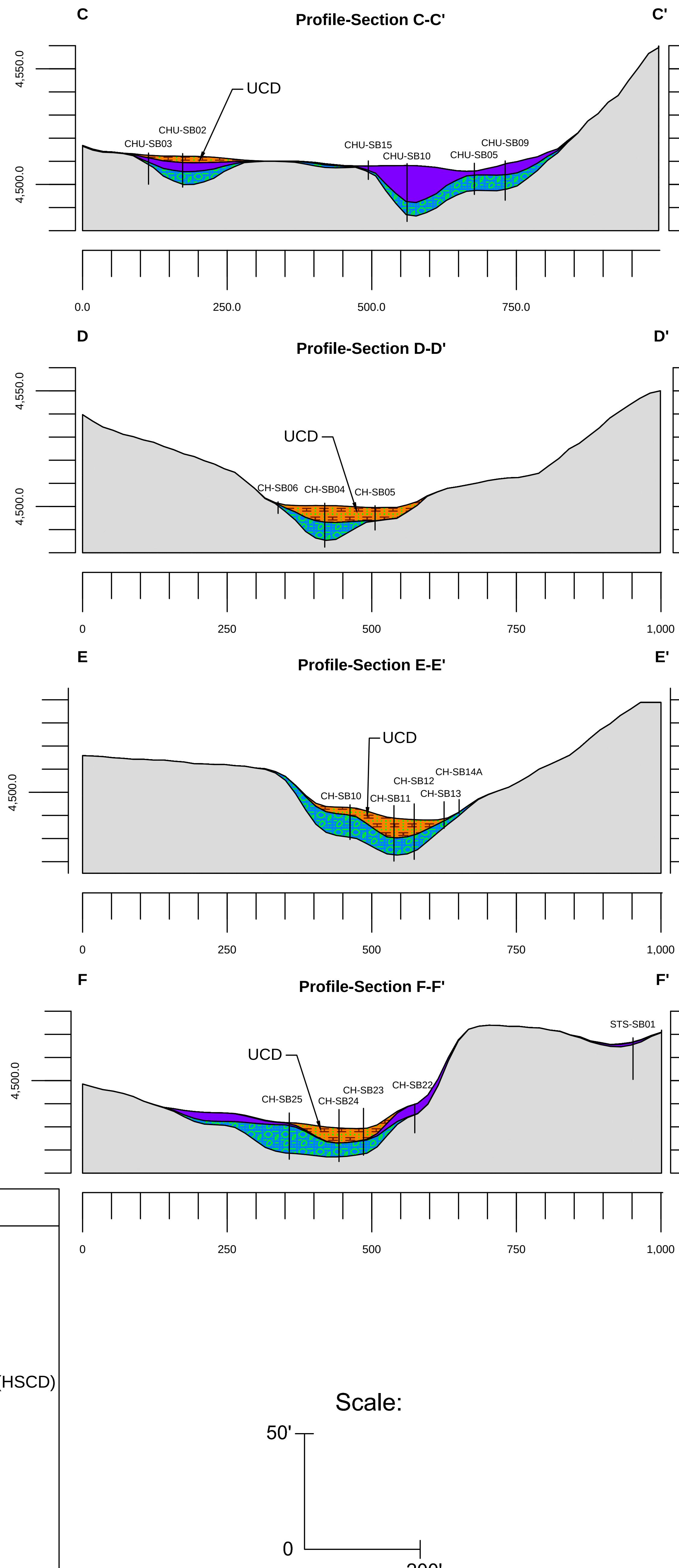
EP-W-09-031
W.A.# 0 - 146

Figure 6-3
Schematic Section Chaparral Gulch
(AA' & BB')
Iron King Mine Site
Dewey-Humboldt, Arizona

J:/SERAS01_projects/ACAD_2013/00-146/DEdgerto_Projects/SEC6_Sch_Section_AA-BB_f6-3.dwg01/20/2015



Stratigraphy

Recent
- Loam
- Uppermost Channel Deposit (UCD)

Quaternary
- HS Tailings (Oxidized)
- Humboldt Smelter Channel Deposit (HSCD)
- HS Tailings (Reduced)
- Lowermost Channel Deposit (LCD)
- Brown Clay
- Principle Fluvial Gravel (PFG)

Bedrock
- Hickey Formation or Iron King Volcanics

Note: Summary of Hydrostratigraphy is displayed in Figure 6-2.

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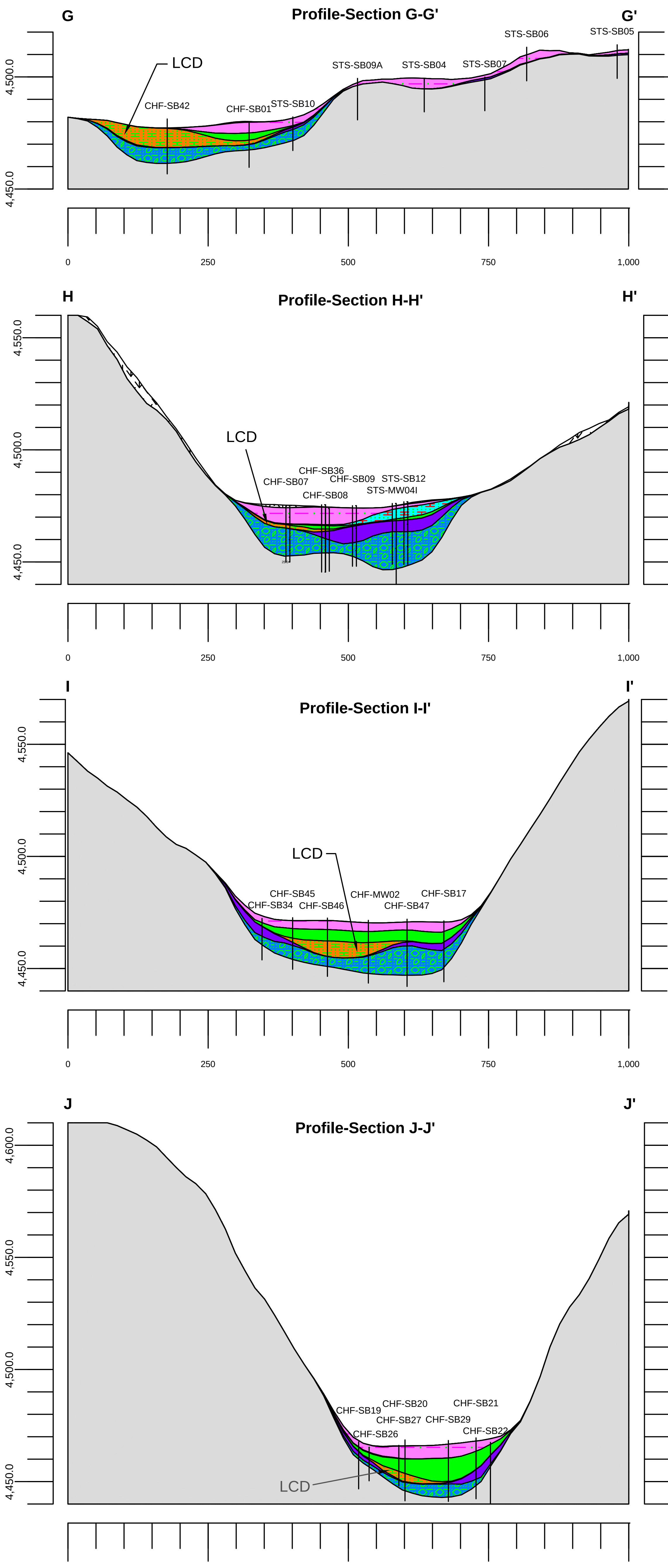
W.A.# 0 - 146

Figure 6-4a
Profile Sections Upper Chaparral Gulch
(CC' to FF')
Iron King Mine Site
Dewey-Humboldt, Arizona

J:/SERAS01_Projects/ACAD_2013/00-146/DEdgerton_Projects/SEC6_PRF_CC_DD_EE_FF_f4-a.dwg

01/21/15



Stratigraphy

Recent
- Loam
- Uppermost Channel Deposit (UCD)

Quaternary
- HS Tailings (Oxidized)
- Humboldt Smelter Channel Deposit (HSCD)
- HS Tailings (Reduced)
- Lowermost Channel Deposit (LCD)
- Brown Clay
- Principle Fluvial Gravel (PFG)

Bedrock
- Hickey Formation or Iron King Volcanics

Note: Summary of Hydrostratigraphy is displayed in Figure 6-2.

Scale:

50'

0

200'

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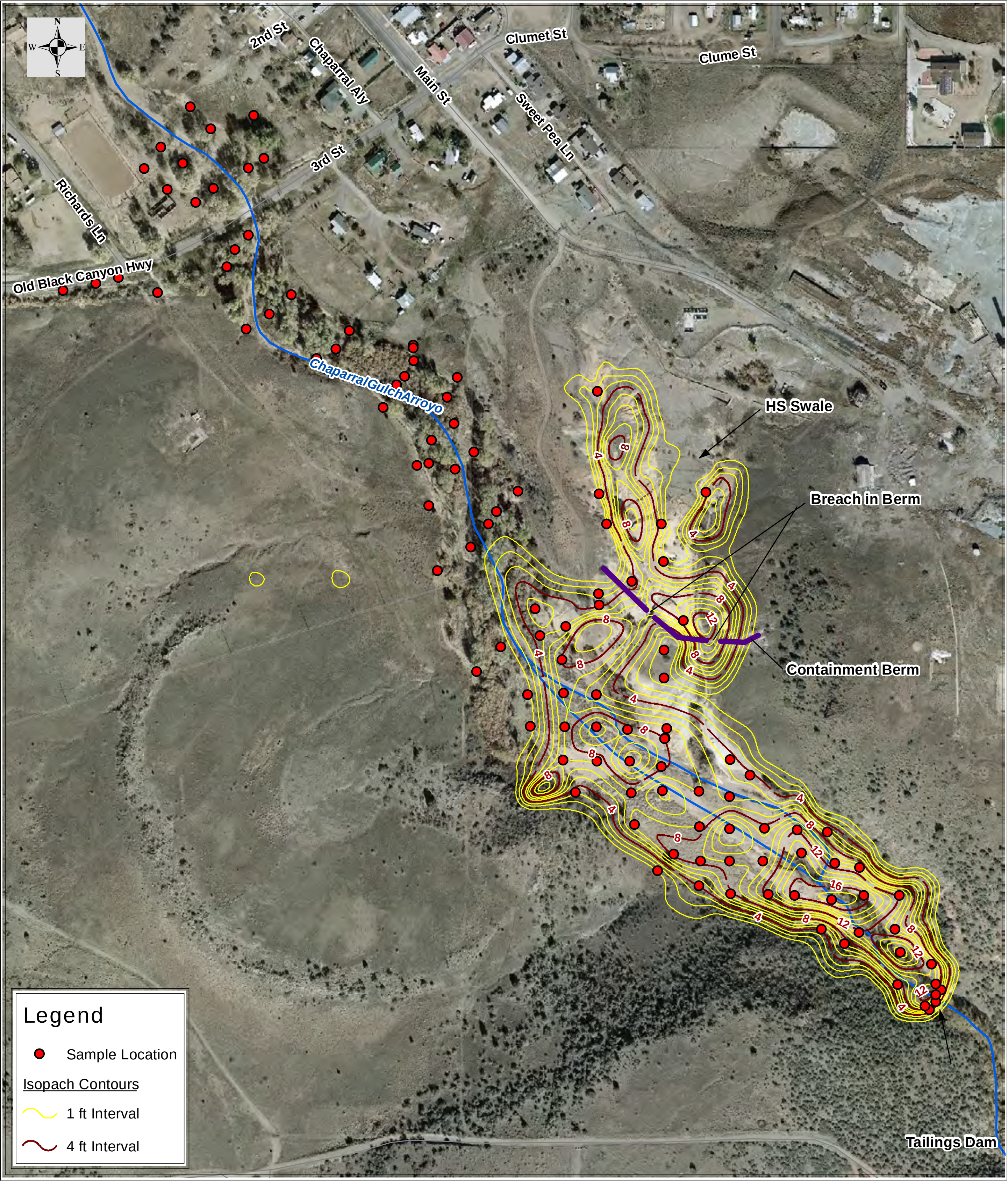
W.A.# 0 - 146

Figure 6-4b
Profile Section Chaparral Gulch Flood Plain
(GG' to JJ')
Iron King Mine Site
Dewey-Humboldt, Arizona

J:/SERAS01_Projects/ACAD_2013/00-146/DEdgerton_Projects/PRF_GG_HH_II_JJ_f6-4b.dwg

01/21/15



Base map created using 2010 orthoimagery, sampling data from 2014, contouring data exported from Rockware

Map Creation Date: 22 January 2015

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

0 400 800 Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC6_Chaparral_Gulch_Models\146_SEC6_Tailings_Isopach_Contours_f6-5

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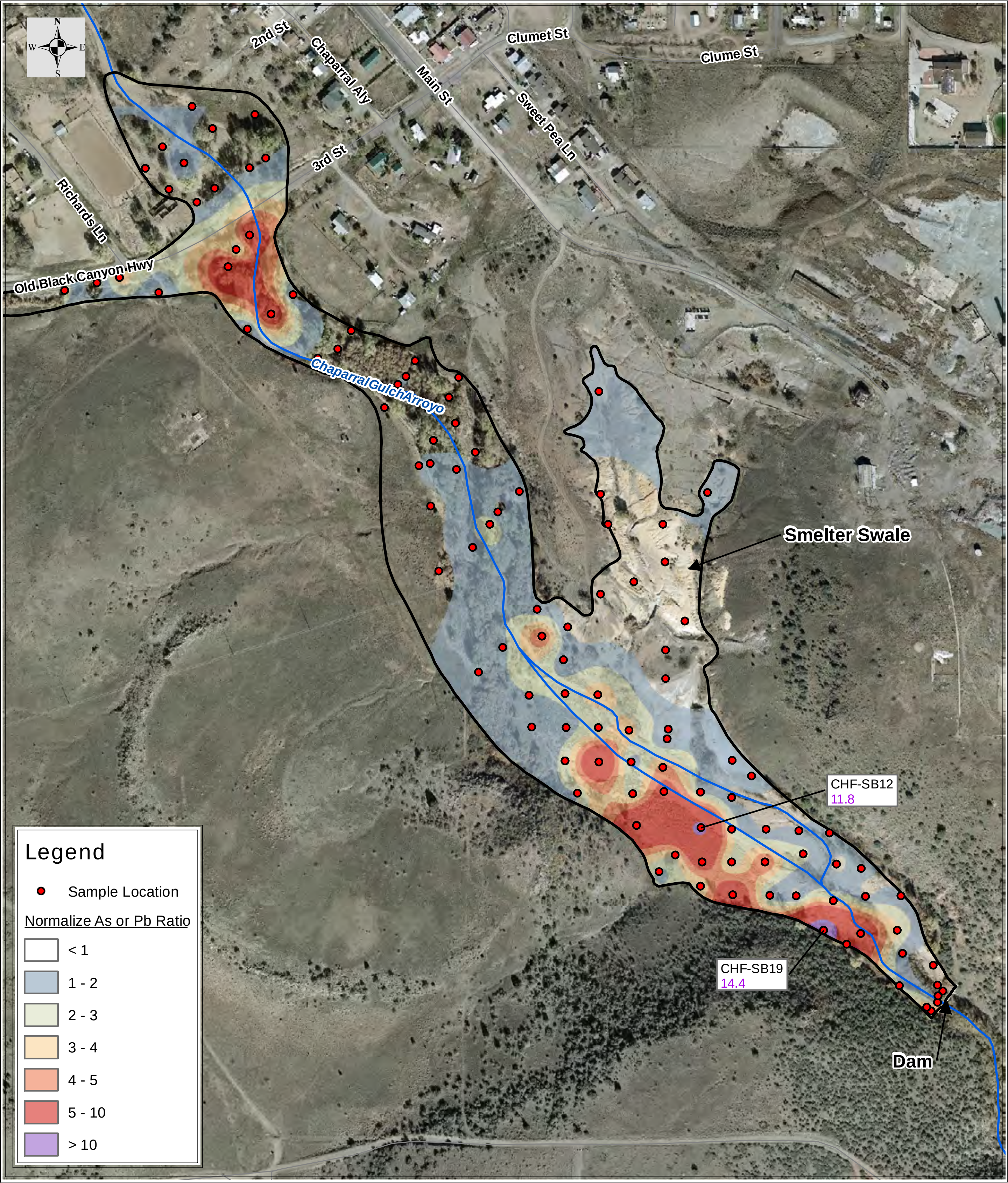
W.A.# 0-146

Figure 6-5
Tailings (Isopach map)
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, sampling data from 2014.

Map Creation Date: 08 January 2015

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Note:
Greater ratio of As/200 mg/kg or Pb/400 mg/kg represents soil exceeding threshold concentrations (contaminated soil).

0 400 800 Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC6_Chaparral Gulch Models\146_SEC6_PlanSection_0-5ft_BelowGrade_f6-6a

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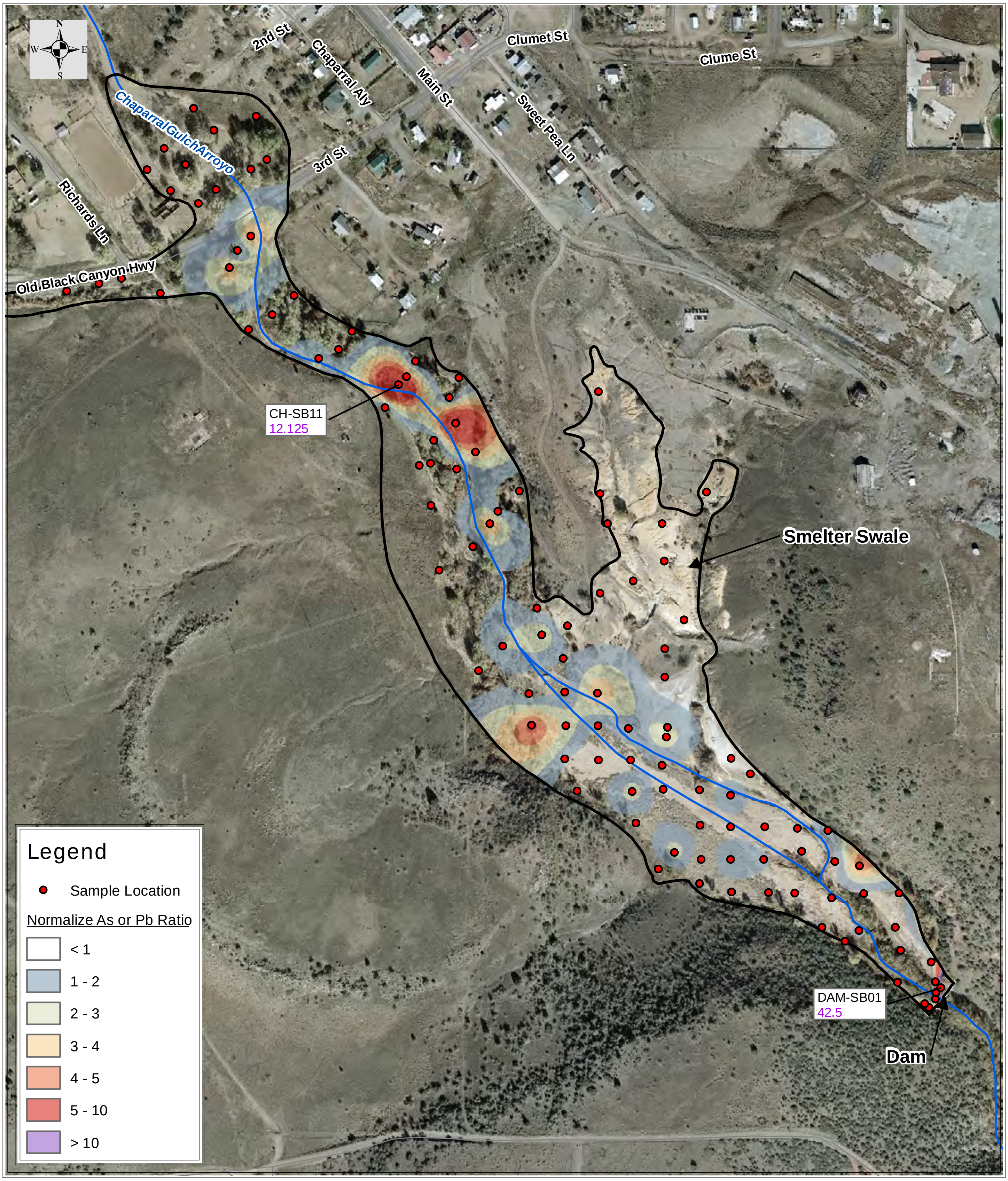
W.A.# 0-146

Figure 6-6a
Plan Section 0-5 ft Below Grade
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, sampling data from 2014.

Map Creation Date: 08 January 2015

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite
\SEC6_Chaparral Gulch Models
\146_SEC6_PlanSection_5-10ft_BelowGrade_f6-6b

Note:
Greater ratio of As/200 mg/kg or Pb/400 mg/kg represents soil exceeding threshold concentrations (contaminated soil).

0 400 800
Feet

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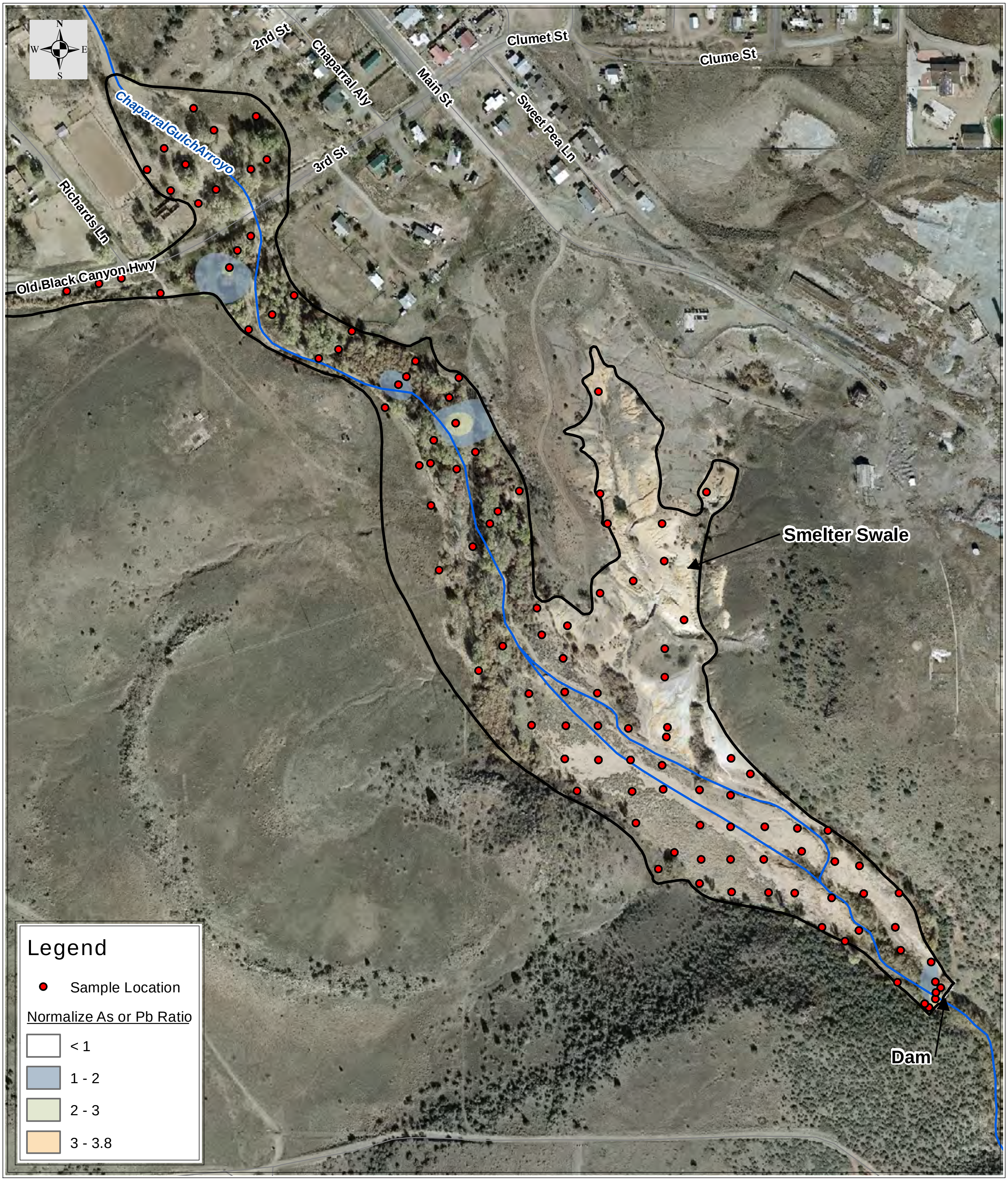
Figure 6-6b
Plan Section 5-10 ft Below Grade
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, sampling data from 2014.

Map Creation Date: 08 January 2015

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC6_Chaparral Gulch Models\146_SEC6_PlanSection_10-15ft_BelowGrade_f6-6c

Note:
Greater ratio of As/200 mg/kg or Pb/400 mg/kg represents soil exceeding threshold concentrations (contaminated soil).

0 400 800 Feet

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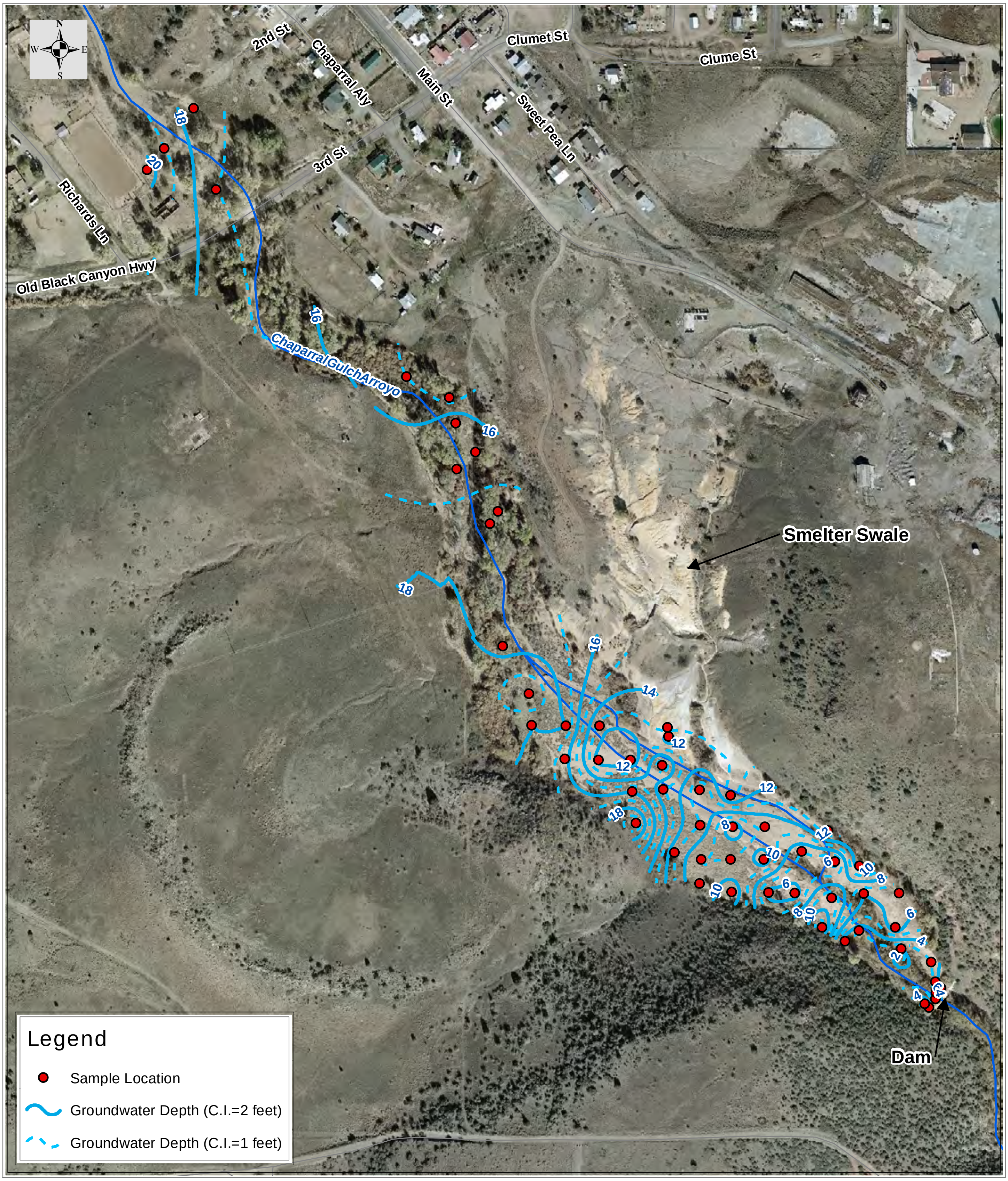
W.A.# 0-146

Figure 6-6c
Plan Section 10-15 ft Below Grade
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, sampling data from 2014.

Map Creation Date: 13 January 2015

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

0 400 800 Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC6_Chaparral Gulch Models\146_SEC6_GW_Depth_WaterMeasurements _f6-7

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EP-W-09-031
W.A.# 0-146

Figure 6-7
Depth to Water Measurements
Iron King Mine Site
Dewey-Humboldt, Arizona

Base map created using 2010 orthoimagery,
sampling data from 2014, contour data exported from Rockware

Map Creation Date: 08 January 2015

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite
\SEC6_Geologic_Models\146_SEC6_Schematic_Groundwater_Flow_f6-8

0 400 800
Feet

U.S. EPA Environmental Response Team
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EP-W-09-031
W.A.# 0-146

Figure 6-8
Schematic Groundwater Flow
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 6-A
Rockworks16™ Modeling Parameters
for the Chaparral Gulch Arroyo
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX B
Rockworks16™ Modeling Parameters™
for the Humboldt Smelter Swale
Iron King Mine Site
Dewey-Humboldt, Arizona

SECTION 7 - GROUNDWATER SAMPLING: NEW AND EXISTING WELLS

7.1 INTRODUCTION

There are a number of private wells and two co-located municipal wells that are used for drinking water and domestic uses in the vicinity of the Site. Knowledge of groundwater quality is essential in order to characterize the potential impacts of the Site on groundwater resources. Groundwater quality data will also provide information for input to a future Site risk assessment and comparison to "*applicable or relevant and appropriate requirements*" (ARARs). The results of the risk assessment and ARARs evaluation will be used to determine if remedial actions are required for groundwater (CH2M Hill, 2013). Potential remedial alternatives for groundwater include institutional controls and the use of municipal drinking water supplies (instead of private wells) in areas where contaminated groundwater is present (i.e., where contaminant concentrations in groundwater exceed drinking water standards and other ARARs).

Prior to 2014, information pertaining to groundwater quality within the Site study area was based on data from 12 existing monitor wells and a limited number of private water supply wells. However, borehole lithologic logs and water level information is generally very limited and/or not available for the private wells. To supplement the existing monitor well network, a number of new wells were installed in 2014 (refer to Sections 1, 4 and 5).

The primary objectives of the groundwater sampling were to:

1) Further evaluate contaminant distributions in groundwater throughout the study area, and

2) Develop a detailed knowledge of the groundwater chemistry for assessing the chemical signatures of the groundwater and understanding the chemical reactions that are occurring along the groundwater flow paths.

Water levels were recorded in the existing monitor wells on three separate occasions (June, July and October 2014) and in the new wells on two occasions (July and October 2014). Both existing and new monitor wells were sampled in July and October 2014.

7.2 METHODOLOGY

Between June 10 and June 12, 2014, water levels were recorded in the existing site monitor wells. Subsequent to this event, water levels and groundwater samples were obtained from both the existing and new monitor wells on two occasions: late July and late October 2014. Monitor well information is summarized in Table 7-1 and the locations are shown in Figure 7-1.

Prior to sampling, static water levels were measured in the wells using an electronic water level indicator in conformance with Scientific, Engineering, Response and Analytical Services (SERAS) standard operating procedure (SOP) #2043, *Water Level Measurement*. A number of wells were found to be dry or only having minimal water, which precluded sampling. These included STS-MW-4S, MTP-MW-01 through -03, MW-08S, and MW-09S. Groundwater indicator parameters could not be obtained for MW-11S in July 2014 and this well was not sampled in October 2014 due to minimal water levels.

All other wells were purged and subsequently sampled using submersible pumps and black polyethylene discharge tubing in accordance with SERAS SOP #2007, *Groundwater Well Sampling*. At each location, attempts were made to purge three well volumes prior to sampling. In a number of instances, wells were purged dry and then required time to recover before being sampled. These wells included MW-02S, MW-04S, MW-07D, MW-08D, MW-09D, MW-11S (July event), and CHF-MW-01 (July event).

Prior to collection of groundwater samples for laboratory analysis, groundwater indicator parameters were measured in the field using calibrated Horiba U-52 multi-parameter water quality meters on a small aliquot of groundwater obtained from each well. The indicator parameters included pH, oxidation/reduction potential (ORP or Eh), dissolved oxygen (DO), specific conductivity, salinity, temperature, TDS and turbidity. Ferrous iron (Fe^{2+}) was additionally measured with field test kits employing the *phenanthroline method* (CHEMetrics, Inc., kit # K-6210).

Groundwater samples were collected for the following laboratory analyses:

- Target Analyte List (TAL) metals: total (unfiltered samples)
- TAL metals: dissolved (filtered samples)
- Water quality parameters, which included: alkalinity/carbonate/bicarbonate, chloride, fluoride, nitrate + nitrite (as N), sulfate, phosphorus (as P), total silica, dissolved organic carbon (DOC), and total dissolved solids (TDS)

A 0.45 micron cartridge filter and peristaltic pump were used to filter required aliquots of groundwater for dissolved TAL metals, phosphorus, nitrate + nitrite, and DOC. A dedicated filter cartridge was used for each well and for each sampling event.

7.3 RESULTS

Water level measurements are presented in Table 7-2. Between mid-June and late October 2014, water levels fluctuated in MW-01S plus or minus (±) 21 feet. Additionally, between late July and late October, water levels in several of the new deep wells increased (recovered) with the most significant increase in MW-2D.

A list of the groundwater samples for both sampling events along with the associated laboratory analyses is presented in Table 7-3. Groundwater indicator parameters for both sampling events, as recorded in the field, are summarized in Table 7-4. The ferrous iron results for groundwater samples are summarized in Table 7-5.

All of the groundwater analytical results can be found in the project SCRIBE file (Appendix A).

7.4 REFERENCES

CH2M Hill, 2013. *Data Gap Analysis Report (draft): Iron King Mine – Humboldt Smelter Superfund Site, Dewey-Humboldt, Yavapai County, Arizona*. Prepared for the U.S. Environmental Protection Agency, Region 9. April 2013.

Chemetrics. 2014. *The Phenanthroline Method (total & soluble; total and ferrous).* http://www.chemetrics.com/Iron

Horiba. 2009.Multi Water Quality Checker U-50 Series. Instruction Manual. http://www.horiba.com/fileadmin/uploads/Process-Environmental/Documents/U-50_Manual_revised_0409.pdf

TABLE 7-1
Monitor Well Summary
Iron King Mine Site
Dewey-Humboldt, Arizona

Well	Latitude	Longitude	MP (ft-amsl)	Well Type	Well head	Screen Top (ft-bgs)	Screen Bottom (ft-bgs)
CHF-MW-01	34.493198	-112.233592	4467.72	2" PVC	SU	2	12
CHF-MW-02	34.494196	-112.235271	4474.60	2" PVC	SU	7.5	22.5
CHF-MW-03	34.495025	-112.236594	4480.62	2" PVC	SU	11	21
STS-MW-4S	34.494937	-112.235909	4476.10	2" PVC	SU	3	8
STS-MW-4I	34.494930	-112.235916	4479.01	2" PVC	SU	18	28
MTP-MW-01	34.498939	-112.247984	4643.42	4" PVC	SU	25	45
MTP-MW-02	34.500554	-112.251444	4749.23	4" PVC	SU	61	81
MTP-MW-03	34.499513	-112.252864	4746.67	4" PVC	SU	86	106
MW-01S	34.498828	-112.232220	4543.59	4" PVC	SU	106	121
MW-02S	34.496463	-112.236637	4516.84	4" PVC	SU	37	52
MW-02D	34.496493	-112.236616	4516.31	4" PVC	SU	306	356
MW-03S	34.497726	-112.248066	4607.28	4" PVC	Flush	23	38
MW-04S	34.500011	-112.248997	4640.68	4" PVC	SU	42	57
MW-05S	34.498252	-112.249225	4640.64	4" PVC	SU	42	57
MW-06D	34.503337	-112.256046	4760.31	4" PVC	SU	315	345
MW-07S	34.499015	-112.246059	4562.49	4" PVC	Flush	14	29
MW-07D	34.499017	-112.245832	4561.69	4" PVC	Flush	325	355
MW-08S	34.499248	-112.249063	4638.62	2" PVC	Flush	16	31
MW-08D	34.499249	-112.249062	4638.59	2" PVC	Flush	45	60
MW-09S	34.501326	-112.253381	4751.91	2" PVC	Flush	52	72
MW-09D	34.501313	-112.253376	4751.65	2" PVC	Flush	158	178
MW-10S	34.501917	-112.241619	4530.29	4" PVC	Flush	34	49
MW-10D	34.501902	-112.241605	4530.11	4" PVC	Flush	294.5	324.5
MW-11S	34.500114	-112.238005	4566.99	4" PVC	Flush	62	77
MW-12S	34.503254	-112.235649	4511.87	4" PVC	Flush	30	45
MW-12D	34.503255	-112.235632	4511.83	4" PVC	Flush	135	175

Horizontal reference: NAD 83; Vertial reference: NAVD 88 (Note: MP elevations for existing wells converted to NAVD 88)

ft-amsl: feet above mean sea level; ft-bgs: feet below ground surface

SU: stick-up (vs. flush-mount); MP: measuring point elevation

Bold lettering = new well (installed in 2014)

TABLE 7-2
Monitor Well Water Level Measurements
Iron King Mine Site
Dewey-Humboldt, Arizona

Well	MP (ft-amsl)	Depth to Water (feet below MP)		
		June 2014	July 2014	October 2014
CHF-MW-01	4467.72	6.13	5.69	4.66
CHF-MW-02	4474.60	10.7	10.9	8.33
CHF-MW-03	4480.62	16.39	16.13	13.44
STS-MW-4S	4476.10	dry	dry	dry
STS-MW-4I	4479.01	14.9	8.89	12.32
MTP-MW-01	4643.42	dry	dry	dry
MTP-MW-02	4749.23	dry	dry	dry
MTP-MW-03	4746.67	dry	dry	dry
MW-01S	4543.59	105.08	115.81	95.55
MW-02S	4516.84	43.16	43.81	41.53
MW-02D	4516.31	NA	334.17	111.79
MW-03S	4607.28	29.05	30.64	27.8
MW-04S	4640.68	47.97	48.41	47.4
MW-05S	4640.64	46.01	47.02	45.03
MW-06D	4760.31	212.4	210.25	210
MW-07S	4562.49	6.69	11.1	8.79
MW-07D	4561.69	31.67	29.2	22.16
MW-08S	4638.62	31.05	31.06	dry
MW-08D	4638.59	40.39	41.42	37.52
MW-09S	4751.91	72.17	72.25	dry
MW-09D	4751.65	93.9	94.35	94.3
MW-10S	4530.29	NA	21.27	20.03
MW-10D	4530.11	NA	96.73	78.91
MW-11S	4566.99	NA	75.5	76.17
MW-12S	4511.87	NA	22.31	20.57
MW-12D	4511.83	NA	85.92	63.5

MP: measuring point; ft-amsl: feet above mean sea level
NA = Not Applicable (not installed or completed at this time)

June 2014 (6/10 - 6/12)
July 2014 (7/28 - 7/30)
October 2014 (10/20)

TABLE 7-3
Laboratory Analysis of Groundwater Samples
Iron King Mine Site
Dewey-Humboldt, Arizona

Well	Sample #	Sample Date	TAL Metals (dissolved)	TAL Metals (total)	Water Quality
CHF-MW-01	CHF-MW-01	7/29/2014	X	X	X
CHF-MW-01	CHF-MW-01a	10/21/2014	X	X	X
CHF-MW-02	CHF-MW-02	7/29/2014	X	X	X
CHF-MW-02	CHF-MW-02a	10/21/2014	X	X	X
CHF-MW-03	CHF-MW-03	7/29/2014	X	X	Silica not analyzed
CHF-MW-03	CHF-MW-03a	10/21/2014	X	X	X
STS-MW-4I	STS-MW-04I	7/29/2014	X	X	X
STS-MW-4I	STS-MW-04Ia	10/21/2014	X	X	X
MW-01S	MW-01S	7/29/2014	X	X	X
MW-01S	MW-01Sa	10/22/2014	D	D	D
MW-02S	MW-02S	7/29/2014	X	X	X
MW-02S	MW-02Sa	10/23/2014	X	X	X
MW-02D	MW-02D	7/31/2014	X	X	X
MW-02D	MW-02Da	10/21/2014	X	X	X
MW-03S	MW-03S	7/29/2014	D	D	D
MW-03S	MW-03Sa	10/22/2014	X	X	X
MW-04S	MW-04S	7/29/2014	X	X	X
MW-04S	MW-04Sa	10/22/2014	X	X	X
MW-05S	MW-05S	7/29/2014	X	X	X
MW-05S	MW-05Sa	10/22/2014	X	X	X
MW-06D	MW-06D	7/28/2014	X	X	X
MW-06D	MW-06Da	10/23/2014	X	X	X
MW-07S	MW-07S	7/30/2014	X	X	X
MW-07S	MW-07Sa	10/22/2014	D	D	D
MW-07D	MW-07D	7/30/2014	X	X	X
MW-07D	MW-07Da	10/22/2014	X	X	X
MW-08D	MW-08D	7/29/2014	X	X	X
MW-08D	MW-08Da	10/22/2014	X	X	X
MW-09D	MW-09D	7/28/2014	X	X	X
MW-09D	MW-09Da	10/23/2014	X	X	X
MW-10S	MW-10S	7/30/2014	X	X	X
MW-10S	MW-10Sa	10/22/2014	X	X	X
MW-10D	MW-10D	7/31/2014	X	X	X
MW-10D	MW-10Da	10/23/2014	X	X	X
MW-11S	MW-11S	7/29/2014	X	NS	NS
MW-12S	MW-12S	7/30/2014	X	X	X
MW-12S	MW-12Sa	10/22/2014	X	X	X
MW-12D	MW-12D	7/30/2014	X	X	X
MW-12D	MW-12Da	10/23/2014	D	D	D

X = Sample collected; D = Duplicate Sample collected; NS = Not Sampled (minimal water in well)

Water Quality: alkalinity/carbonate/bicarbonate, chloride, fluoride, nitrate + nitrite (as N), sulfate, phosphorus (as P), silica, dissolved organic carbon, and total dissolved solids

TABLE 7-4
Groundwater Field Measurements
Iron King Mine Site
Dewey-Humboldt, Arizona

Well	Date	Time	Conductivity (mS/cm)	DO (mg/L)	ORP (mV)	pH (units)	Salinity (percent)	Temperature (Celsius)	TDS (g/L)	Turbidity (NTU)
CHF-MW-01	7/29/2014	11:10	2.2	9.8	-138	7.35	-	19.2	-	173
CHF-MW-02	7/29/2014	10:25	2.4	8.6	157	6.62	-	19.2	-	125
CHF-MW-03	7/29/2014	12:58	2.5	12.6	-76	7.89	-	21.7	-	512
MW-01S	7/29/2014	18:10	22.7	4.2	123	7.22	-	20.8	-	24.3
MW-02S	7/29/2014	14:00	0.9	5.4	93	7.92	-	20.7	-	324
MW-02D	7/31/2014	12:50	0.7	6.6	89	8.43	-	20.1	-	85
MW-03S	7/29/2014	17:30	2.6	7.2	66	7.27	1.3	19.8	1.7	29.8
MW-04S	7/29/2014	16:00	3.1	3.5	137	6.79	1.6	22.3	2.0	9.1
MW-05S	7/29/2014	14:10	3.0	4.8	125	7.11	1.6	22.4	1.9	19
MW-06D	7/28/2014	21:30	0.7	6.3	153	7.42	0.3	22.7	0.4	15.7
MW-07S	7/30/2014	10:40	3.2	10.0	110	7.15	1.7	17.9	2.1	8.6
MW-07D	7/30/2014	16:42	0.8	4.2	-313	10.19	0.4	25.4	0.4	25
MW-08D	7/29/2014	10:35	3.9	9.3	22	6.69	2.1	21.1	2.5	680
MW-09D	7/28/2014	14:10	1.6	8.2	75	7.82	0.8	21.2	1.0	15.1
MW-10S	7/30/2014	12:30	1.2	4.3	92	8.59	-	20.6	-	120
MW-10D	7/31/2014	13:05	0.6	6.1	86	8.57	-	21.9	-	72.6
MW-12S	7/30/2014	15:30	0.9	6.9	93	8.64	-	21.0	-	124
MW-12D	7/30/2014	16:30	1.4	4.0	149	8.04	-	20.5	-	44.6
STS-MW-4I	7/29/2014	14:45	2.2	5.5	43	7.55	-	21.5	-	291
CHF-MW-01	10/21/2014	15:45	3.2	9.1	-73	6.79	0.2	18.2	2.0	524
CHF-MW-02	10/21/2014	14:20	2.4	8.4	121	6.66	0.1	18.1	1.5	3.7
CHF-MW-03	10/21/2014	13:30	2.6	8.7	204	6.37	0.1	18.9	1.6	233
MW-01S	10/22/2014	11:45	11.9	8.0	147	7.29	0.7	19.6	7.0	37.8
MW-02S	10/23/2014	14:45	0.0	9.7	125	7.39	0.0	22.2	0.0	118
MW-02D	10/21/2014	12:30	0.0	6.9	99	8.76	0.0	30.2	-	163
MW-03S	10/22/2014	9:40	2.6	7.6	152	7.03	0.1	16.9	1.7	14.6
MW-04S	10/22/2014	14:45	3.3	8.4	151	6.89	0.2	21.4	2.1	7.7
MW-05S	10/22/2014	15:45	3.2	10.1	249	6.88	0.2	24.9	2.0	126
MW-06D	10/23/2014	15:05	0.8	10.6	228	7.33	1.0	23.2	-	123
MW-07S	10/22/2014	9:55	3.2	9.3	249	6.48	0.2	18.6	-	16.1
MW-07D	10/22/2014	10:25	0.8	9.6	-78	10.3	0.0	20.0	-	98
MW-08D	10/22/2014	15:25	4.1	8.0	-49	6.59	0.2	23.6	2.6	152
MW-09D	10/23/2014	14:10	2.0	12.5	223	6.76	0.1	23.7	-	0
MW-10S	10/22/2014	13:25	1.1	11.4	219	7.8	0.1	21.0	-	18.4
MW-10D	10/23/2014	16:35	1.0	7.9	114	8.29	0.0	23.0	2.1	39.4
MW-12S	10/22/2014	15:05	1.0	11.9	229	7.76	0.0	20.4	-	206
MW-12D	10/23/2014	16:00	1.5	12.0	234	7.58	0.1	20.3	-	10.1
STS-MW-4I	10/21/2014	12:50	2.6	8.5	269	6.29	0.1	19.0	1.7	19.6

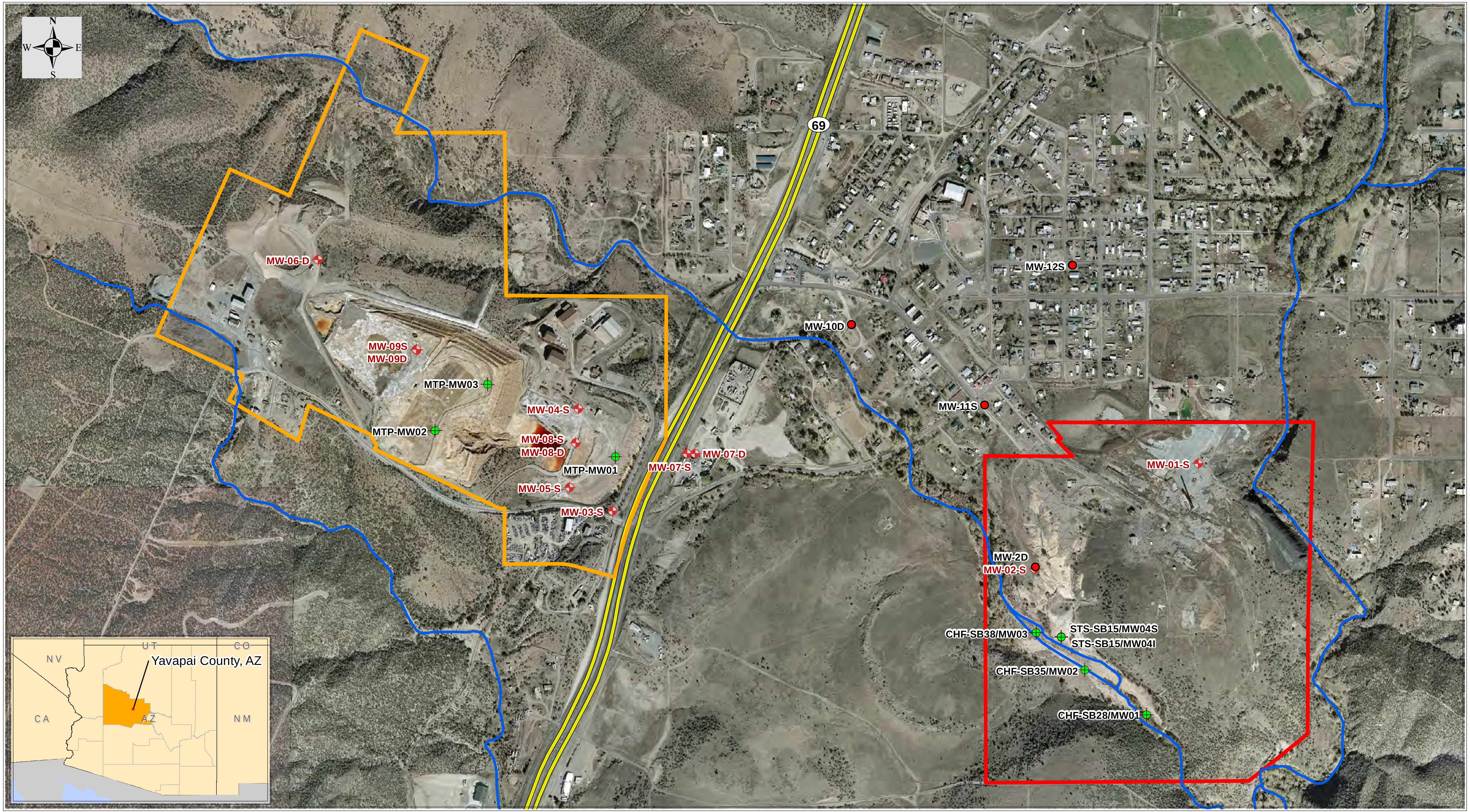
mS/cm - millisiemens per centimeter; DO - dissolved oxygen (milligrams per liter); ORP - oxidation-reduction potential (millivolts);
TDS - total dissolved solids (grams per liter); NTU - nephelometric turbidity units

TABLE 7-5
Ferrous Iron in Groundwater
Iron King Mine Site
Dewey-Humboldt, Arizona

Well	Date	Ferrous Iron (ppm)	
CHF-MW-01	10/21/2014	>10	
CHF-MW-02	10/21/2014	0.4	
CHF-MW-03	10/21/2014	0.2	
MW-01S	10/22/2014	0.05	
MW-01S	10/22/2014	0.05	
MW-02S	10/23/2014	0.1	
MW-02D	10/21/2014	0.6	
MW-03S	10/22/2014	0.05	
MW-04S	7/29/2014	0.1	
MW-04S	10/22/2014	0.05	U
MW-5S	7/29/2014	0.3	
MW-05S	10/22/2014	0.2	
MW-6D	7/28/2014	0.05	
MW-06D	10/23/2014	0.05	
MW-7S	7/30/2014	0.05	
MW-07S	10/22/2014	0.05	
MW-07D	10/22/2014	0.1	
MW-8D	7/29/2014	8.5	
MW-08D	10/22/2014	4	
MW-9D	7/28/2014	0.05	
MW-09D	10/23/2014	0.05	
MW-10S	10/22/2014	0.05	
MW-10D	10/23/2014	0.1	
MW-12S	10/22/2014	0.1	
MW-12D	10/23/2014	0.05	U
STS-MW-4I	10/21/2014	0.1	

U - not detected at or above the minimum detection limit

ppm - parts per million



Base map created using 2010 orthoimagery,
monitor well location from GPS survey.

Map Creation Date: 10 October 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC7_Groundwater_Sampling
\146_SEC7_Monitoring_Well_Locations_f7-1

Legend

ERT/SERAS - Mornitor Wells (2014)
ERT/SERAS - Tailing Wells (2014)
Existing Well Location

Area of Interest
Iron King Mine
Humboldt Smelter

0 750 1,500
Feet

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 7-1
Monitoring Well Locations
Iron King Mine Site
Dewey-Humboldt, Arizona

SECTION 8 – SURFACE WATER SAMPLING AND MONITORING

8.1 INTRODUCTION

The Chaparral Gulch watershed comprises an area of approximately 9-square miles (Figure 8-1). The headwaters of the watershed originate within the foothills of the Bradshaw Mountains within the Prescott National Forest. Tributaries to Chaparral Gulch consist entirely of unnamed ephemeral washes.

The upper portions of the watershed consist of undeveloped mountain and hill slope areas with dense vegetation. Vegetation in the upper portions of the watershed consists of desert hackberry and manzanita brush with scattered pinon-juniper trees (Cardno, 2014). The vegetation in the lower undeveloped portions of the watershed consists of scattered brush, prickly pear cactus, various types of trees and grasses. The main channel of Chaparral Gulch slopes easterly at an average gradient of approximately 4 percent (%). Gradients approaching or even exceeding 10% (or 10 feet vertical drop per 100 feet horizontal distance) are common along sections of the gulch, especially downstream of the Chaparral Gulch Dam.

Major portions of the Iron King Mine (IKM) and Humboldt Smelter (HS) sites fall within the Chaparral Gulch watershed (Figure 8-2).

The primary objectives of the surface water sampling and monitoring were to:

1) Assess the impact of site sources on surface water quality in the Chaparral Gulch (downstream of the dam) and the adjoining Agua Fria River during the summer 2014 monsoon season when rainfall, surface water flow, and sediment transport are typically at their highest;

2) Collect sediment samples in Chaparral Gulch from the base of the dam to the Agua Fria confluence (over a distance of approximately 1,500 feet) to determine sediment thickness above underlying bedrock and metal concentrations within the sediments; and

3) Estimate peak discharges for surface water flow in Chaparral Gulch (downstream of the dam) during the summer 2014 monsoon season.

8.2 METHODOLOGY

8.2.1 Surface Water Sampling

Two types of surface water samples were collected during this investigation:

- Baseline flow samples and
- Storm water samples using dedicated sampling devices

Baseline flow samples were manually collected during *baseflow* conditions. Baseflow is the runoff that has resulted from the accumulation of water in the watershed from past storm events. It appears as *stream* *flow* even if a rainfall event has not occurred. Baseflow consists of both *interflow* and *groundwater flow* that are intercepted by a stream or drainage course.

Six baseline samples (DAM-SW01 through DAM-SW06) were collected on May 6, 2014 in accordance with Scientific, Engineering, Response and Analytical Services (SERAS) standard operating procedure (SOP) #2013, *Surface Water Sampling*. Samples were analyzed for Target Analyte List (TAL) metals and water quality parameters (alkalinity/carbonate/bicarbonate, chloride, fluoride, nitrate + nitrite (as N), sulfate, phosphorus (as P), total silica, dissolved organic carbon (DOC), and total dissolved solids (TDS). A 0.45-micron cartridge filter and peristaltic pump were used to filter required aliquots of surface water for those analyses that required field filtration (i.e., TAL dissolved metals, phosphorus, nitrate + nitrite, and DOC). A dedicated filter cartridge was used for each sample location. Additionally, field measurements were obtained on sample aliquots using a calibrated Horiba U-52 multi-parameter water quality meter, which included pH, oxidation-reduction potential (ORP or Eh), specific conductivity, temperature, dissolved oxygen (DO), and turbidity. Sampling locations and results for this particular set of samples are presented in SECTION 9 (*Biological Survey and Bioassessment Sampling*) and are not further discussed in this section.

Dedicated sampling devices were installed at nine locations (Figure 8-3) to collect storm water samples in the absence of field personnel. While the storms within this region can reach high intensity (typically occurring during July and August), they are generally both infrequent and of low duration. Thus, by the time field personnel could feasibly mobilize to the site, a runoff event may have completely subsided.

The dedicated sampling devices (described in Appendix 8-A) were installed and utilized in accordance with the manufacturer's guidelines. Each device held approximately 1-liter (L) of water. For locations where both total and dissolved metals, water quality parameters, and field measurements were to be evaluated, four devices were installed to capture the required sample volume. Additionally, at two locations (SWD-06 and SWD-08), eight devices (or two sets) were installed in an attempt to monitor two different flow heights during individual rainfall-runoff events. A list of the sampling locations is as follows (see Figure 8-3):

- SWD-01: Chaparral Gulch, immediately west/northwest of the Highway 69 overpass**
- SWD-02: Chaparral Gulch, immediately south/southeast of Third Street**
- SWD-03: Chaparral Gulch, along the edge of the smelter tailings swale**
- SWD-04: Chaparral Gulch drainage, immediately above dam**
- SWD-05: Along Chaparral Gulch, downstream of dam
- SWD-06: Agua Fria River, downstream of the Chaparral Gulch confluence
- SWD-07: Along Chaparral Gulch, downstream of SWD-05
- SWD-08: Agua Fria River, upstream of the Chaparral Gulch confluence
- SWD-09: Along the south side of Third Street, west of Chaparral Gulch**

** Total metals only (one 1-L sampling device)

Local rainfall was monitored by retrieving daily data from the National Weather Service's website (Flagstaff, Arizona forecast office). The closest weather station is located at Prescott Municipal Airport (Love Field), approximately 14.7 miles northwest of the site. Subsequent to rainfall events, with rainfall accumulations typically equal to or greater than 0.5 inches, staff were deployed to site at the earliest possible dates to check the sampling devices and retrieve water samples that had been collected. After initial sample collection in late July/early August 2014, the devices were thoroughly cleaned and re-set. Attempts were made to retrieve additional samples on two subsequent occasions.

For all sampling events, it was found that some if not many of the devices did not completely fill with water, thus limiting both the number of samples collected and types of analyses that could be performed (especially field measurements). Because of this problem, multiple flow heights could not feasibly be evaluated at SWD-06 and SWD-08 without sacrificing a suite of analyses, field duplicate samples, or both. Because the rainfall appeared to be rather localized within the region, a rainfall event in Prescott did not necessarily equate to the same magnitude event within the Chaparral Gulch watershed (and vice versa), which to some extent, confounded the sampling efforts.

8.2.2 Sediment Sampling

Beginning at the base of the dam and at regularly spaced intervals downstream, a hand auger was advanced through the sediment at eight locations identified as DAM-SED01 through DAM-SED08 (Figure 8-3) down to underlying bedrock (or what was perceived to be bedrock). At most locations, a minimum of two sediment samples (surface and total depth) were collected for pH paste testing (in the field) and analysis of TAL metals. Sediment samples were collected in accordance with SERAS SOP #2016, *Sediment Sampling*.

8.2.3 Surface Water Monitoring

Surveying and Field Observations

During July 2014, a SERAS subcontractor completed a field survey downstream of the Chaparral Gulch Dam. Channel cross-section measurements were obtained at two locations (Figure 8-4) where pressure transducers had been installed by SERAS to monitor changes in water height (or flow) over time. At both locations, survey data were gathered at an estimated perpendicular to the existing flow line of Chaparral Gulch. The sections (C-C’ and D-D’) were separated by a horizontal distance of approximately 69 feet. A longitudinal profile (E-E’) along the primary channel was also surveyed between the two cross sections, which extended an additional 16 feet beyond the sections, in both upstream and downstream directions.

Subsequent to the survey, field observations were performed during July 2014 to assess physical characteristics of the surveyed sections. This information was used to select appropriate values for the Manning’s roughness coefficient (or Manning’s n) that would subsequently be incorporated into hydraulic calculations for determining hydraulic parameters of interest (e.g. discharge and average velocity).

Selection of appropriate values for Manning’s n is very significant to the accuracy of computed water surface profiles. Values of Manning’s n are highly variable and depend on a number of factors including: surface roughness; vegetation; channel irregularities and alignment; obstructions; size and shape of the channel; stage and discharge; and seasonal changes.

Based on the field observations, values for Manning's n were determined along the entire length of both channel cross sections using suggested values that are listed in the HEC-RAS Hydraulic Reference Manual (USACE, 2010). Three (3) categories of Manning's n were used for the cross sections:

Natural Streams – main channels: very weedy reaches, deep pools, or floodways with heavy stands of timber and brush

- Minimum 0.070
- Normal 0.100
- Maximum 0.150

Natural Streams – flood plains: brush (medium to dense brush in summer)

- Minimum 0.070
- Normal 0.100
- Maximum 0.160

Excavated or Dredged Channels – rock cuts; jagged and irregular (for side slopes in Section D-D')

- Minimum 0.035
- Normal 0.040
- Maximum 0.050

Flow Monitoring

Slotted polyvinyl chloride (PVC) pipes were installed at cross sections C-C' and D-D' in the primary channel of Chaparral Gulch where standing water was present. Note: Section D-D' was also the location where one set of the dedicated surface water sampling devices had previously been installed (i.e. SWD-05). Dedicated pressure transducers with data logging capability were inserted into each of the pipes, positioned approximately 2-inches off the bottom, to monitor changes in flow height (or water surface elevation) from early July through late October 2014. The transducer at section D-D' was intended as the "primary" monitoring point as the section appeared to be more ideal for monitoring surface water flow. The transducer at section C-C' was originally intended as a "backup" in the event that the primary one failed.

Hydraulic Calculations

Given the field conditions and extended time frame for this study, direct measurements could not be made for open channel flow. Thus, the determination of discharge and average velocity were determined indirectly by the slope-area method (ASTM, D5130). Knowing the flow height, channel geometry, and other channel conditions, standard methods for open channel flow were used to determine the hydraulic parameters of interest.

A spreadsheet program (*xsecAnalyzer*, Version 15), developed by the Natural Resources Conservation Service (NRCS), was used to perform the hydraulic calculations. This tool provides for examination of stream or river cross-sections and determination of hydraulic parameters, such as flow area, discharge and average velocity.

The discharge at Section D-D' was initially derived for peak and average flows as the channel cross section appeared to be more ideal for measuring surface water flow (based on field observations). This section is bounded by natural rock walls on either side. Peak discharges at Section C-C' (upstream of

Section D-D') were calculated next. Values for Manning's n along Section C-C' were adjusted in an effort to calibrate both peak and average discharges to those derived for Section D-D'. To attain an initial gross calibration, the flood plain Manning's n needed to be decreased to a value of 0.070, which was still within the range of suggested values for the field conditions; albeit at the low end (USACE, 2010).

Considering that the cross sections are relatively close together (approximately 69 feet apart), and assuming minimal concentrated inflow between them, it can then be assumed that the discharges at both should be reasonably equal. A mathematical method was developed as an Excel spreadsheet program (using Visual Basic) that "optimized" the Manning's n between both cross sections for paired flow heights at any given time (i.e. for the entire monitoring period). This in turn, led to deriving one unique or optimized discharge for both cross sections for any given pair of flow heights (or water surface elevations) at a given time.

Rainfall Monitoring

Local rainfall was monitored by retrieving daily data from the National Weather Service's website (Flagstaff, Arizona forecast office). The closest weather station is located at Prescott Municipal Airport (Love Field), approximately 14.7 miles northwest of the site. As previously mentioned, because rainfall appeared to be rather localized within the region, a rainfall event in Prescott did not necessarily equate to the same magnitude event (if any rainfall) within the Chaparral Gulch watershed (and vice versa). Thus, exact or definitive correlations could not be made between rainfall and surface water flow within Chaparral Gulch.

8.3 RESULTS

8.3.1 Surface Water Sampling

A summary of the dedicated surface water samples that were collected in 2014 (along with the specific analyses) is presented in Table 8-1. As indicated in the table, only one sample (from SWD-03) was collected during the October 2014 sampling event. Note: Subsequent to the mid August 2014 sampling event, the devices at SWD-01 and SWD-02 could not be located and were assumed to be either buried beneath sediments or possibly washed away downstream during peak flows.

A limited number of surface water field measurements are presented in Table 8-2. As previously explained in Section 8.1, limited sample volume precluded proper acquisition of field parameters in most instances.

All analytical results can be found in the project Scribe file (Appendix A).

8.3.2 Sediment Sampling

Depth to bedrock measurements are presented in Table 8-3. At location DAM-SED05, bedrock was not encountered at a maximum auger depth of five feet below grade.

A summary of collected sediment samples (with respective depth intervals) is presented in Table 8-4. Given the shallow depth to bedrock, only one sediment sample (per location) was collected at DAM-SED06 and DAM-SED07. Additionally, a second deeper sample was not collected at DAM-SED04 as the material, being very loose and saturated, could not be retained by the hand auger sampling device.

All analytical results can be found in the project Scribe file (Appendix A).

8.3.3 Surface Water Monitoring

Surveying and Field Observations

Acquired survey data are attached in Appendix 8-B, which include tabulated survey data for Sections C-C', D-D' and E-E' (one sheet); and graphical illustrations of C-C', D-D' and E-E' (3 sheets). The channel cross sections also include the selected values for Manning's n based on field observations. The sections in plan-view are shown in Figure 8-4.

Photo documentation for Sections C-C' and D-D' is attached in Appendix 8-C.

Flow Monitoring and Hydraulic Data

The flow monitoring data are quite extensive (10,608 lines of data) and thus, will only be provided as an electronic file (Excel). The flow monitoring began on July 2 and ended on October 20, 2014. Flow heights were measured at 15 minute intervals. The data include both water height (above mean channel bottom) and water surface elevations (above mean sea level) for both cross sections. A graphical plot of the complete data set can be found in Appendix 8-D.

Hydraulic data for recorded peak flows in Chaparral Gulch are summarized in Table 8-5. In addition to the listed average flow, seven (7) significant peak flow events were recorded during the monitoring period. The table lists the date and time for each peak flow event, approximate peak durations (in hours), recorded water height, water surface elevation, and derived values for discharge (Q) and average velocity (V). For flow events having more than one peak, the highest peak flow data are provided, which was the first peak in all cases. Where this occurred, the smaller peaks closely followed the initial peak. Daily rainfall (as recorded in Prescott) and optimized discharge (Q-prime) between both cross sections are also shown in the table.

Individual peak flows ranged from approximately 1.3 to over 9 hours. The average discharge was determined to be less than 1 cubic foot per second (cfs) with peak discharges (under Q-prime) ranging from approximately 5 to 247 cfs. Channel velocities ranged from approximately 1.4 feet per second (fps) at average discharge to over 6 fps at Section C-C' on 8/18/14. Compared to a previous flood hazard study of Chaparral Gulch (Cardno, 2014), the highest peak discharge of 247 cfs falls between a 2-year and 5-year rainfall-runoff event.

Example data runs (i.e. screen shots) for the NRCS spreadsheet program (for both C-C' and D-D') are attached in Appendix 8-D. Electronic files will also be provided (Excel macro-enabled worksheets). An example hydrograph for the peak event on 8/10/14 can also be found in Appendix 8-D.

As with the flow monitoring data, the Manning's n and flow optimization spreadsheet program will only be presented as an electronic file (Excel macro-enabled worksheet; approximately 6 megabytes in size). A write-up for this method along with a number of graphical plots is attached in Appendix 8-E.

Rainfall Data

Daily rainfall data (both tabulated and a histogram plot) are presented in Appendix 8-F. The period extends from July 1 to October 24, 2014. For comparison, daily rainfall at the time of peak flow events was also included in Table 8-5. However, as previously explained, because the rainfall monitoring station is located approximately 14.7 miles from the site, definitive correlations between rainfall and surface water flow in Chaparral Gulch cannot be made as the storms within the region are rather localized.

8.4 REFERENCES

American Society for Testing and Materials (ASTM) D5130-95. Standard Test Method for Open-Channel Flow Measurement of Water Indirectly by Slope-Area Method. (Re-approved 2014).

Cardno, Inc., 2014. Chaparral Gulch Flood Hazard Study, Yavapai County, Arizona: Technical Support Data Notebook. Prepared for the Yavapai County Flood Control District, Prescott, Arizona. FCD # 0142. April 14, 2014.

Natural Resources Conservation Service, 2014. *xsecAnalyzer* Spreadsheet Program, Version 15. January 2014.

U.S. Army Corps of Engineers (USACE), 2010. HEC-RAS River Analysis System, Hydraulic Reference Manual, Version 4.1. Institute for Water Resources, Hydrologic Engineering Center, Davis, California. January 2010.

TABLES

TABLE 8-1
Summary of Dedicated Surface Water Samples
Iron King Mine Site
Dewey-Humboldt, Arizona

Location	Sample #	Sample Date	TAL Metals (dissolved)	TAL Metals (total)	Water Quality Parameters
SWD-01	SWD-01	7/30/2014		X	
SWD-02	SWD-02b	8/15/2014		X	
SWD-03	SWD-03	7/30/2014		X	
	SWD-03a	8/4/2014	X		
	SWD-03c	10/2/2014		X	
SWD-04	SWD-04	7/30/2014		X	
	SWD-04b	8/15/2014		X	
SWD-05	SWD-05	7/30/2014		X	X*
	SWD-05a	8/4/2014	X	X	X**
	SWD-05b	8/15/2014	X	X	X
SWD-06	SWD-06a	8/4/2014	X	X	X
	SWD-06b	8/15/2014	X	X	X
SWD-07	SWD-07	7/30/2014		X	
	SWD-07a	8/4/2014	X		X*
	SWD-07b	8/15/2014	X	X	
SWD-08	SWD-08a	8/4/2014	X	X	X
	SWD-08b	8/15/2014	D	D	D
SWD-09	SWD-09b	8/15/2014		X	

X = Sample collected; D = Duplicate Sample collected

TAL - Target Analyte List

Water Quality Parameters: alkalinity/carbonate/bicarbonate, chloride, fluoride, nitrate + nitrite (as N), sulfate, phosphorus (as P), silica, dissolved organic carbon, and total dissolved solids

*Analyzed for alkalinity/carbonate/bicarbonate, chloride, fluoride, sulfate, and total dissolved solids

**Analyzed for nitrate + nitrite (as N), phosphorus (as P), silica and dissolved organic carbon

TABLE 8-2
Surface Water Field Measurements
Iron King Mine Site
Dewey-Humboldt, Arizona

Location	Date	Conductivity mS/cm	ORP mV	pH S.U.	Turbidity NTU
SWD-05	8/5/2014	1.6	104	7.88	585
SWD-06	8/5/2014	0.75	-84	7.62	1,000
SWD-07	8/5/2014	0.96	83	8.66	1,000
SWD-08	8/5/2014	0.77	-79	7.49	1,000

mS/cm = millisiemens per centimeter
ORP - Oxidation Reduction Potential
mV = millivolts
S.U. = standard units
NTU = nephelometric turbidity units

TABLE 8-3
Depth to Bedrock Measurements
Iron King Mine Site
Dewey-Humboldt, Arizona

Location	Date	Depth to Bedrock (feet)
DAM-SED01	5/7/2014	4.2
DAM-SED02	5/7/2014	4.5
DAM-SED03	5/7/2014	3.5
DAM-SED04	5/7/2014	4.0
DAM-SED05	5/7/2014	>5.0
DAM-SED06	5/7/2014	0.5
DAM-SED07	5/7/2014	0.5
DAM-SED08	5/7/2014	2.0

> = Greater than

TABLE 8-4
Summary of Sediment Samples
Iron King Mine Site
Dewey-Humboldt, Arizona

Location	Sample #	Sample Date	Depth From (feet)	Depth To (feet)
DAM-SED01A	DAM-SED01A	5/6/2014	0.0	0.5
DAM-SED01B	DAM-SED01B	5/6/2014	2.5	3.0
DAM-SED01C	DAM-SED01C	5/6/2014	3.5	4.0
DAM-SED02A	DAM-SED02A	5/6/2014	0.0	0.5
DAM-SED02B	DAM-SED02B	5/6/2014	1.5	2.0
DAM-SED02C	DAM-SED02C	5/6/2014	4.0	4.5
DAM-SED03A	DAM-SED03A	5/6/2014	0.0	0.5
DAM-SED03B	DAM-SED03B	5/6/2014	3.0	3.5
DAM-SED04A	DAM-SED04A	5/6/2014	1.0	1.5
DAM-SED04B	NR	5/6/2014	3.5	4.0
DAM-SED05A	DAM-SED05A	5/6/2014	0.0	0.5
DAM-SED05B	DAM-SED05B	5/6/2014	2.5	3.0
DAM-SED05C	DAM-SED05C	5/6/2014	3.0	3.5
DAM-SED05D	DAM-SED05D	5/6/2014	3.5	4.0
DAM-SED05E	DAM-SED05E	5/6/2014	4.5	5.0
DAM-SED06A	DAM-SED06A	5/6/2014	0.0	0.5
DAM-SED07A	DAM-SED07A	5/6/2014	0.0	0.5
DAM-SED08A	DAM-SED08A	5/6/2014	0.0	0.5
DAM-SED08B	DAM-SED08B	5/6/2014	1.0	1.5

Analysis of all samples included pH paste test (in field) and Target Analyte List (TAL) metals
NR - no sample recovery with hand auger

TABLE 8-5
Summary of Peak Flows in Chaparral Gulch
Iron King Mine Site
Dewey-Humboldt, Arizona

Daily Rainfall (date/total inches)	Peak Flow Event (date/time)	Approximate Peak Durations	Section C - C'				Section D - D'				Q - prime (cfs)
			Water Height (ft)	W.S. EL (ft)	Q (cfs)	V (fps)	Water Height (ft)	W.S. EL (ft)	Q (cfs)	V (fps)	
na	Average Flow	na	0.615	4426.455	0.92	1.41	0.572	4421.492	0.83	1.42	0.88
7/3/14: 0.01	7/3/14, 18:45	1 peak: 4 hours	1.999	4427.839	21.6	3.59	1.727	4422.647	23.6	2.41	23.1
8/3/14: 0.14	8/3/14, 16:15	1 main peak: 3.8 hrs	1.222	4427.062	4.19	2.06	1.148	4422.068	5.84	2.12	5.2
8/10/14: 0.14	8/10/14, 19:30	1 peak: 3.3 hrs	1.727	4427.567	14.2	3.18	1.681	4422.601	21.2	2.39	18.0
8/12/14: 0.96	8/12/14, 19:15	2 peaks: 9.75 & 9 hrs	1.930	4427.770	20.4	3.63	1.741	4422.661	24.3	2.42	22.5
8/13/14: 0.50											
8/18/14: 0.34	8/18/14, 19:15	4 peaks: 1.3, 4.5, 3.5 & 6.2 hrs	3.705	4429.545	291.4	6.45	3.279	4424.199	214.4	4.58	246.7
8/19/14: 1.19											
8/26/14: 0.89	8/26/14, 14:45	1 peak: 3 hrs	2.255	4428.095	32.7	3.83	1.312	4422.232	9.21	2.31	21.0
9/8/14: 0.34	9/8/14, 5:45	1 peak: 2 hrs	1.546	4427.386	9.72	2.75	1.206	4422.126	6.9	2.19	8.5

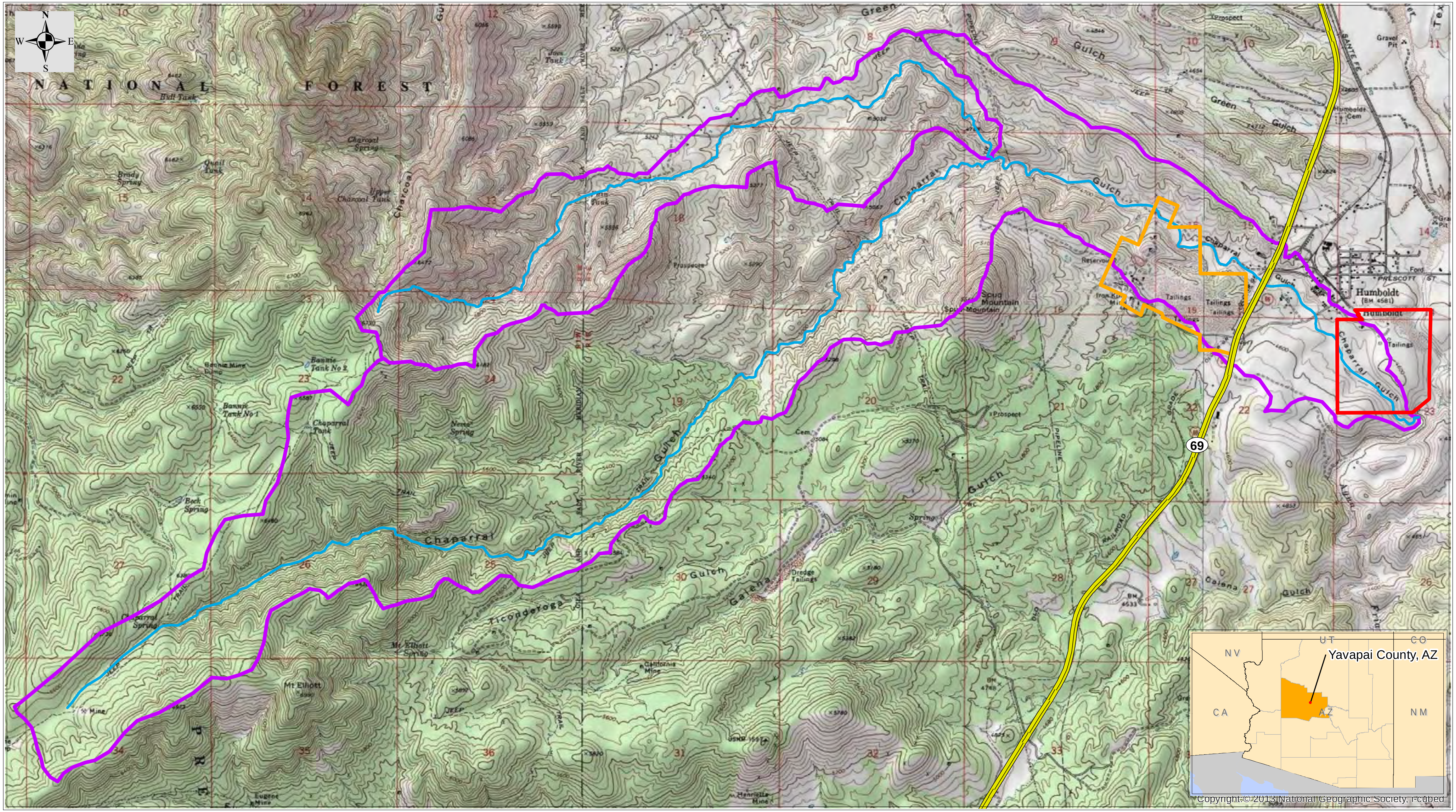
ft - feet
Q - discharge
cfs - cubic feet per second
V - average velocity
fps - feet per second
hrs - hours
Water Height = height above average channel bottom
W.S. EL - water surface elevation (above mean sea level)
na - not applicable

Daily rainfall recorded at Prescott Municipal Airport (Love Field)

Note: For flow events having more than one peak, the highest peak flow data are provided, which was the first peak in all cases.
Where this occurred, the smaller peaks closely followed the initial peak.

Q -prime is the "optimized discharge" based on optimization of Manning's n values between both cross sections.

FIGURES



Base map created using ESRI USA Topo Map, watershed derived from USGS DEM data.

Map Creation Date: 20 January 2015

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\Hydrologic_Monitoring_Plan\146_SEC8_Chaparral_Gulch_Watershed_f8-1.mxd

Legend

Chaparral Gulch Arroyo

Watershed of Chaparral Gulch

Area of Interest

Iron King Mine

Humboldt Smelter

0 2,600 5,200 Feet

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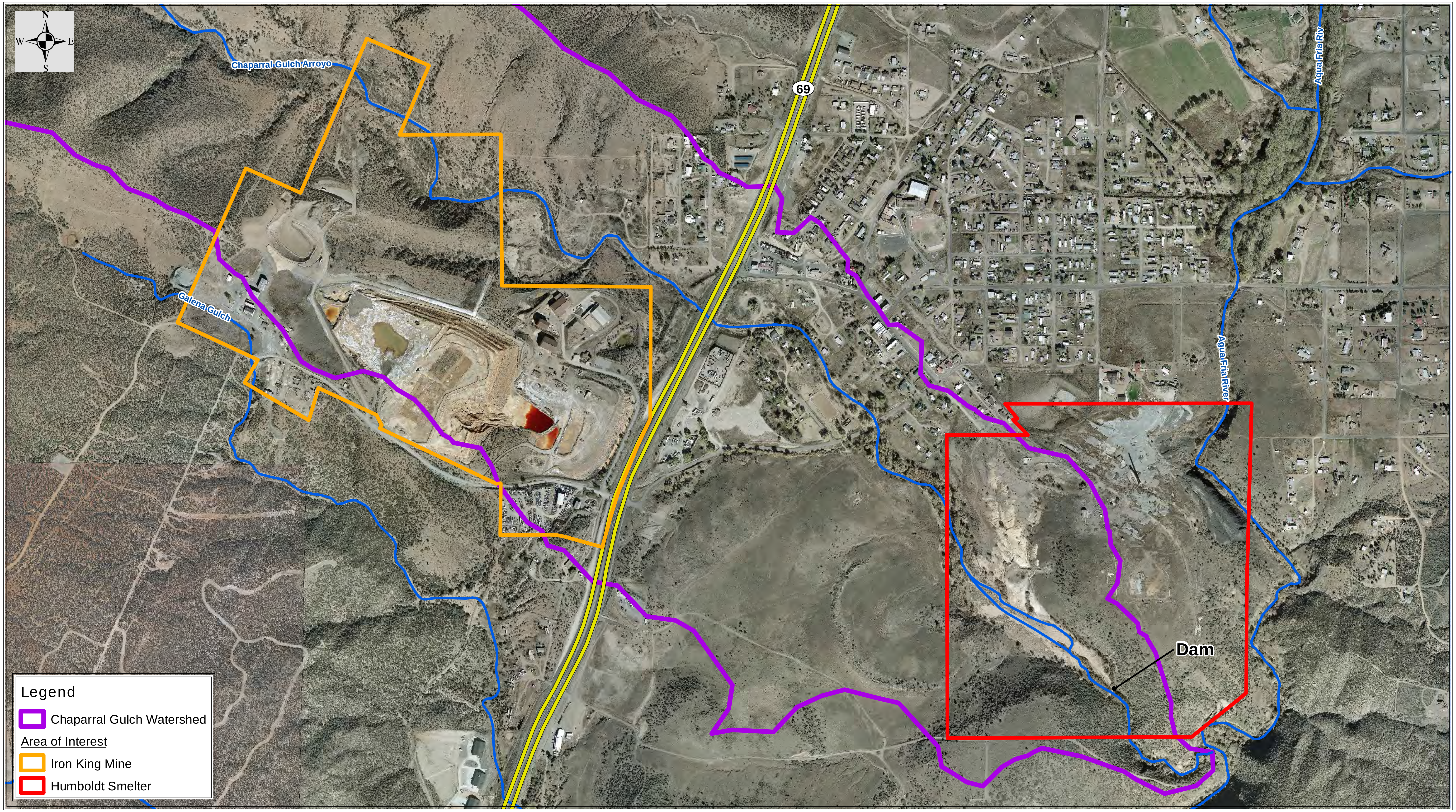
Figure 8-1
Chaparral Gulch Watershed
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using ESRI USA Topo map, watershed derived from USGS DEM data.

Map Creation Date: 20 January 2015

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\Hydrologic_Monitoring_Plan
\146_SEC8_Chaparral_Gulch_Watershed_LowerReach_f8-2.mxd

0 800 1,600
Feet

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Figure 8-2
Chaparral Gulch Watershed
Lower Reach
Iron King Mine Site
Dewey-Humboldt, Arizona

Base map created using 2010 orthoimagery,
sample location GPS survey data from 2014.

Map Creation Date: 08 January 2015

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\Hydrologic_Monitoring_Plan\146_SEC8_Surface_Water_Sediment_Sample_Location_f8-3.mxd

Legend
- Sediment Sample Location
- Storm Water Sampling Devices

0 600 1,200 Feet

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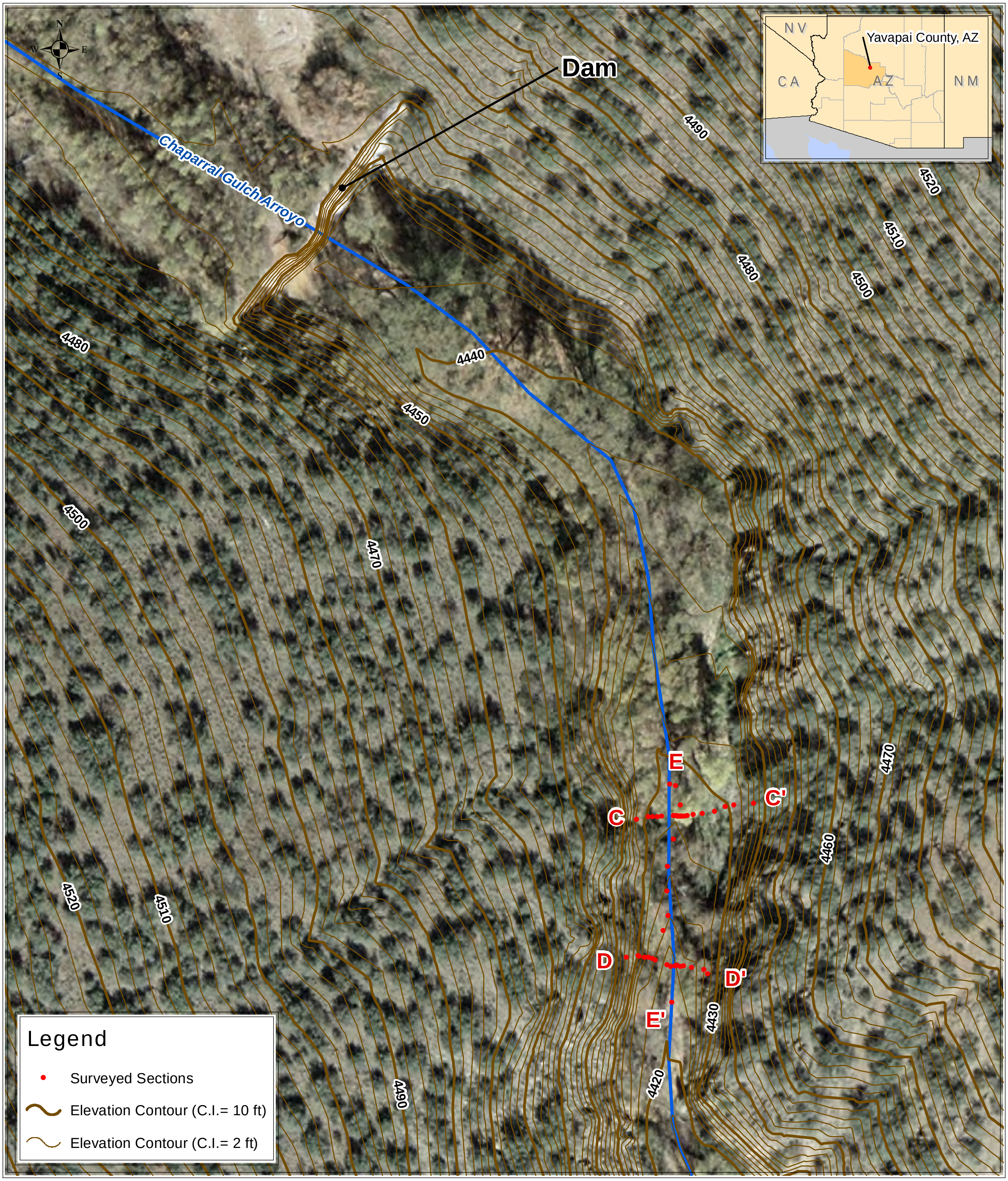
Figure 8-3
Surface Water and Sediment Sample Locations
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery,
cross-section plane location by survey company.

Map Creation Date: 19 November 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite
\IKM_Survey_CrossSection
\146_SEC8_ChGulch_SurveySection_Downtream_ofDam_f8-4

0 60 120
Feet

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W.A.# 0-146

Figure 8-4
Chaparral Gulch Surveyed Sections
Downstream of Dam
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 8-A
Dedicated Surface Water Sampling Device Information
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 8-B
Survey Data
(1 table and 3 illustrations)
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 8-C
Photo Documentation
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 8-D
Flow Monitoring and Hydraulic Data
(4 illustrations)
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 8-E
Manning's n and Flow Optimization Method
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 8-F
Daily Rainfall Data
(1 table and 1 illustration)
Iron King Mine Site
Dewey-Humboldt, Arizona

SECTION 9 - Biological Survey and Bioassessment Sampling

9.1 INTRODUCTION

The Humboldt Smelter (HS) area is covered in approximately 17.5 acres of yellow-orange tailings, 15 acres of grey smelter ash (“dross”), and 10.5 acres of slag. These mine and smelter wastes are sources of lead and arsenic contamination to neighboring areas including sections of Chaparral Gulch, the Agua Fria River, and adjoining drainage channels and outfalls. The objective of this biological effort was to assess riparian corridors and upland areas within the site boundaries that would provide suitable habitat for wildlife and to provide estimates of bioaccumulation for an Ecological Risk Assessment (ERA).

9.2 METHODOLOGY

Pre-selected locations were sampled during this field effort. Plant material, soil, sediment, and surface water were collected and analyzed for Target Analyte List (TAL) metals. Select sediment samples from the Agua Fria River were also analyzed for dioxin/furans and total organic carbon (TOC). Table 9-1 outlines the samples and associated laboratory analyses. Selected surface water samples from the Agua Fria River were analyzed for the water quality parameters as outlined in Table 9-2. The number of samples, analyses desired, and sample matrices were pre-selected prior to fieldwork by the EPA at locations where data was lacking.

Much of the habitat in and around Iron King Mine has been previously defined. Therefore the majority of this biological assessment effort focused on the habitat associated with the riparian corridor of the Agua Fria. Observations on the benthic community and fish population, within the streams and corridors at each of the sampling locations were included at selected locations along the Agua Fria. Any incidental wildlife observed while traveling from throughout the Site was carefully recorded. All observations during field and laboratory efforts were documented in accordance with SERAS SOP #4001, *Logbook Documentation* and SERAS SOP #2002, *Sample Documentation*.

9.2.1 Bioaccessibility Analysis

Ten surface samples of tailings material were collected from the main tailings pile (MTP) (Figure 9-1) for analysis of hexavalent chromium and *in vitro* bioaccessibility (IVBA) testing for lead (Pb) and arsenic (As). Five additional soil samples were collected along Galena Gulch for IVBA analyses indicated on Figure 9-1 as GAL-01 through GAL-05.

9.2.2 Co-located Plant and Soil Samples.

Plant material and associated soil were collected as part of the bioassessment sampling effort. Samples of plant material for analyses were selected based on their proximity to the MTP. The MTP is primarily barren of vegetation. The samples selected focused on grass species. Samples of selected grass were judgmentally (biased) selected within general areas near the MTP where arsenic levels by field portable x-ray Fluorescence (FP XRF; Section 13.2) were found to be elevated during the nonresidential sampling effort in 2014 (Section 12, Figure 12-1). Artificial structures and unvegetated areas were eliminated prior to selection of the actual sampling locations and an effort was made to collect the same grass species from all locations. The grasses were just beginning to emerge from dormancy and much of the vegetative portion was remaining growth from the previous year’s growing season. Grass collected on southern slopes and protected locations had more new green growth on them than grass in exposed areas. Identification was hindered due to lack of floral structure from the previous season, although a few isolated floral structures combined with other characteristics allowed fairly certain identification of the grass as Hairy Grama (*Bouteloua hirsuta*). Each sampling point was centered within a 1.0 meter (m) by 1.0 m square. The square was then divided into four quadrats. Plant density (number of plants per unit area), plant community (species), and soil coverage by vegetation were evaluated for each quadrant independently, according to SERAS SOP #2037, *Terrestrial Plant Community Sampling*. The mean of the parameters calculated for each quadrat represents the vegetative coverage at that sampling point. At some locations the clump of grass was the only vegetation found within the quadrat.

After completion of the site vegetation assessment, one quadrat of the above ground biomass within the 1.0 m by 1.0 m square was collected in accordance with SERAS SOP #2034, *Plant Biomass Determination*. The density of the overall plot was minimal; most of the grass occurred in isolated clumps. Because of this, i the whole clump was used for analyses. Areas adjacent to the grass clump were often barren or contained other plant species. In general, additional biomass samples were not available from the plots. The above ground plant parts used for analyses were cut at 1.0 centimeter (cm) above the soil surface and, if necessary, rinsed with deionized (DI) water and blotted dry with paper towels. A field duplicate was collected at BIOPL-09. Samples were placed in Ziploc bags and preserved at 4 degrees Celsius (^{0}C) prior to submitting to the laboratory for metals analyses. Plant samples were collected on February 27, 2014 and labeled BIOPL-## where "##" represents a unique number one through ten. The locations are indicated on Figure 9-1 as "BIO-01" through "BIO-10)

The table below documents the percent (%) vegetative cover for each quadrat observed while collecting the plant samples for analyses. Each quadrat represents one quarter of a square meter.

Plant Identification	Quadrat 1 %	Quadrat 2 %	Quadrat 3 %	Quadrat 4 %	Average
BIOPL-01	80	20	90	90	70
BIOPL-02	0	40	0	0	10
BIOPL-03	40	40	30	20	32.5
BIOPL-04	30	40	45	40	38.75
BIOPL-05	70	30	70	0	42.5
BIOPL-06	20	0	0	0	5
BIOPL-07	30	05	0	0	8.75
BIOPL-08	20	0	0	0	5
BIOPL-09	30	20	85	15	37.5
BIOPL-10	30	20	0	10	15

Co-located soil sampling was conducted immediately after the vegetation assessment was completed. For each sampling point, a composite of four surface (0-15 cm below ground surface) soil samples was collected from the quadrats of the same square as the vegetation sampling (co-located) and composited. The majority of the grass roots occurred within this upper layer of soil. Each composite soil sample was mixed thoroughly before being placed into a 4-ounce glass jar. Soil samples were packaged and shipped to predetermined laboratories for chemical analysis. All samples were collected in accordance with SERAS SOP #2012, *Soil Sampling*. These samples were likewise labeled BIOSS-## where "##" represents a unique number one through ten. Plant and soil samples collected at the same location were given the same unit number (e.g. BIOSS-01 and BIOPL-01 were both collected at “BIO-01” on Figure 9-1).

9.2.3 Sediment and Surface Water Pairs in the Agua Fria

Sediment and sediment/surface water pairs were collected at the eleven sampling locations within the Agua Fria indicated in Figure 9-1 and outlined in Table 9-1 during the week of May 6, 2014. Sediment was collected according to SERAS SOP #2016, *Sediment Sampling* and surface water was collected according to SERAS SOP #2013, *Surface Water Sampling*. Sediment and surface water samples were analyzed for TAL metals. A select group of subsamples from the Agua Fria were also subject to additional analysis (Table 9-1). As part of the sampling effort outlined in Chapter 8 additional surface water and sediment were collected at the same time and in the same general vicinity. These samples were labeled “DAM-SED##” for sediment and “DAM-SW##” for surface water. Surface water field measurements for these additional “DAM-SW##” samples are included in Table 9-2.

No water was present in the Chaparral Gulch at the time of sampling, with the single exception of a small amount of surface water present below the dam. The majority of the gulch was dry and mostly devoid of vegetation, indicating past and periodic scouring. Surface water samples could not be collected in this gulch. The pH of sediment from all locations was measured in the field. All field analyses and chemical analyses can be found in the associated Scribe database (Appendix A).

9.2.4 Benthic Macroinvertebrate Sampling

An Arizona Game and Fish Department Scientific Collecting Permit was obtained by SERAS prior to fieldwork and benthic collection within the Agua Fria. Water quality parameters and stream flow rates were recorded in the Agua Fria at three locations upstream to downstream, respectively related to the Site (AGBIO-01, AGBIO-06, and AGBIO-11). For the future Site ERA, a limited biological survey occurred to identify species that may be present at the Site. A biological survey had been conducted previously by EA Engineering, Science and Technology, Inc. in 2009 entitled “Biological Evaluation of the Iron King Mine-Humboldt Smelter Superfund Site”. Additional field observations were made during this sampling event, particularly while sampling in and around the Agua Fria.

Benthic macroinvertebrate samples were collected at six sampling locations, AGBIO-01, AGIO-04, AGIO-06, AGBIO-08, AGBIO-09 and AGBIO-11, along the Agua Fria following rapid bioassessment protocols (Barbour *et al* 1999) during the week of May 6, 2014. . The collection procedure employed a long-handled, D-frame net, measuring approximately 45-cm-wide and 20-cm-tall, with 500-micron mesh. An area equal to the width of the net and extending 1-m upstream of the net was sampled. The river bed in this area was disturbed for a period of approximately one minute by rigorously disturbing the bottom substrate with the feet, dislodging organisms, which were swept into the net by the river current. Five one-minute kick-net samples were collected at each sampling location. In most areas the thick presence of algae and firm substrate limited disturbance of the bottom sediment. At times, additional sweeps of the net were made in different microhabitats at the sampling location to better determine the biota present. The benthic organisms were placed into a white 5-gallon bucket and/or white shallow tray and identified by a U.S. Fish and Wildlife Biologist to the lowest taxonomic level and listed on the field data sheet. The organisms or a representative subset of the organisms were then collected for archiving and possible future or more rigorous identification. These voucher specimens were shipped to the Scientific, Engineering, Response and Analytical (SERAS) facility in Edison, New Jersey (NJ). To prevent damage to the organisms during transport, samples were transferred to polyethylene sample bottles after removing large debris, stones, and other extraneous material. Samples were preserved with 70 % isopropyl alcohol and shipped in polypropylene containers to the United States Environmental Protection Emergency Response Team (ERT)/SERAS Biology Laboratory for taxonomic determinations. Sampling and processing benthic macroinvertebrate samples followed SERAS SOP #2054, *Benthic Macroinvertebrate Sampling*.

9.3 OBSERVATIONS

Laboratory analytical results for analytes in plants soil, sediment and water can be found in the Scribe file (Appendix A). Results of the Benthic Community Survey may be found in Appendix 9-A. Photographs may be found in Appendix 9-B. The site is located in the Arizona Chaparral Subtype of the Interior Chaparral Biotic Community (Browne and Lowe). This is composed of open grasslands, chaparral, and sparse woodlands.

9.3.1 February 2014: In the Nonresidential Areas

The tailings of the actual MTP at Iron King Mine (IKM) are very different from the native soil and this area has very little vegetation. In fact, the heart of the MTP is devoid of vegetation with the exception of some re-vegetation test plots set up by the University of Arizona. Native vegetation is growing on these test plots but only with ample soil amendments and regular irrigation. Much of the upland appears to be dominated by shrub live oak (*Quercus turbinella*). Minimal animal life was observed; although that was more likely dependent on the early season resulting in weather that was quite cool at night, particularly for endotherms.

Common Rock Doves (*Columba livia*) were living on the smelter stack, and quail were readily apparent near residences of the town. A roadrunner (*Geococcyx californianus)* was frequently observed near the driveway of the on-site trailer. Gambel's Quail (*Callipepla gambelii*) were fairly common and frequently observed near the entrance to the Dross area. Mourning doves (*Zenaida macrooura*) were also observed frequently at one of the residences near the entrance to the Dross area probably due to bird feeders. Cows were often grazed in or around the Site and evidence of past and present cow grazing was noticeable. Deer tracks were observed in some areas although no actual deer were seen. A couple of desert cottontails (*Sylvilagus auduboni)* were noted while sampling the nonresidential upland areas.

Junipers, Arizona walnut (*Juglands major*), Manzanita (*Arctostaphylos), Ceanonthus,* Velvet Mesquite (*Prosopis velutina*), and sagebrush (*Artemesia ludoviciana*) were also commonly observed on Site. In some areas the shrubs were dense and "trees" grew to 6-feet high but in the majority of the area the shrubs were smaller and stunted and large areas of barren ground were found between individual trees. The non-native trees, Tree of Heaven (*Ailanthus altissima*) and Siberian Elm (*Ulmus pumila*), were found particularly along lower portions of the Chaparral Gulch; the latter also noted near the Agua Fria. Two cactus species, *Opuntia phaecantha* and especially *Opuntia whippei*, were relatively abundant, particularly north of the mine and around and southwest of the dross pile. Because of the late winter season, forbs and grasses were less noticeable and consisted primarily of the dried stalks from the previous growing season leaving little for positive identificati`on. Prickly Poppy (*Argenone pleiacantha*) was observed along the roadcuts among the grasses. Agave and Yucca were observed on occasion while walking through the Site. Russian Thistle (*Salsola tragus*) was found to be very common on Site, noted particularly along the fences and growing around the disturbed edges of the dross area. These are the familiar but not native “tumbleweeds”.

Small mammal burrows were extremely numerous over parts of the Site. These were readily apparent along the Agua Fria and in areas west of the floodplain. The actual small mammals were not observed and are most likely nocturnal. A few small lizards were observed but not frequently, probably more due to the season and cool nights.

A general habitat map for the Site was created several months after the fieldwork and was based primarily on an aerial photo combined with a general knowledge of the Site (figure 9-2). Species observed throughout the Site and associated habitats are listed below:

Common Name	Scientific Name	Habitat Type
Duck	*?*	Riparian
Yellow Finch type bird	*?*	Riparian
Hummingbird	*?*	Riparian
Agave	*Agave sp.*	Semidesert Grassland
Tree of Heaven	*Ailanthus altissima*	Developed/Residential
Mezzanite	*Arctostaphylos sp.*	Chaparral
Prickly Poppy	*Argenone pleiacantha*	Semidesert Grassland
Sagebrush	*Artemesia ludoviciana*	Chaparral
Hairy Grama Grass	*Bouteloua hirsuta*	Semidesert Grassland
Arizona Toad (?)	*Bufo sp.*	Riparian (aquatic)
Gambel's Quail	*Callipepla gambelii*	Developed/Residential
Sedges	*Carex sp.*	Riparian
Rock Dove	*Columba livia*	Disturbed/Bare Soil
Roadrunner	*Geococcyx californianus*	Chaparral
Arizona Walnut	*Juglans major*	Chaparral
Rushes	*Juncus sp.*	Riparian
Mud Turtle	*Kinosternon arizonense*	Riparian
Water Cress	*Nasturtium officinale*	Riparian
Cactus	*Opuntia phaecantha*	Semidesert Grassland
Cholla	*Opuntia whippei*	Semidesert Grassland
Harris' Hawk	*Parrabuteo unicintus*	Riparian
Fremont's Cottonwood	*Populus fremontii*	Riparian
Poplars	*Populus sp.*	Riparian
Velvet Mesquite	*Prosopis velutina*	Chaparral
Shrub Live Oak	*Quercus turbinella*	Chaparral
Dace (species uncertain)	*Rhinichthys osculus (?)*	Riparian (aquatic)
Goodding's Willow	*Salix gooddingii*	Riparian
Willow	*Salix sp.*	Riparian
Russian Thistle ("Tumbleweeds")	*Salsola tragus*	Grassland, Disturbed
Cottontail	*Sylvilagus auduboni*	Semidesert Grassland
Tamarisks	*Tamarix sp.*	Riparian
Yucca	*Yucca sp.*	Semidesert Grassland
Mourning Dove	*Zenaida macrooura*	Developed/Residential

9.3.2 May 2014: Along the Agua Fria and Chaparral Gulch

The IKM Site is generally a desert and significant rainfall had not occurred prior to sampling and noting observations in early May 2014 along the Agua Fria. Three natural waterways are found on Site, the Agua Fria, Chaparral Gulch, and Galena Gulch. The Agua Fria is the only perennial stream of the three and both gulches were quite dry during the sampling events. The focus of the biological observations of the riparian community occurred within and along the Agua Fria adjacent to the Site, which was much "greener" and more diverse than the rest of the Site. The Agua Fria flows south and then west along the eastern and southeastern boundary of the Site. At the time of sampling the water within the Agua Fria was shallow, often only a foot or so deep and the stream was generally 10-feet or so in width. The overall channel is deeper and exhibits evidence of much greater depth and flow at times, most likely immediately after storm events. The edges of the Agua Fria contain abundant aquatic herbaceous vegetation.

The stream bottom consists of generally smaller stones, gravel and coarse sands. Nearly the entire stream bottom was found to be covered with a very thick layer of green string algae. This string algae is indicative of excessive nutrient loading and eutrophication from farms, pasture, or runoff from residential irrigation upstream of the Site. The shallow borders of the stream are framed with an almost monoculture of nonnative water cress (*Nasturtium officinale*). The stream occasionally is bordered by walls of stone or, adjacent to the Site, slag. Grasses and forbs were difficult to identify during the sampling effort as it was the beginning of the growing season. Grasses were abundant and well established in open areas along the riparian corridor and sedges and rushes (*Carex* , *Juncus*, and *Scirpus spp*.) were locally abundant along the stream.

The outside of the stream corridor, unlike much of the desert Site, contained many trees. Trees included abundant willows (*Salix gooddingii* and other *Salix spp.*) and Poplars, predominantly *Populus fremontii*. The nonnative Tamarisks (*Tamarix sp.*) were also abundant along the Agua Fria and parts of the gulch. Cattails were present below the dam in the Chaparral Gulch, the only part of the Gulch with standing water at the time of sampling. A dead coyote (*Canis latrans)* was also observed in this gulch not far from the dam.

Bird life was extremely abundant along the Agua Fria. Although too quick in flight to identify the species, hummingbirds were observed at several locations. A small yellow finch-type bird was very abundant in the trees bordering the Agua Fria. A large Harris' Hawk (*Parrabuteo unicintus*) was startled from a resting place on a rock above the Agua Fria and another or same Harris' Hawk was observed at another time in the air. Swallows, a duck, and other birds were seen or heard in abundance. A type of large snail, grasshoppers, damselflies, dragonflies and other insects were also common in this riparian area. A bird nest (unoccupied) was observed in a hole in the bank of the lower Chaparral Gulch. Small mammal burrows were extremely numerous over parts of the Site. These were readily apparent along the Agua Fria and in areas west of the floodplain. The actual small mammals were not observed.

Fish were readily apparent along the Agua Fria. These appeared to be a small species of Dace (*Rhinichthys osculus?).* Crayfish were abundant at all locations, some quite large. Tadpoles were also found at one of the sampling locations and appeared to be from a species of toad (*Bufo*) although no adult toads were observed. An old male mud turtle (*Kinosternon arizonense*) was also observed in the shallow of the Agua Fria while walking from one sampling location to another. A fairly diverse benthic community was found at all of the locations examined. No real differences in the benthic community, species or general abundance of organisms was observed at the different locations upstream and downstream of the Site. Although the stream was somewhat compromised (e.g. by excess nutrients entering the stream upstream of the area of interest) and had a fair number of nonnative species associated with it, the stream was still very functional and supported a diversity of organisms. The health and the diversity of the stream remained consistent along the stretch examined and did not visibly appear to be impacted adjacent to or downstream of the slag/Site when compared to locations upstream.

Freshwater Invertebrates in the Agua Fria (May 2014)	
Baetidea	
Ephemerellidae	
Physa	
Chironimidae	
Crayfish	
Gammarus	
Hemiptera	Boatman and Striders
Planariidae	
Simuliidae	
Hydropsychidae	
Tipulidae	
Amphipoda	
Odonata	Dragonfly juveniles
Odonata	Damselfly juveniles
Dytiscidae	Predaceous Diving Beetle adult
Fish (fry)	Species unknown

9.4 REFERENCES

Barbour, Michael T., Faulkner C., Gerritsen J., and Stribling, J.B. 1999. Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. Second Edition. EPA 841-B-99-002.
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Brown, David and Charles Lowe, 1980, *Biotic Communities of the Southwest*, Republished by University of Utah Press, 1994; Brown, David, ed., 1994, *Biotic Communities: Southwestern United States and Northwestern Mexico*, Salt Lake City: University of Utah Press

EA Engineering, Science and Technology, Inc. January 2009. *Biological Evaluation of the Iron King Mine-Humboldt Smelter Superfund Site*. EnviroSystems Management Project and Report No. 1432-08. http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dc283e6c5d6056f88257426007417a2/a5c1e8e6b65cce26882576fd0075b8ac/$FILE/Biological%20Evaluation.pdf

TABLE 9 - 1
Bioaccessibility & Bioassessment Sampling: Summary of Analyses
Iron King Mine Site
Dewey-Humboldt, Arizona

	Bioaccessibility Samples		Bioassessment Samples									
	Soils		Soils	Plant Tissue	Sediment				Surface water			
	IKM Main Tailings Pile	Galena Gulch			Agua Fria River	Chaparral Gulch Upstream of Floodplain		Dam/Area behind the Dam	Agua Fria River	Chaparral Gulch Downstream of Dam	Dam/Area behind the Dam	
Laboratory Analysis/Test	MTP	GAL	BIOSS	BIOPL	AG	CH	CHD	DAM	AG	CHD	DAM	TOTALS
IVBA (As and Pb)	10	6	-	-	-	-	-	-	-	-	-	**16**
TAL Metals, Total	-	-	10 (1)	10 (1)	11 (2)	10	2 (1)	18	11 (1)	1	6	**79 (6)**
TAL Metals, Dissolved	-	-	-	-	-	-	-	-	11 (1)	1	6	**18 (1)**
Dioxin/Furans	-	-	-	-	6	-	-	-	-	-	-	**6**
Total Organic Carbon	-	-	-	-	6	-	-	-	-	-	-	**6**
Water Quality	-	-	-	-	-	-	-	-	3	-	6 (1)	**9 (1)**

Number of Samples (Number of Duplicate Samples)
IVBA - in vitro bioaccessibility
As - arsenic; Pb - lead
TAL - Target Analyte List
Dioxins/Furans - 17 congeners
Water Quality: alkalinity/carbonate/bicarbonate, chloride, fluoride, nitrate + nitrite (as N), sulfate, phosphorus (as P), silica, dissolved organic carbon, and total dissolved solids

TABLE 9-2

Surface Water Field Measurements

Iron King Mine Site

Dewey-Humboldt, Arizona

Location	Date	Conductivity	Dissolved Oxygen	ORP	pH (standard units)	Temperature (Celsius)	Turbidity (NTU)
AG-BIOSW01	5/6/2014	0.5	11.6	261	7.3	14.5	10.5
AG-BIOSW06	5/7/2014	0.5	11.4	217	8.2	10.5	3.2
AG-BIOSW11	5/8/2014	0.5	15.3	141	8.2	11.5	4.2
DAM-SW01	5/6/2014	3.2	10.1	249	6.3	16.7	-
DAM-SW02	5/6/2014	2.2	12.3	217	7.1	16.4	-
DAM-SW03	5/6/2014	2.5	11.5	67	7.3	15.4	-
DAM-SW04	5/6/2014	2.6	8.9	143	7.6	14.5	-
DAM-SW05	5/6/2014	0.8	11.9	127	8.0	16.1	-
DAM-SW06	5/6/2014	0.8	12.4	139	8.2	15.5	-

Conductivity (millisiemens per centimeter); DO - dissolved oxygen (milligrams per liter); ORP - oxidation-reduction potential (millivolts); Turbidity (nephelometric turbidity units)

Base map created using 2010 orthoimagery, sample Location from GPS survey in 2014.

Map Creation Date: 30 September 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC9_Bio-Survey & Sampling\146_SEC9_Bio_SamplingLocation_Dsize_f9-1

0 380 760 Feet

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EP-W-09-031
W.A.# 0-146

Figure 9-1
Bioaccessibility and Bioassessment Sampling Locations
Iron King Mine Site
Dewey-Humboldt, Arizona

Base map created using ESRI World Imagery data,
and habitat polygon by digitizing.

Map Creation Date: 05 October 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC9_Bio-Survey & Sampling\146_SEC9_Bio_Habitat_Map_Dsize_f9-2

This Habitat Map of the Iron King Mine Site was created by Lockheed Martin/SERAS remotely several months after field sampling occurred. This Habitat Map should be used as a rough guide to the habitat types and distribution found at the Iron King Mine Site. The distribution of habitat types on the map has not been confirmed in the field. Divisions between one habitat and another are rough estimates and some habitat types may overlap in some areas.

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 9-2
Habitat Map
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 9-A
Field Data Sheets: Benthic Organisms in the Agua Fria
Iron King Mine Site
Dewey-Humboldt, Arizona

APPENDIX 9-B
Photographs for the Biological Survey and Bioassessment
Iron King Mine Site
Dewey-Humboldt, Arizona

SECTION 10 - Soil Ecological Testing

10.1 INTRODUCTION

A bench-scale plant growth study and agronomic analyses of Site floodplain (FP) soils and representative soil from the Main Tailings Pile (MTP) and Dross Pile were conducted to assess why the unvegetated areas exist, intermixed and adjacent to well vegetated areas within the same Site area. It was observed during the execution of other Site activities that there are large, barren, unvegetated areas on the floodplain in the region of the lower part of Chaparral Gulch, northwest of the Dam and southwest of the smelter and stack. These unvegetated areas are located in close proximity to well vegetated areas on the same floodplain. The "soil" (primarily tailings) appeared superficially the same for the vegetated and unvegetated areas. It was decided that the collection of soil samples within this area would provide better insight as to why some areas are able to naturally revegetate while other large similar areas remain barren.

10.2 METHODOLOGY

10.2.1 Soil Sampling

Surficial soil samples were collected from 0-6 inches ["] below ground surface [bgs]) and subsurface samples at 18" bgs within both the barren and vegetated floodplain. The surface soil is representative of where seedlings and most plant roots would naturally be present and subsurface soil sample provides information as to whether the soil below the root zone influences the chemistry of the surface soil. Analyzing the surface and subsurface soils will provide information that may be useful towards characterizing conditions on the Site that will assist in the future revegetation of all or part of these barren tailings *in situ*. Revegetation would improve soil quality and reduce soil erosion. The presence of vegetation would also enhance groundwater recharge and improve surface water quality (and therefore water quality in the Agua Fria) due to reduced runoff. For comparison and further characterization, soil was also collected from the surface of the MTP and the Dross area.

Composite soil samples were collected from four areas at Iron King Mine and at two depths at two of those areas on May 9th, 2014. Each soil sample consisted of a 5-point composite from each area. Locations were recorded using a global positioning system (GPS). The soils were shipped back to the Scientific, Engineering, Response and Analytical Services (SERAS) facility in Edison, New Jersey (NJ) While collecting these soil samples, it was observed that a salt crust was present on the surface of most of the unvegetated portions of the floodplain. For this reason, an additional composite surface sample was collected from the top surface (approximately 0.5 inches) of the vegetated and unvegetated floodplain and analyzed for pH and electrical conductivity only. All soil analyses are listed on Table 10-3. The bulk soil samples collected were identified as Plant ECOSS01 through:

Plant ECOSS01= Barren Floodplain Surface

Plant ECOSS02 = Barren Floodplain 18" Depth

Plant ECOSS03 = Vegetated Floodplain Surface

Plant ECOSS04 = Vegetated Floodplain 18" Depth

Plant ECOSS05= Dross Surface

Plant ECOSS06= Main Tailings Pile Surface

10.2.2 Soil Characterization

The soil samples were analyzed at the Rutgers University Soil Testing Laboratory in New Brunswick, NJ. The "Ecological Research Test" was conducted on each sample, which included reporting of plant nutrients, pH, soluble salt levels, cation exchange capacity, organic matter content, percentage of sand/silt/clay, soil textural class, and gravel content. As it was known that these soils are acidic and high in sulfur, an "acid producing test" was also included as part of the analyses. A plant bioassay was performed in the SERAS Biology Laboratory in Edison, NJ.

Results of the soil agronomic analyses can be found in Appendix 10-A. A summary of the agronomic analyses can be found in Appendix 10-B.

A subsample of these soils was also submitted for a bioaccessibility assay. The *in vitro* bioaccessibility assay provides a rapid alternative to *in vivo* assays for predicting relative bioaccessibility of lead, arsenic, and cadmium in soils. The method is based on the concept that solubilization in gastrointestinal fluid is likely to be an important determinant to bioavailability *in vivo*. The method measures the extent of solubilization in an extraction solvent that resembles gastric fluid. The fraction which solubilizes in an *in vitro* system is referred to as *in vitro* bioaccessibility (IVBA), which may then be used as an indicator of *in vivo* relative bioavailability (RBA). Concentration and bioaccessibility percentages of the metals of interest are displayed in the table below and the full report may be found in Appendix 10-C. Results of the bioaccessibility study are tabulated in Table 10-1.

10.2.3 Plant Bioassay

Laboratory studies in the SERAS Plant Growth Room were conducted to examine the performance of plants on the collected Iron King Mine soils. A commercial potting soil mixture was used as a positive control. The study focused on the soil samples collected from the floodplain to compare plant performance in a laboratory setting on soil from the vegetated and unvegetated areas of the floodplain. The very distinctive Site "soils" from the MTP and Dross Pile were also included in this study. The objective was to evaluate the soils through agronomic analyses and observation using a plant bioassay. The plant bioassay utilized oats (*Avena sativa*) due to their quick germination, availability and common use. Germination, survival, and overall performance and appearance were recorded. Each soil type was replicated a minimum of three times (three pots) for each soil type.

For each replicate, a 4.5-inch azalea pot was used, each pot holding 0.5 liters of the selected soil mixture. A commercial potting soil (Miracle Grow Organic Choice Potting Mix) was used as a positive control. Twenty individual seeds of oats were counted out and planted in each pot, pressed approximately 0.5 centimeters (cm) below the soil surface. Barren seed or overly large or small seeds were excluded from the planting. These pots were then placed on dedicated individual saucers, randomized in position and kept in the SERAS growth room with a 16 hour/8 hour day/night photoperiod under fluorescent lighting. Temperature was kept at 24 ± 2 degrees Celsius (°C) during the course of the study and pots were watered as needed. The oats were allowed to grow for three weeks before completion of the observations. Above ground shoots were harvested and dried at 70 °C for 24 hours and then stored for possible future analyses. Photographs of the oats and overall plant bioassay may be found in Appendix 10-D.

Germination rates and general plant appearance were observed throughout the period. Table 10-2 illustrates germination over time. Germination was good in all of the floodplain soils although it was slightly better on the soil from vegetated portions of the floodplain. After a few days of growth, a distinct difference between plants grown on soil from the barren portion of the floodplain and plants grown in soil from the vegetated portions of the floodplain became readily apparent. Oats grown in the soil from vegetated portions of the floodplain appeared to grow normally and had good color. Oats in soil from barren areas of the floodplain grew but were obviously stunted and stressed. This held true for both the surface soil and the soil collected at 18 inch bgs. Coloration on the plants in the barren soils was poor and the leaf tips browned. The dross material proved particularly toxic to the Oat seedlings and zero germination occurred. The soil/tailings from the MTP were almost equally toxic, although a couple of extremely stunted seedlings emerged towards the end of the testing period.

10.3 RESULTS AND DISCUSSION

Soils obtained from the Site were characterized and tested for their ability to support plant growth. Note that the units presented for soil testing results vary (Appendix 10-A). The mixed units presented in the soil testing reports may be confusing if not familiar with soil testing and fertilizer application rates. Units may be interchanged and converted as needed. In general, application rates and some soil results are based on 1-acre (43,560 square feet). Depth is based on one furrow slice, which is standardized as 6.7 inches deep; therefore, resulting in 24,394 cubic feet (ft^3) of soil per acre. Based on a standard "average" bulk soil density of 1.33 grams/centimeter, one acre of soil is rounded to 2,000,000 pounds of soil. Pounds per acre may be divided by 2 to yield results in parts per million (ppm); ppm may be multiplied by two to give results in pounds per acre.

The differences seen in the field between the barren areas of the floodplain and vegetated areas of the floodplain were also mirrored during the laboratory growth study (Table 10-2). Although growth was possible in the soil from the barren areas, it was severely inhibited as compared to the growth observed in the soil from the vegetated areas of the floodplain. The pH was acidic for all of these soils, although the pH of the barren soils was found to be lower than the pH of the vegetated floodplain soils. This lower pH may contribute to greater plant stress. Electrical conductivity was high in all of these soils, which will cause stress on plants and particularly germinating seedlings. The surface crust from the barren soils demonstrated a particularly low pH (3.6) coupled with an extremely high electrical conductivity of 7.74 milliohms per centimeter (mmho/cm). These conditions create a very harsh environment which would inhibit germination of seed and growth of seedlings. Finally, the acid-producing test showed that soils both at surface and depth from the barren areas of the floodplain classify as acid-producing soils. Acid-producing soils can not be amended with lime to correct the pH and generally need to be buried or otherwise removed from the environment. Although none of the other soils were classified as acid-producing, all of the collected soils (except the dross) scored a "4" on the Acid Sulfate and had a low pH after oxidation indicating that the soils are all strongly acidic (with the exception of the dross). The conclusion of an acid producing soil only allows for positive or negative response. An acid producing soil will have an acid sulfide score at or near 4.0 (indicating the highest amount of precipitate) and an oxidized pH less than (<) 3.0. For negative cases in which pH-after-oxidation is below or near 3.0 and an acid sulfide core is greater than or equal to (≥) 2, the possibility of some amount of acid sulfide material in the sample should be considered.

The low pH and high electrical conductivity of these soils are of greater interest than the concentrations of metals and plant nutrients in these soils. It should be noted that the organic material content of all of the soils is very low. Organic matter helps to hold moisture and contribute to the binding of metals. The pH of the dross material was found to be near neutral (7.2), but the electrical conductivity was the highest of all of the soils tested (15.0 mmho/cm), which is probably what prevented seed germination on the dross. The MTP also had a high electrical conductivity (4.57 mmho/cm) combined with a low pH, which creates conditions toxic for plant growth. Vegetation was sparse in the heart of both the MTP and in the dross. Vegetation does occur around the perimeter of the dross and occasionally within the pile but this may represent shallow layers of dross or mixing with native or other soils.

In conclusion, the Site soils are compromised. Most of the site soils (except the dross) have extremely low pH and all soils have high electrical conductivity. The metal content is high and plant nutrient content is low in all of the soils. Soil structure is compromised and microbial populations will also be affected. The barren areas of the floodplain also appear to be acid-producing soils. Wicking to the soil surface in the barren areas creates salt precipitates, which will further inhibit germination of new plants. The addition of organic material (to improve soil structure and provide plant nutrients) may assist revegetation on some of the marginal Site soils, particularly if irrigation was provided during germination and establishment. Revegetation of the acid-producing barren soils would be extremely difficult. Further testing would be recommended before implementing a large scale revegetation effort.

TABLE 10-1
SUMMARY OF BIOACCESSIBILITY TESTING RESULTS
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Location	Bioaccessibility: Total (mg/kg)			Soil Concentration (mg/kg)			Bioaccessibilty (percent)		
	As	Cd	Pb	As	Cd	Pb	As	Cd	Pb
ECOSS-01 (Barren Floodplain Surface)	47.9	1	2.7	394.63	2.68	343.88	12.1	37.6	0.8
ECOSS-02 (Barren Floodplain 18” Depth)	33.4	0.3	3.1	551.19	1.62	665.12	6.1	18.6	0.5
ECOSS-03 (Vegetated Floodplain Surface)	23.2	1.5	9.5	267.75	3.64	287.63	8.7	40.9	3.3
ECOSS-04 (Vegetated Floodplain 18” Depth)	32.2	2.1	16.8	268.43	4.11	282	12	51.1	6
ECOSS-05 (Dross Surface)	5.1	10.7	407.9	56.14	27.17	771.81	9.1	39.2	52.9
ECOSS-06 (MainTailings Pile Surface)	850.6	8.2	207.5	6868.16	41.9	2723.95	12.4	19.6	7.6

mg/kg = milligrams per kiloram

TABLE 10-2
OAT GERMINATION
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Treatment/Pot	Number of Germinated Seeds					Final Percentage of Oat Germination
	Day 2	Day 3	Day 4	Day 7	Day 21	
Potting Soil (Control)	0	9	17	17	18	90
Potting Soil (Control)	0	9	15	17	17	85
Potting Soil (Control)	0	10	19	20	20	100
ECOSS-01 (Barren Floodplain Surface)	0	3	16	16	16	80
ECOSS-01 (Barren Floodplain Surface)	0	5	14	14	14	70
ECOSS-01 (Barren Floodplain Surface)	0	4	14	16	17	85
ECOSS-02 (Barren Floodplain 18" Depth)	0	4	15	17	17	85
ECOSS-02 (Barren Floodplain 18" Depth)	0	5	15	16	16	80
ECOSS-02 (Barren Floodplain 18" Depth)	0	8	17	17	17	85
ECOSS-03 (Vegetated Floodplain Surface)	0	5	20	20	20	100
ECOSS-03 (Vegetated Floodplain Surface)	0	7	18	20	20	100
ECOSS-03 (Vegetated Floodplain Surface)	0	8	16	16	16	80
ECOSS-04 (Vegetated Floodplain 18" Depth)	0	9	15	17	17	85
ECOSS-04 (Vegetated Floodplain 18" Depth)	0	13	18	18	18	90
ECOSS-04 (Vegetated Floodplain 18" Depth)	0	10	15	17	17	85
ECOSS-05 (Dross Surface)	0	0	0	0	0	0
ECOSS-05 (Dross Surface)	0	0	0	0	0	0
ECOSS-05 (Dross Surface)	0	0	0	0	0	0
ECOSS-06 (Main Tailings Pile Surface)	0	0	0	0	2	10
ECOSS-06 (Main Tailings Pile Surface)	0	0	0	0	2	10
ECOSS-06 (Main Tailings Pile Surface)	0	0	0	0	2	10

TABLE 10-3
SUMMARY OF SAMPLE ANALYSIS FOR SOIL ECOLOGICAL TESTING
IRON KING MINE SITE
DEWEY-HUMBOLDT, ARIZONA

Laboratory Analysis/Test	Number of Samples Per Location							
	ECOSS-01	**ECOSS-01A**	**ECOSS-02**	**ECOSS-03**	**ECOSS-03A**	**ECOSS-04**	**ECOSS-05**	**ECOSS-06**
	Surface Barren Flood Plain	***Surface Barren Crust***	***Depth 18" Barren Flood Plain***	***Surface Vegetated Flood Plain***	***Surface Vegetated Crust***	***Depth 18" Vegetated Flood Plain***	***Dross***	***Main Tailings Pile***
pH	1	1	1	1	1	1	1	1
Electrical Conductivity (mmho/cm)	1	1	1	1	1	1	1	1
Lime Requirement Index	1	1	1	1	1	1	1	1
Phosphorus (pounds per acre)	1	x	1	1	x	1	1	1
Potassium (pounds per acre)	1	x	1	1	x	1	1	1
Magnesium (pounds per acre)	1	x	1	1	x	1	1	1
Calcium (pound per acre)	1	x	1	1	x	1	1	1
Zinc (ppm)	1	x	1	1	x	1	1	1
Copper (ppm)	1	x	1	1	x	1	1	1
Manganese (ppm)	1	x	1	1	x	1	1	1
Boron (ppm)	1	x	1	1	x	1	1	1
Iron (ppm)	1	x	1	1	x	1	1	1
M3 Extractable Lead (ppm)	1	x	1	1	x	1	1	1
EPA estimated Pb (ppm)	1	x	1	1	x	1	1	1
Soil Texture	1	x	1	1	x	1	1	1
Sand (%)	1	x	1	1	x	1	1	1
Silt (%)	1	x	1	1	x	1	1	1
Clay (%)	1	x	1	1	x	1	1	1
Organic Matter (%)	1	x	1	1	x	1	1	1
Organic Carbon (%)	1	x	1	1	x	1	1	1
Nitrate N (ppm)	1	x	1	1	x	1	1	1
Ammonium N (ppm)	1	x	1	1	x	1	1	1
Total Kjedal N (%)	1	x	1	1	x	1	1	1
Oxidized pH	1	x	1	1	x	1	1	1
Acid Sulfate Score (0-4)	1	x	1	1	x	1	1	1
Acid-producing Soil (Y/N)?	1	x	1	1	x	1	1	1
Bioaccessibility	1	x	1	1	x	1	1	1

ppm = parts per million
Pb = lead
% = percent
N = nitrogen

Appendix 10-A

Soil Agronomic Analyses

Iron King Mine Site

Dewey-Humboldt, Arizona

Appendix 10-B

Agronomic Analyses Summary Comparison Table

Iron King Mine Site

Dewey-Humboldt, Arizona

Appendix 10-C

Bioaccessiblity Report

Iron King Mine Site

Dewey-Humboldt, Arizona

Appendix 10-D

Photographs of Oats and Plant Bioassay

Iron King Mine Site

Dewey-Humboldt, Arizona

SECTION 11 – Soil Sampling: Residential Properties

11.1 INTRODUCTION

Surficial soil sampling was conducted on residential properties located in the vicinity of the Iron King Mine (IKM) and Humboldt Smelter (HS) sites. The field effort, as specified by EPA Region 9, focused on properties that may have been (or were believed to be) impacted by site-related contamination. The acquired data will be used in conjunction with previously collected data for EPA Region 9 to assess human health risk to residents on properties within the Area of Potential Site Impacts (APSI). The APSI is a physical boundary (previously determined by EPA Region 9 and their contractor), outside which there is no need to conduct further residential investigation. Based on previously collected data for EPA Region 9, properties outside the APSI did not require sampling for risk purposes because it was determined (by EPA Region 9 and their contractor) that the IKM-HS sites have not impacted those areas even though natural levels of arsenic (As), in particular, may occur. While some of the yards in the APSI were previously sampled, insufficient sampling coverage or questionable data resulted in collecting additional samples from those yards during this sampling event.

Figure 11-1 shows two primary categories of yards designated for sampling within the APSI, including:

1. Yards requiring yard-specific risk characterization.

2. Yards located within an area designated for an area-based risk screening. Based on the results of the area-based screening, some of these properties were elevated to yard-specific risk characterization.

All soil samples were analyzed in the field for As, lead (Pb), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn) using field portable x-ray fluorescence (XRF) units (Section 13.2). Ten (10) percent (%) of the samples were submitted for confirmation target analyte list (TAL) metals analysis. A limited number of residential samples were also be submitted for *in vitro* bioaccessibility (IVBA) analysis. All field and laboratory data are included in the site-specific Scribe file (Appendix A).

In addition to data obtained during this investigation, metals data collected by EPA Environmental Response Team (ERT) and Scientific, Engineering, Response and Analytical Services (SERAS) personnel in August 2103 (Lockheed Martin SERAS, 2013) and IVBA data collected by EPA Region 9 in April/May 2013 have been summarized in this report and included in the Scribe database. In April/May 2013, EPA Region 9 personnel collected 19 samples from residential properties for IVBA analysis. The samples were shipped to SERAS (Edison, New Jersey) who subcontracted the work to ACZ Laboratories, Inc. (Steamboat Springs, Colorado). No sample location data or other field data were provided to SERAS. The analytical results were validated by SERAS personnel and included in this report (Appendix B) and the site Scribe database.

In August 2013, ERT and SERAS personnel mobilized to the site to assess a cluster of 10 residential properties in the vicinity of intersection of Jones and Well Streets that were anticipated to contain elevated Pb and As concentrations in the surface soils (Appendix 11-A). A total of 254 surface and 27 subsurface samples (9 samples at 10 to 14inches, 9 samples at 22 to 24 inches and 9 samples at 34 to 38 inches below ground surface [bgs]) were collected and analyzed by field portable XRF. Based on the XRF results, five removal areas were delineated (Lockheed Martin SERAS, 2013). These data are included in this report and in the Scribe database (Appendix A).

11.2 METHODOLOGY

The methodology for residential sampling was written by EPA Region 9 and their contractor: *Scope and Field Approach for Residential Risk-Based Sampling – Planned 2013-14 Field Event* (December 2013). Minor modifications were made to that methodology as directed by EPA and described below.

11.2.1 Residential Property Access

Property access was obtained by EPA ERT with support from SERAS. Access Packets were prepared and assembled, which included Access Agreements, Property Questionnaires, a self-addressed postage-paid return envelope, and a site Fact Sheet (provided by EPA Region 9). The Access Packets were initially hand delivered to all residents (owners/tenants) that were present on their property at the time of the visit. For most properties, at least five attempts were made to hand deliver the Access Packets. Attempts were made during the evening and on the weekends to visit as many of the residents as possible. If the Access Packets still could not be hand delivered, they were mailed via the U.S. Postal Service. At least three attempts were made to send the Access Packets to non-responsive residents. In cases where the Access Packets were returned due to an incorrect address, the Yavapai County Geographic Information System (GIS) parcel database and Intelius, Inc. online public records database was searched in an attempt to locate a proper address for each resident. In many cases the property owner(s) and/or tenant(s) provided a completed Access Agreement without a Property Questionnaire.

Ultimately, the decision to continue or discontinue the pursuit to gain access for each non-responsive resident was made by the EPA. If there was a tenant living on the property, access was acquired from both the tenant and property owner.

All signed Access Agreements and Property Questionnaires were assigned a sequential access (ACC) identifier, scanned and retained. Electronic copies of the Access Agreements and Property Questionnaires are included (Appendix 11-B). A few property owners refused to sign the access agreement but provided verbal agreement to allow their yards to be sampled. Verbal access was documented by EPA ERT and sampling was conducted per the instruction of EPA ERT.

Throughout the project, a residential property access database (Access Database) was maintained to track property access status (Appendix 11-C). The Access Database links the ACC identifier, SERAS Property ID, EA Number, Correct EA Number and Parlabel as specified below:

PARLABEL – This parcel identification is used by Yavapai County (http://gis.yavapai.us/v4) and is a combination of the Tax Book #-Map #-Parcel #. In some cases, parcel numbers have associated physical addresses and in some cases, they do not. The parcel identification will change if a parcel is subdivided.

ACC_Number – This identifier was assigned by SERAS personal sequentially as Access Agreements and Property Questionnaires were received from the property owner(s). These numbers are required to link either a SERAS Property ID or EA Number to the appropriate Access Agreement and Property Questionnaire.

Sample ID and Location – These are the sample number and sample location assigned to each sample by the sampling team. Samples in some cases were unintentionally collected on the wrong property and therefore the Sample Identification (ID)/Location did not always match the correct property ID or EA Number (Property IDs used on site prior to this investigation). The Correct EA Num field was added to be used to identify the actual property each sample was collected from.

EA Number – These were used during previous sampling events as yard sampling identifiers. For properties that did not have a previous EA number, an EA number was created for this round of sampling. In some cases samples were unintentionally collected on the wrong property. In these cases the EA

Number and Sample Number were based on the property intended to be sampled, not the actual property sample. In cases where this occurred, corrections to the EA Number were made in the Correct EA Num field.

Correct_EA_Num – This field indicates the EA property number from which each sample was collected. It is in the SCRIBE (Microsoft Access) database in the Location table in the LocationComment field.

SERAS Property ID - These are unique property IDs that were created for this round of sampling since EA Numbers were not provided until after sampling was initiated. The ID consisted of either RA for *yard-specific risk characterization* or RS for *area-based risk screening*, then by an Area designation (A through U), followed by a unique consecutive three digit number. For example, RSB-002 would be an area-based risk screening property in area B. Properties for which access was required, but were not part of the residential risk-based sampling, were also tracked in the Access Database. All of these properties were given an NR prefix followed by a unique three-digit ID.

For clarification purposes, parcels and properties or yards, as used in the context of this reporting, are defined as follows:

- A parcel is an area of land as defined by the Yavapai County GIS database and is associated with an owner (business or person). Parcels may or may not have a physical address.

- A property or yard, which is used interchangeably throughout this document, is the area that will be assessed by the risk assessment (Risk Management Area). It was determined by ERT personnel in the field and is the area which the resident(s) may potentially utilize. A property or yard typically consisted of a single parcel, but in some instances, may only include a subsection of a parcel or alternatively, multiple combined parcels.

In general, if a single dwelling existed on multiple small parcels, the multiple parcels were grouped as a single property or yard; whereas, if multiple residents (e.g. tenants) had separate dwellings/areas of use on a single parcel, the parcel was split into multiple properties or yards. In cases where there were no dwellings on a parcel, each parcel was considered a single property or yard even if adjacent parcels were owned by the same business or person. The exception to this was for extremely small parcels (less than 0.1 acre) that would likely not have sufficient land area to build a dwelling. In these instances, the multiple parcels were combined as a single property or yard.

11.2.2 Residential Property Boundaries

Residential Property Boundaries were obtained as a GIS shapefile from the Yavapai County GIS database. In the field, it was noticed that these boundaries were not always accurate and in some cases were shifted by up to 15 to 25 feet from the actual property boundary. Sampling teams were told not to rely on these boundaries if they did not appear to be correct and instead rely on property boundary features (fences, tree lines, roads) that were a more accurate estimate of true property boundaries. If the samplers were unsure of the actual property boundary due to a non-descript unmarked boundary with no property boundary features, no sampling was conducted within 20 feet of the unresolved property boundary. In some instances, due to unmarked property boundaries, samples were collected outside the intended property boundary. All sample locations were checked after the sampling was completed and if sampling did occur outside the property boundary, a sample team was redeployed to collect additional samples from the correct property.

At the conclusion of the project, ERT modified the original property boundaries GIS file to match the actual boundaries observed in the field (Appendix 11-D). Since in not all cases could the Sample

ID/Sample Location be used to determine which property the sample was collected from, a "Correct_EA_Num" field was added to the database to identify the actual property where the sample was collected.

11.2.3 Area-based Risk Screening

Area-based risk screening was performed on properties located on the periphery of the APSI that were believed to have a lower chance of contamination. Area-based risk screening collected a population of soil data, which was used to evaluate the upper-confidence limit (UCL) for a defined area that incorporated multiple yards (10 to 40 yards per area). These areas were designated by letters A through J on Figure 11-1. The UCL generally is used by risk assessors as an exposure point concentration for a reasonable maximally exposed individual in a risk assessment.

These properties were screened on a per-area basis instead of a per-property basis; therefore, not every property in the area needed to be sampled to attain a statistically significant data set. For each property that was randomly selected within the area to be sampled, two to six samples were collected as specified by the EPA Region 9. The larger the properties size, the larger the number of samples that were collected on the property. Specific sample locations on each property were selected by EPA ERT personnel to provide maximum spatial coverage for the property.

As each area was completed, XRF metals data and sample location maps were provided to EPA Region 9. EPA Region 9 evaluated the data to screen out areas with low UCLs. No additional sampling or assessment was needed for those areas. For areas (or parts of areas) with high UCLs, additional sampling was conducted on those properties as described below in the Yard-Specific Risk Characterization section.

Any additional samples collected outside or beyond the originally planned scope of work (i.e., *Scope and Field Approach for Residential Risk-Based Sampling*) were performed under the direction of EPA ERT and/or EPA Region 9.

11.2.4 Yard-Specific Risk Characterization

Yard-specific risk characterization was performed for properties within the APSI, that based on previous sampling, were most likely to be impacted by site contamination or on properties in areas (or parts of areas) with elevated UCLs (see Section 11.2.3). For these properties, data were collected to assess risk on a yard-specific basis. Although yards will be evaluated individually, they were grouped in areas for logistical purposes, designated by letters K through U on Figure 11-1. Properties selected by EPA Region 9 to be sampled during this investigation included: 1) properties within the APSI that were not previously sampled by EPA, 2) properties that were previously sampled but had insufficient data, and 3) properties that were previously sampled that had suspected erroneous data. The data collected during this investigation will be used to supplement data previously collected within the APSI for EPA. The number of samples collected per yard was based on the parcel size, according to the following:

Property Size (acres)	Surface Samples* (0 to 2 inches)	Subsurface Samples* (10 to 14 inches)
<1	10	1
1 to 3	15	2
>3	20	3

*Previous data may be used in addition to samples collected during this sampling event to obtain specified sample numbers.

Surface samples were collected at a depth between 0 and 2 inches and subsurface samples were collected at a depth between 10 and 14 inches. Sampling locations were determined by EPA ERT personnel and were selected based on property layouts with special focus placed on play areas, areas close to the house, pet areas and any areas frequented by resident(s). Any visible tailings or potential contaminated soil observed in the field was detailed on field data sheets for review by EPA Region 9. Properties that contained visible tailings or localized elevated lead and/or arsenic concentrations were identified as hot spots. Additional sampling and in-situ XRF was performed to delineate these hot spots.

At the discretion of EPA ERT personnel, on some properties, samples that were previously collected were used in order to meet the sampling criteria stated above. For example, if a yard previously had five surface samples collected on the property but needed ten surface samples to meet the above criteria, a minimum of five samples would have been collected during this sampling event.

11.2.5 Soil Sampling Methods

Soil samples for XRF analysis were collected with decontaminated trowels, hand augers and spoons. Soil sample collection and non-dedicated equipment decontamination at each location was conducted in accordance with SERAS standard operating procedure (SOP) #2012, *Soil Sampling* and SERAS #2006, *Sampling Equipment Decontamination.* All non-dedicated sampling equipment (trowels and hand augers) were decontaminated prior to sampling at each location.

Decontamination was performed by spraying the sampling equipment using a detergent (such as Alconox) diluted in distilled water and scrubbing with a brush. After all visible soil was removed; the sampling equipment was rinsed with distilled water and then air-dried.

For surface soil samples, the ground was cut with a decontaminated stainless steel trowel or spoon to a depth of 2 inches bgs. If there was gravel, peat, cover bark, needles, detritus, sticks, or some other such material overlying the soils, this material was removed prior to sampling and the actual top 2 inches of the soil was collected. Any vegetation, rocks and debris were removed from the soil and then the sample was thoroughly mixed and placed into a labelled self-sealing plastic sample bag.

For subsurface samples, holes were hand-augered to a depth of 14 inches bgs using a decontaminated stainless steel auger. The excess soil was set aside for backfilling the hole. The subsurface soil sample was collected from the bottom four inches of the last soil grab, directly from the bottom of the auger head, and placed into a stainless steel bowl. The vegetation, rocks and debris were removed and the sample was thoroughly mixed and placed into a labelled self-sealing plastic sample bag. The holes were backfilled using previously removed materials to match the existing grade.

The sample bags were labelled with date/time of collection, sample ID, depth of collection and sampler's name. The soil, while in the sample bag, was thoroughly shaken and mixed back and forth for 15 to 30 seconds and squeezed repeatedly between thumb and forefinger to break up any colloidal or semi-consolidated materials. Cohesive material was crushed, smeared, crumbled, and tumbled again within the bag to achieve as much mixing as was practical. Each sample collection point was recorded on a paper map and recorded digitally using a Trimble differential GPS. Sample data along with any notable observations were recorded on a property-specific field data sheet (Appendix 11-E). The samples were then brought to a central processing location to be entered in the Scribe database prior to XRF analysis (Section 13.2).

11.2.6 IVBA Analysis

In April and May 2013, EPA Region 9 personnel collected 19 samples for IVBA analysis of Pb and As. The samples were shipped to SERAS and then analyzed by a subcontract laboratory (ACZ Laboratories). No sample locations were provided for these samples.

During the 2014 investigation, 21 soil samples collected from residential properties were selected by EPA Region 9, based on their Pb and As concentrations, and submitted to a subcontract laboratory for IVBA analysis. In addition to the samples specified above, five soil samples were collected in Galena Gulch and ten soil samples were collected on the Main Tailings Pile (Section 9), which were also submitted for IVBA Pb and As analysis. IVBA samples were analyzed by Katahdin Analytical Services.

11.3 RESULTS

Access Teams consisting of one ERT and one SERAS team member began visiting residents on December 4, 2013 to distribute Access Packets to obtain permission from the resident to sample their property. If the residents were present, they were given the Access Packets and then either completed them while the Access Team was present or returned them via mail. If the residents were not present, the Access Team would return usually up to five times (including evening and weekend visits). If the resident still could not be contacted, the Access Packet was sent to the resident via mail. If there was a tenant on the property, then access was acquired from both the owner and the tenant. All Access Forms and Residential Questionnaires were given a Document Number (ACC###), which were linked to the Property IDs in the Access Database, and then scanned (Appendix D). In total, sampling access was obtained from 383 properties and denied from 48 properties. There were also a limited number of properties where no response could be obtained from the owner/resident or the owner could not be located.

Once access was obtained from a sufficient number of properties, residential sampling was initiated on January 22, 2014. As sampling continued, ongoing efforts were made to continue to obtain access to all properties selected for sampling by EPA Region 9.

Sampling teams typically consisted of one ERT team member and one SERAS team member. Sampling started on properties that were part of the area-based risk screening (Area A through Area J). As metals XRF data were obtained for these properties, it was transmitted to EPA Region 9 for area-based risk screening. If the area was determined to have the potential for risk to the residents, the property in the area was elevated to yard-based risk characterization. This was the case for about half of the properties in Area A and all of the properties in Area J. For these properties, additional sampling was conducted to meet the criteria as specified in Section 11.2.4, Yard-Specific Risk Assessment. Sampling of properties for yard-based risk screening (Area J through Area U and part of Area A) was started on January 30, 2014 and continued intermittently through May 8, 2014.

In total, 4,400 samples were collected from 379 properties (Table 11-1 and Figures 11-2A through 11-2U). All field XRF data and TAL metals confirmation data were imported into the Scribe database (Appendix A). Based on field observations and at the discretion of ERT personnel, some smaller parcels were combined to make a single property for risk assessment purposes. These were properties that were very small in size (typically less than 0.1 acre) and a single resident inhabited these adjacent parcels (Table 11-2). In one instance, a single parcel (EA #138/SERAS Prop # RAQ-101) was split into multiple properties (138A, 138B and 138C) for risk assessment purposes. This was done since there was a large parcel that was divided and rented to multiple tenants, each with a separate dwelling.

On properties where mine tailings were observed by the sampling teams or where “hotspots” were detected, additional sampling and in-situ XRF analyses was performed as directed by ERT to delineate these areas. This information was incorporated in an In-Situ Hot Spot Assessment Report prepared by ERT and included in Appendix F.

Regarding the IVBA analyses, 40 soil samples were collected on residential properties (21 during this investigation and 19 by EPA Region 9 in April/May 2013), 10 samples from the Main Tailings Pile, and five samples from Galena Gulch (see Section 9). All IVBA data were validated and imported to the SCRIBE database. The IVBA is summarized in Table 11-3.

11.4 REFERENCES

Archaeological Consulting Services, Ltd. (ACS) 2008. A cultural resource and historic building survey for a remedial investigation/feasibility study at the Iron King Mine-Humboldt Smelter Superfund site, Dewey-Humboldt, Yavapai County, Arizona, 102p.

EA Engineering, Science, and Technology, Inc. (EA) 2010. Iron King Mine - Humboldt Smelter Superfund Site, Dewey-Humboldt, Yavapai County, Arizona, 1509p.

Ecology and Environment, Inc. (E&E) 2012. Iron King Mine – Humboldt Smelter Removal Report, Dewey-Humboldt Yavapai County, Arizona, 67p. Doc: 09:002693.2155.01RF

Lockheed Martin SERAS, 2013. Technical Memorandum: Accelerated Residential Sampling, Iron King Mine and Humboldt Smelter Superfund Site, Dewey-Humboldt, Arizona. WA # 0-146. October 30, 2013.

TABLE 11-1

Residential Sampling Summary

Iron King Mine Site

Dewey-Humboldt, Arizona

December 2014

Area	Number of Properties (Number of Samples)	
	Area-based Risk Screening	Yard-specific Risk Characterization
Area A	9 (32)	8 (140)
Area B	4 (17)	0 (0)
Area C	16 (47)	0 (0)
Area D	14 (50)	0 (0)
Area E	18 (38)	0 (0)
Area F	16 (33)	0 (0)
Area G	5 (17)	0 (0)
Area H	5 (19)	0 (0)
Area J	1 (4)	12 (221)
Area L	0 (0)	17 (327)
Area M	0 (0)	15 (175)
Area N	0 (0)	26 (304)
Area O	0 (0)	66 (761)
Area P	0 (0)	42 (439)
Area Q	0 (0)	21 (373)
Area R	0 (0)	34 (469)
Area S	0 (0)	12 (212)
Area T	0 (0)	9 (174)
Area U	0 (0)	13 (267)
Accelerated Residential Sampling	0 (0)	10 (281)
Subtotal	88 (257)	285 (4,143)
Total	373 (4,400)	

TABLE 11-2
Residential Sampling Summary by Area
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
00W	258	00W	28	Access obtained by EPA	402-07-040B	Yard-Specific Risk Characterization
30W	246	30W	33	Access obtained by EPA	402-07-042A	Yard-Specific Risk Characterization
36W	229	36W	45	Access obtained by EPA	402-07-041	Yard-Specific Risk Characterization
40W	NA	40W	15	Access obtained by EPA	402-07-044D	Yard-Specific Risk Characterization
45J	234	45J	21	Access obtained by EPA	402-07-062A	Yard-Specific Risk Characterization
55J	228	55J	18	Access obtained by EPA	402-07-062B	Yard-Specific Risk Characterization
60J	227	60J	20	Access obtained by EPA	402-07-052M	Yard-Specific Risk Characterization
70J	NA	70J	31	Access obtained by EPA	402-07-061B	Yard-Specific Risk Characterization
80J	NA	80J	33	Access obtained by EPA	402-07-060A	Yard-Specific Risk Characterization
85J	236	85J	37	Access obtained by EPA	402-07-063B	Yard-Specific Risk Characterization
RAA-001	1101A	1101A	11	ACC0295	402-08-033	Yard-Specific Risk Characterization
RAA-002	1102	1102	17	ACC0022	402-08-031A	Yard-Specific Risk Characterization
RAA-003	1101B	1101B	11	ACC0295	402-08-033A	Yard-Specific Risk Characterization
RAA-004	1104A	1104A	11	ACC0306	402-08-031B	Yard-Specific Risk Characterization
RAA-005	1104B	1104B	17	ACC0306	402-08-027U	Yard-Specific Risk Characterization
RAA-006	1106	1106	24	ACC0304	402-08-081	Yard-Specific Risk Characterization
RAA-007	1107	1107	23	ACC0304	402-08-081A	Yard-Specific Risk Characterization
RAA-008	1108	1108	24	ACC0216	402-08-027N	Yard-Specific Risk Characterization
RAJ-002	1902	1902	17	ACC0128	402-05-081	Yard-Specific Risk Characterization
RAJ-003	1903	1903	30	ACC0127	402-05-096C	Yard-Specific Risk Characterization
RAJ-006	1906	1906	18	ACC0126	402-05-093C	Yard-Specific Risk Characterization
RAJ-007	1907	1907	17	ACC0082	402-05-092B	Yard-Specific Risk Characterization
RAJ-008	1908	1908	17	ACC0114	402-05-092A	Yard-Specific Risk Characterization
RAJ-009	1909	1909	13	ACC0074	402-05-091	Yard-Specific Risk Characterization
RAJ-010	1910	1910	17	ACC0280	402-05-090	Yard-Specific Risk Characterization
RAJ-011	1911	1911	17	ACC0109	402-05-089	Yard-Specific Risk Characterization
RAJ-012	1912	1912	17	ACC0290	402-05-087B	Yard-Specific Risk Characterization
RAJ-013	1913	1913	18	ACC0078	402-05-087A	Yard-Specific Risk Characterization
RAJ-014	1914	1914	19	ACC0100	402-05-085B	Yard-Specific Risk Characterization

TABLE 11-2
Residential Sampling Summary by Area
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RAJ-015	1915	1915	17	ACC0113	402-05-085A	Yard-Specific Risk Characterization
RAL-002	2102	2102	17	ACC0281	402-08-027Q	Yard-Specific Risk Characterization
RAL-003	2103A	2103A	17	ACC0220	402-08-029P	Yard-Specific Risk Characterization
RAL-004	2103B	2103B	17	ACC0220	402-08-029Q	Yard-Specific Risk Characterization
RAL-005	2105	2105	23	Verbal Access	402-08-029L	Yard-Specific Risk Characterization
RAL-008	2108	2108	17	ACC0011	402-08-083H	Yard-Specific Risk Characterization
RAL-009	2109	2109	17	ACC0175	402-08-083J	Yard-Specific Risk Characterization
RAL-010	2110	2110	17	ACC0284	402-08-083A	Yard-Specific Risk Characterization
RAL-011	2111A	2111A	17	ACC0012	402-08-060L	Yard-Specific Risk Characterization
RAL-012	2112	2112	17	ACC0011	402-08-060Q	Yard-Specific Risk Characterization
RAL-013	2111B	2111B	18	ACC0012	402-08-060N	Yard-Specific Risk Characterization
RAL-014	2114	2114	20	ACC0218	402-08-060R	Yard-Specific Risk Characterization
RAL-015	2115	2115	17	ACC0011	402-08-060J	Yard-Specific Risk Characterization
RAL-016	2116	2116	23	ACC0073	402-08-028V	Yard-Specific Risk Characterization
RAL-017	2117	2117	23	ACC0076	402-08-060	Yard-Specific Risk Characterization
RAL-018	2118	2118	23	ACC0196	402-08-060D	Yard-Specific Risk Characterization
RAL-019	2119A	2119A	27	ACC0269	402-08-028Z	Yard-Specific Risk Characterization
RAL-020	2119B	2119B	17	ACC0269	402-08-028Z	Yard-Specific Risk Characterization
RAM-001	2201	2201	11	ACC0203	402-08-029J	Yard-Specific Risk Characterization
RAM-002	2202	2202	13	ACC0279	402-08-029C	Yard-Specific Risk Characterization
RAM-003	2203	2203	11	ACC0204	402-08-041Z	Yard-Specific Risk Characterization
RAM-004	2204	2204	17	ACC0198	402-08-041Y	Yard-Specific Risk Characterization
RAM-005	2005	2005	11	ACC0062	402-08-014D	Yard-Specific Risk Characterization
RAM-008	170A	170A	8	ACC0005	402-08-062	Yard-Specific Risk Characterization
RAM-009	2009	2009	11	ACC0060	402-08-019L	Yard-Specific Risk Characterization
RAM-011	2211	2211	12	ACC0205	402-08-019S	Yard-Specific Risk Characterization
RAM-014	2014	2014	14	ACC0005	402-08-024A	Yard-Specific Risk Characterization
RAM-015	2215	2215	11	ACC0302	402-08-025B	Yard-Specific Risk Characterization
RAM-016	2216	2216	11	ACC0213	402-08-026B	Yard-Specific Risk Characterization

TABLE 11-2
Residential Sampling Summary by Area
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RAM-101	255	255	9	ACC0098	402-08-029K	Yard-Specific Risk Characterization
RAM-102	254	254	8	ACC0096	402-08-030L	Yard-Specific Risk Characterization
RAM-103	170B	170B	11	ACC0005	402-08-061	Yard-Specific Risk Characterization
RAM-104	121	121	17	ACC0189	402-08-085B	Yard-Specific Risk Characterization
RAN-004	2304	2304	11	ACC0273	402-09-017L	Yard-Specific Risk Characterization
RAN-005	2305	2305	11	ACC0309	402-09-017K	Yard-Specific Risk Characterization
RAN-007	2307	2307	11	ACC0069	402-09-017H	Yard-Specific Risk Characterization
RAN-008	2308	2308	11	ACC0050	402-09-017G	Yard-Specific Risk Characterization
RAN-010	2310	2310	11	ACC0006	402-09-009E	Yard-Specific Risk Characterization
RAN-011	2311	2311	11	ACC0035	402-09-008	Yard-Specific Risk Characterization
RAN-012	2312	2312	11	ACC0219	402-09-005C	Yard-Specific Risk Characterization
RAN-013	2313	2313	11	ACC0219	402-09-005B	Yard-Specific Risk Characterization
RAN-014	2314	2314	11	ACC0037	402-09-005A	Yard-Specific Risk Characterization
RAN-015	2315	2315	11	ACC0036	402-09-010A	Yard-Specific Risk Characterization
RAN-016	2316	2316	11	ACC0219	402-09-012A	Yard-Specific Risk Characterization
RAN-017	2317	2317	11	ACC0219	402-09-012B	Yard-Specific Risk Characterization
RAN-018	2318	2318	11	ACC0298	402-09-016C	Yard-Specific Risk Characterization
RAN-019	2319A	2319A	11	ACC0307	402-09-016A	Yard-Specific Risk Characterization
RAN-020	2319B			ACC0307	402-09-016B	Yard-Specific Risk Characterization
RAN-022	2322	2322	11	ACC0232	402-09-014	Yard-Specific Risk Characterization
RAN-023	2323	2323	11	ACC0038	402-09-026B	Yard-Specific Risk Characterization
RAN-024	2324	2324	11	ACC0046	402-09-026C	Yard-Specific Risk Characterization
RAN-025	2325	2325	11	ACC0007	402-09-026A	Yard-Specific Risk Characterization
RAN-026	2326	2326	11	ACC0045	402-09-023K	Yard-Specific Risk Characterization
RAN-027	2327	2327	11	ACC0045	402-09-023L	Yard-Specific Risk Characterization
RAN-028	2328	2328	11	ACC0065	402-09-023F	Yard-Specific Risk Characterization
RAN-029	2329	2329	11	ACC0033	402-09-023H	Yard-Specific Risk Characterization
RAN-030	2330	2330	11	ACC0047	402-09-023J	Yard-Specific Risk Characterization
RAN-103	2393	2393	26	ACC0134	402-08-032C	Yard-Specific Risk Characterization

TABLE 11-2
Residential Sampling Summary by Area
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RAN-104	2394	2394	11	ACC0047	402-09-023G	Yard-Specific Risk Characterization
RAN-106	2396	2396	11	ACC0206	402-08-032D	Yard-Specific Risk Characterization
RAO-001	2401	2401	11	ACC0050	402-09-032	Yard-Specific Risk Characterization
RAO-002	2402	2402	12	ACC0243	402-09-019B	Yard-Specific Risk Characterization
RAO-119	2489			ACC0257	402-09-019E	Yard-Specific Risk Characterization
RAO-003	2403	2403	11	ACC0050	402-09-020A	Yard-Specific Risk Characterization
RAO-004	2404	2404	11	ACC0050	402-09-031	Yard-Specific Risk Characterization
RAO-006	2406	2406	13	ACC0244	402-10-074C	Yard-Specific Risk Characterization
RAO-007	2407	2407	-	ACC0027	800-27-006M	Yard Dropped (some samples were collected EA# 2406)
RAO-008	2408	2408	27	ACC0245	402-10-074D	Yard-Specific Risk Characterization
RAO-009	2409	2409	16	ACC0246	402-06-102R	Yard-Specific Risk Characterization
RAO-010	2410	2410	14	ACC0247	402-06-102U	Yard-Specific Risk Characterization
RAO-012	307	307	14	ACC0029	402-10-029A	Yard-Specific Risk Characterization
RAO-015	2415	2415	15	ACC0207	402-10-026A	Yard-Specific Risk Characterization
RAO-016	2416	2416	11	ACC0248	402-10-011A	Yard-Specific Risk Characterization
RAO-017	2417	2417	22	ACC0249	402-10-010A	Yard-Specific Risk Characterization
RAO-018	2418			ACC0049	402-10-009A	Yard-Specific Risk Characterization
RAO-019	232	232	4	ACC0192	402-10-008A	Yard Dropped (some samples collected in right-of-way adjacent to property)
RAO-020	2420	2420	11	ACC0225	402-10-033	Yard-Specific Risk Characterization
RAO-022	2422	2422	10	ACC0225	402-10-031A	Yard-Specific Risk Characterization
RAO-025	2425	2425	11	ACC0178	402-10-018	Yard-Specific Risk Characterization
RAO-026	2426	2426	11	ACC0087	402-10-017	Yard-Specific Risk Characterization
RAO-027	2427	2427	11	ACC0250	402-10-016	Yard-Specific Risk Characterization
RAO-028	2428	2428	11	ACC0251	402-10-015	Yard-Specific Risk Characterization
RAO-029	2429	2429	11	ACC0252	402-10-014	Yard-Specific Risk Characterization
RAO-030	2430	2430	12	ACC0253	402-10-013	Yard-Specific Risk Characterization
RAO-031	2431			ACC0254	402-10-012	Yard-Specific Risk Characterization

TABLE 11-2
Residential Sampling Summary by Area
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RAO-032	2432	2432	-	ACC0027	800-27-005X	Yard Dropped (some samples were collected EA# 2433)
RAO-033	2433	2433	19	ACC0291	402-10-073	Yard-Specific Risk Characterization
RAO-034	2434	2434	11	ACC0255	402-10-025	Yard-Specific Risk Characterization
RAO-035	2435	2435	11	ACC0223	402-10-022	Yard-Specific Risk Characterization
RAO-036	310	310	11	ACC0183	402-10-020A	Yard-Specific Risk Characterization
RAO-037	2437A	2437	11	ACC0268	402-10-046A	Yard-Specific Risk Characterization
RAO-038	2437B			ACC0268	402-10-046B	Yard-Specific Risk Characterization
RAO-039	2439A	2439	17	ACC0268	402-10-048C	Yard-Specific Risk Characterization
RAO-040	2439B			ACC0268	402-10-049C	Yard-Specific Risk Characterization
RAO-041	2439C			ACC0268	402-10-049D	Yard-Specific Risk Characterization
RAO-042	215A	215A	11	ACC0002	402-10-051	Yard-Specific Risk Characterization
RAO-043	215B	215B	13	ACC0002	402-10-052	Yard-Specific Risk Characterization
RAO-044	2444	2444	11	ACC0268	402-10-050A	Yard-Specific Risk Characterization
RAO-045	O12	O12	11	ACC0231	402-10-062	Yard-Specific Risk Characterization
RAO-046	O11	O11	11	ACC0059	402-10-061B	Yard-Specific Risk Characterization
RAO-047	O10	O10	11	ACC0058	402-10-061A	Yard-Specific Risk Characterization
RAO-048	O09	O09	11	ACC0056	402-08-040A	Yard-Specific Risk Characterization
RAO-049	2449	2449	11	ACC0028	402-08-066T	Yard-Specific Risk Characterization
RAO-055	214A	214A	10	ACC0002	402-08-045C	Yard-Specific Risk Characterization
RAO-056	2456	2456	11	ACC0276	402-08-071T	Yard-Specific Risk Characterization
RAO-057	2457	2457	11	ACC0276	402-08-071Q	Yard-Specific Risk Characterization
RAO-058	2458	2458	11	ACC0276	402-08-071R	Yard-Specific Risk Characterization
RAO-059	2459A	2459A	11	ACC0079	402-08-071S	Yard-Specific Risk Characterization
RAO-060	2459B	2459B	11	ACC0079	402-08-071L	Yard-Specific Risk Characterization
RAO-061	309	309	11	ACC0067	402-08-071K	Yard-Specific Risk Characterization
RAO-062	2462	2462	11	ACC0276	402-08-071H	Yard-Specific Risk Characterization
RAO-101	O07A	O07A	11	ACC0200	402-08-044B	Yard-Specific Risk Characterization
RAO-102	O07B	O07B	11	ACC0144	402-08-044F	Yard-Specific Risk Characterization

TABLE 11-2
Residential Sampling Summary by Area
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RAO-103	O07C	O07C	11	ACC0226	402-08-044E	Yard-Specific Risk Characterization
RAO-104	O07D	O07D	11	ACC0226	402-08-044D	Yard-Specific Risk Characterization
RAO-105	224	224	10	ACC0002	402-10-064D	Yard-Specific Risk Characterization
RAO-106	225A	225AB	17	ACC0002	402-10-064F	Yard-Specific Risk Characterization
RAO-107	225B			ACC0002	402-10-060A	Yard-Specific Risk Characterization
RAO-108	225C	225C	11	ACC0002	402-10-058	Yard-Specific Risk Characterization
RAO-109	214B	214B	8	ACC0221	402-08-045D	Yard-Specific Risk Characterization
RAO-110	128 and O19	128	24	ACC0001	402-10-043C	Yard-Specific Risk Characterization
RAO-114	127			ACC0001	402-10-054A	Yard-Specific Risk Characterization
RAO-111	223	223	9	ACC0266	402-10-070E	Yard-Specific Risk Characterization
RAO-112	147	147	7	ACC0227	402-10-050C	Yard-Specific Risk Characterization
RAO-113	215C	215C	12	ACC0002	402-10-052	Yard-Specific Risk Characterization
RAO-115	233	233	12	ACC0184	402-10-040	Yard-Specific Risk Characterization
RAO-117	133	133	11	ACC0099	402-07-006	Yard-Specific Risk Characterization
RAO-118	222	222	15	ACC0256	402-10-005A	Yard-Specific Risk Characterization
RAO-120	2490	2490	17	ACC0258	402-10-006A	Yard-Specific Risk Characterization
RAO-122	2492	2492	11	Town of Dewey-Humboldt	800-27-005L	Yard-Specific Risk Characterization
RAO-201	198	198	4	ACC0305	402-10-041	Yard-Specific Risk Characterization
RAP-002	2502A	2502	22	ACC0201	402-06-060	Yard-Specific Risk Characterization
RAP-003	2502B			ACC0201	402-06-059	Yard-Specific Risk Characterization
RAP-004	2504	2504	11	ACC0237	402-06-058	Yard-Specific Risk Characterization
RAP-005	2505	2505	11	ACC0303	402-06-057	Yard-Specific Risk Characterization
RAP-007	2507	2507	11	ACC0190	402-06-044H	Yard-Specific Risk Characterization
RAP-008	2508	2508	11	ACC0024	402-06-043S	Yard-Specific Risk Characterization
RAP-009	2509A	2509	11	ACC0191	402-06-043R	Yard-Specific Risk Characterization
RAP-010	2509B			ACC0191	402-06-043P	Yard-Specific Risk Characterization
RAP-011	2511	2511	11	ACC0233	402-06-042A	Yard-Specific Risk Characterization
RAP-012	2512	2512	11	ACC0236	402-06-035A	Yard-Specific Risk Characterization
RAP-014	2514	2514	11	ACC0208	402-06-033	Yard-Specific Risk Characterization

TABLE 11-2
Residential Sampling Summary by Area
Iron King Mine Site
Dewey-Humboldt, Arizona
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SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RAP-015	2515	2515	11	ACC0211	402-06-032	Yard-Specific Risk Characterization
RAP-016	2516	2516	11	ACC0018	402-06-030	Yard-Specific Risk Characterization
RAP-017	2517	2517	11	ACC0041	402-06-031	Yard-Specific Risk Characterization
RAP-018	2518	2518	11	ACC0238	402-06-041	Yard-Specific Risk Characterization
RAP-019	145	145	11	ACC0239	402-06-040B	Yard-Specific Risk Characterization
RAP-020	2520	2520	11	ACC0064	402-06-040A	Yard-Specific Risk Characterization
RAP-021	2521	2521	11	ACC0064	402-06-038A	Yard-Specific Risk Characterization
RAP-022	2522	2522	11	ACC0064	402-06-037	Yard-Specific Risk Characterization
RAP-023	2523	2523	11	ACC0055	402-06-047	Yard-Specific Risk Characterization
RAP-024	2524	2524	11	ACC0222	402-06-046	Yard-Specific Risk Characterization
RAP-025	2525	2525	11	ACC0040	402-06-045	Yard-Specific Risk Characterization
RAP-026	2526	2526	11	ACC0042	402-06-053C	Yard-Specific Risk Characterization
RAP-027	2527	2527	11	ACC0186	402-06-067A	Yard-Specific Risk Characterization
RAP-029	2529	2529	16	ACC0224	402-06-064A	Yard-Specific Risk Characterization
RAP-030	2530A	2530	15	ACC0261	402-06-063	Yard-Specific Risk Characterization
RAP-031	2530B			ACC0261	402-06-062	Yard-Specific Risk Characterization
RAP-032	2532	2532	9	ACC0015	402-06-071A	Yard-Specific Risk Characterization
RAP-035	2535	2535	12	ACC0210	402-06-078A	Yard-Specific Risk Characterization
RAP-036	2536	2536	14	ACC0193	402-06-077	Yard-Specific Risk Characterization
RAP-037	2537	2537	9	ACC0152	402-06-085A	Yard-Specific Risk Characterization
RAP-038	2538	2538	11	ACC0041	402-06-084	Yard-Specific Risk Characterization
RAP-039	2539	2539	11	ACC0263	402-06-095	Yard-Specific Risk Characterization
RAP-040	2540	2540	11	ACC0106	402-06-094B	Yard-Specific Risk Characterization
RAP-041	2541	2541	11	ACC0106	402-06-094A	Yard-Specific Risk Characterization
RAP-042	2542	2542	11	ACC0209	402-06-093	Yard-Specific Risk Characterization
RAP-045	2545	2545	11	ACC0083	402-06-098A	Yard-Specific Risk Characterization
RAP-049	2549	2549	11	ACC0054	402-06-089	Yard-Specific Risk Characterization
RAP-050	2550	2550	11	ACC0051	402-06-083	Yard-Specific Risk Characterization
RAP-051	230	230	11	ACC0275	402-06-082	Yard-Specific Risk Characterization

TABLE 11-2
Residential Sampling Summary by Area
Iron King Mine Site
Dewey-Humboldt, Arizona
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SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RAP-052	311	311	11	ACC0181	402-06-076	Yard-Specific Risk Characterization
RAQ-001	181	181	13	ACC0053	402-07-084A	Yard-Specific Risk Characterization
RAQ-002	2602	2602	14	ACC0137	402-07-083A	Yard-Specific Risk Characterization
RAQ-003	2603	2603	21	ACC0137	402-07-082B	Yard-Specific Risk Characterization
RAQ-006	2606	2606	11	ACC0101	402-07-022B	Yard-Specific Risk Characterization
RAQ-009	308	308	11	ACC0115	402-07-019A	Yard-Specific Risk Characterization
RAQ-010	2610	2610	11	ACC0057	402-07-027	Yard-Specific Risk Characterization
RAQ-012	2612	2612	11	ACC0217	402-07-025D	Yard-Specific Risk Characterization
RAQ-015	2615	2615	11	ACC0166	402-07-023B	Yard-Specific Risk Characterization
RAQ-101	138	138A	11	ACC0259	402-07-028D	Parcel Split into 3 Yards
RAQ-101	138	138B	11	ACC0259	402-07-028D	Parcel Split into 3 Yards
RAQ-101	138	138C	12	ACC0259	402-07-028D	Parcel Split into 3 Yards
RAQ-102	**259 and 260**	**259**	**24**	ACC0027	800-27-005T	Yard-Specific Risk Characterization
RAQ-103	**105**	**105**	24	ACC0151	402-06-028J	Yard-Specific Risk Characterization
RAQ-104	**108**	**108**	23	ACC0241	402-06-028S	Yard-Specific Risk Characterization
RAQ-105	**107**	**107**	**38**	ACC0004	402-06-028R	Yard-Specific Risk Characterization
RAQ-106	**203**	**203**	**32**	ACC0197	402-06-028M	Yard-Specific Risk Characterization
RAQ-107	109	109	14	ACC0154	402-06-028U	Yard-Specific Risk Characterization
RAQ-108	221	221	32	ACC0154	402-06-028K	Yard-Specific Risk Characterization
RAQ-109	303	303	13	ACC0106	402-07-011A	Yard-Specific Risk Characterization
RAQ-201	2691	2691	11	ACC0297	402-07-030C	Yard-Specific Risk Characterization
RAQ-202	141	141	7	ACC0299	402-07-031A	Yard-Specific Risk Characterization
RAQ-203	2693	2693	11	ACC0308	402-07-089D	Yard-Specific Risk Characterization
RAQ-204	120	120	5	ACC0312	402-07-017G	Yard-Specific Risk Characterization
RAR-001	2701	2701	12	ACC0215	402-07-107	Yard-Specific Risk Characterization
RAR-002	2702	2702	11	ACC0286	402-07-108	Yard-Specific Risk Characterization
RAR-004	2704A	2704	17	ACC0282	402-07-051A	Yard-Specific Risk Characterization
RAR-005	2704B			ACC0282	402-07-049A	Yard-Specific Risk Characterization
RAR-007	2707	2707	11	ACC0180	402-07-047	Yard-Specific Risk Characterization

TABLE 11-2
Residential Sampling Summary by Area
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Dewey-Humboldt, Arizona
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SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RAR-008	2708	2708	11	ACC0301	402-07-045A	Yard-Specific Risk Characterization
RAR-009	2709	2709	11	ACC0240	402-07-043	Yard-Specific Risk Characterization
RAR-010	2710	2710	22	ACC0240	402-07-044B	Yard-Specific Risk Characterization
RAR-011	2711			ACC0240	402-07-044A	Yard-Specific Risk Characterization
RAR-013	2713A	2713	13	ACC0311	402-07-038	Yard-Specific Risk Characterization
RAR-014	2713B			ACC0311	402-07-039	Yard-Specific Risk Characterization
RAR-015	2715	2715	11	ACC0271	402-07-040A	Yard-Specific Risk Characterization
RAR-018	2718	2718	11	ACC0068	402-07-054	Yard-Specific Risk Characterization
RAR-019	2719	2719	14	ACC0277	402-07-055A	Yard-Specific Risk Characterization
RAR-020	2720	2720	12	ACC0277	402-07-055B	Yard-Specific Risk Characterization
RAR-023	2723	2723	11	ACC0070	402-07-057	Yard-Specific Risk Characterization
RAR-024	2724	2724	11	ACC0274	402-07-058	Yard-Specific Risk Characterization
RAR-025	2725	2725	11	ACC0277	402-07-055A	Yard-Specific Risk Characterization
RAR-026	2726	2726	11	ACC0085	402-07-059B	Yard-Specific Risk Characterization
RAR-036	2736	2736	11	ACC0270	402-07-065A	Yard-Specific Risk Characterization
RAR-038	173	173	11	ACC0292	402-07-064C	Yard-Specific Risk Characterization
RAR-040	2740	2740	11	ACC0146	402-07-069	Yard-Specific Risk Characterization
RAR-041	2741	2741	11	ACC0155	402-07-074A	Yard-Specific Risk Characterization
RAR-043	2743A	2743A	19	ACC0142	402-07-075E	Yard-Specific Risk Characterization
RAR-044	2743B	2743BC	24	ACC0142	402-07-075G	Yard-Specific Risk Characterization
RAR-045	2743C		13	ACC0142	402-07-075J	Yard-Specific Risk Characterization
RAR-047	191A	191A	17	ACC0143	402-05-001D	Yard-Specific Risk Characterization
RAR-048	2748	2748	17	ACC0264	402-05-004	Yard-Specific Risk Characterization
RAR-049	2749	2749	16	ACC0090	402-05-005	Yard-Specific Risk Characterization
RAR-050	2743D	2743D	25	ACC0142	402-05-001G	Yard-Specific Risk Characterization
RAR-051	2743E	2743E	34	ACC0142	402-07-075E	Yard-Specific Risk Characterization
RAR-052	2752	2752	18	ACC0300	402-07-076	Yard-Specific Risk Characterization
RAR-053	2753	2753	11	ACC0173	402-07-077A	Yard-Specific Risk Characterization
RAR-055	2755	2755	11	ACC0170	402-07-077E	Yard-Specific Risk Characterization

TABLE 11-2
Residential Sampling Summary by Area
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Dewey-Humboldt, Arizona
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SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RAR-056	2756	2756	11	ACC0234	402-07-077F	Yard-Specific Risk Characterization
RAR-101	191B	191B	18	ACC0143	402-05-001E	Yard-Specific Risk Characterization
RAS-001	2801	2801	17	ACC0145	402-05-069	Yard-Specific Risk Characterization
RAS-004	2804	2804	23	ACC0077	402-05-072	Yard-Specific Risk Characterization
RAS-005	2805	2805	17	ACC0283	402-05-080D	Yard-Specific Risk Characterization
RAS-006	2806	2806	17	ACC0283	402-05-080C	Yard-Specific Risk Characterization
RAS-007	2807	2807	17	ACC0136	402-05-077B	Yard-Specific Risk Characterization
RAS-008	2808	2808	17	ACC0092	402-05-077A	Yard-Specific Risk Characterization
RAS-010	2810	2810	17	ACC0017	402-05-074	Yard-Specific Risk Characterization
RAS-101	268	268	17	ACC0165	402-05-070B	Yard-Specific Risk Characterization
RAS-102	253	253	17	ACC0104	402-05-070A	Yard-Specific Risk Characterization
RAS-104	261	261	17	ACC0177	402-05-079	Yard-Specific Risk Characterization
RAS-105	160	160	17	ACC0285	402-05-075	Yard-Specific Risk Characterization
RAS-106	183	183	17	ACC0157	402-05-073	Yard-Specific Risk Characterization
RAT-001	2901	2901	24	ACC0102	402-11-032A	Yard-Specific Risk Characterization
RAT-002	167B	167B	17	ACC0111	402-11-031D	Yard-Specific Risk Characterization
RAT-003	2903	2903	23	ACC0080	402-11-033H	Yard-Specific Risk Characterization
RAT-101	199	199	17	ACC0103	402-11-004B	Yard-Specific Risk Characterization
RAT-102	115	115	18	ACC0292	402-11-004C	Yard-Specific Risk Characterization
RAT-103	167A	167A	13	ACC0111	402-11-003	Yard-Specific Risk Characterization
RAT-104	106	106	17	ACC0156	402-11-005	Yard-Specific Risk Characterization
RAT-105	126	126	17	ACC0265	402-11-006	Yard-Specific Risk Characterization
RAT-106	167C	167C	24	ACC0111	402-11-031C	Yard-Specific Risk Characterization
RAU-001	3001	3001	32	Verbal Access	402-11-046C	Yard-Specific Risk Characterization
RAU-004	3004	3004	18	ACC0202	402-11-047C	Yard-Specific Risk Characterization
RAU-005	3005	3005	23	ACC0176	402-11-038Y	Yard-Specific Risk Characterization
RAU-006	3006A	3006A	17	ACC0296	402-11-038Z	Yard-Specific Risk Characterization
RAU-007	3006B	3006B	23	ACC0296	402-11-072E	Yard-Specific Risk Characterization
RAU-008	3008	3008	23	ACC0075	402-11-038G	Yard-Specific Risk Characterization

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Residential Sampling Summary by Area
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SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RAU-009	3009	3009	23	ACC0199	402-11-047B	Yard-Specific Risk Characterization
RAU-010	3010	3010	17	Verbal Access	402-11-038L	Yard-Specific Risk Characterization
RAU-011	3011	3011	17	ACC0168	402-11-069F	Yard-Specific Risk Characterization
RAU-012	3012	3012	17	ACC0071	402-11-069H	Yard-Specific Risk Characterization
RAU-013	3013A	3013A	19	ACC0148	402-11-069K	Yard-Specific Risk Characterization
RAU-014	**3013B**	**3013B**	**15**	ACC0148	402-11-069L	Yard-Specific Risk Characterization
RAU-015	**3015**	**3015**	**19**	ACC0288	402-11-069N	Yard-Specific Risk Characterization
RSA-009	1109	1109	2	ACC0214	402-08-098	Area-based Risk Screening
RSA-011	1111	1111	4	ACC0214	402-08-096	Area-based Risk Screening
RSA-012	1112	1112	4	ACC0214	402-08-095	Area-based Risk Screening
RSA-014	1114	1114	4	ACC0214	402-08-093	Area-based Risk Screening
RSA-016	1116	1116	3	ACC0214	402-08-089	Area-based Risk Screening
RSA-019	1119	1119	3	ACC0214	402-08-091	Area-based Risk Screening
RSA-021	1121	1121	4	ACC0214	402-08-119	Area-based Risk Screening
RSA-022	1122	1122	4	ACC0214	402-08-120	Area-based Risk Screening
RSA-023	1123	1123	4	ACC0214	402-08-121	Area-based Risk Screening
RSB-001	1201	1201	6	ACC0097	402-08-028F	Area-based Risk Screening
RSB-003	1203	1203	4	ACC0066	402-02-269S	Area-based Risk Screening
RSB-006	1206	1206	4	ACC0093	402-02-269R	Area-based Risk Screening
RSB-008	1208	1208	3	ACC0016	402-02-269U	Area-based Risk Screening
RSC-001	1301	1301	3	ACC0140	402-08-070	Area-based Risk Screening
RSC-002	1302	1302	4	ACC0089	402-08-059V	Area-based Risk Screening
RSC-003	1303	1303	3	ACC0019	402-08-061C	Area-based Risk Screening
RSC-004	1304	1304	3	ACC0117	402-08-061M	Area-based Risk Screening
RSC-005	1305	1305	2	ACC0116	402-08-061H	Area-based Risk Screening
RSC-008	1308	1308	6	ACC0010	402-08-070A	Area-based Risk Screening
RSC-012	1312	1312	6	ACC0023	402-08-082A	Area-based Risk Screening
RSC-016	1316	1316	2	ACC0061	402-08-069L	Area-based Risk Screening
RSC-019	1319	1319	2	ACC0088	402-08-080C	Area-based Risk Screening

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Residential Sampling Summary by Area
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SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RSC-024	1324	1324	2	ACC0034	402-08-072	Area-based Risk Screening
RSC-025	1325	1325	2	ACC0117	402-08-069M	Area-based Risk Screening
RSC-027	1327	1327	2	ACC0117	402-08-069R	Area-based Risk Screening
RSC-028	1328	1328	2	ACC0117	402-08-069S	Area-based Risk Screening
RSC-039	1339	1339	2	ACC0119	402-08-010A	Area-based Risk Screening
RSC-040	1340	1340	3	ACC0039	402-08-059P	Area-based Risk Screening
RSC-041	1341	1341	3	ACC0032	402-06-113N	Area-based Risk Screening
RSD-001	1401	1401	3	ACC0086	402-06-110C	Area-based Risk Screening
RSD-011	1411A	1411A	3	ACC0107	402-06-113W	Area-based Risk Screening
RSD-012	1411B	1411B	2	ACC0107	402-06-123A	Area-based Risk Screening
RSD-017	1417	1417	3	ACC0172	402-06-002H	Area-based Risk Screening
RSD-018	1418	1418	4	ACC0120	402-06-018G	Area-based Risk Screening
RSD-020	1420	1420	3	ACC0212	402-06-113R	Area-based Risk Screening
RSD-021	1421	1421	4	ACC0262	402-06-113S	Area-based Risk Screening
RSD-022	1422	1423B	2	ACC0131	402-06-113E	Area-based Risk Screening
RSD-023	1423	1423A	3	ACC0131	402-06-001F	Area-based Risk Screening
RSD-024	1424	1424	3	ACC0131	402-06-001G	Area-based Risk Screening
RSD-026	1426A	1426A	4	ACC0084	402-06-109P	Area-based Risk Screening
RSD-027	1426B	1426B	12	ACC0084	402-06-109J	Area-based Risk Screening
RSD-029	1429	1429	2	ACC0005	402-06-003F	Area-based Risk Screening
RSD-031	1431	1431	2	ACC0020	402-06-003H	Area-based Risk Screening
RSE-002	1502	1502	2	ACC0170	402-06-117R	Area-based Risk Screening
RSE-003	1503	1503	2	ACC0124	402-06-117U	Area-based Risk Screening
RSE-004	1504	1504	2	ACC0147	402-06-117T	Area-based Risk Screening
RSE-006	1506	1506	2	ACC0125	402-06-117F	Area-based Risk Screening
RSE-007	1507	1507	3	ACC0105	402-06-117W	Area-based Risk Screening
RSE-011	1511	1511	2	ACC0110	402-06-124	Area-based Risk Screening
RSE-013	1513	1513	3	ACC0031	402-06-119G	Area-based Risk Screening
RSE-015	1515	1515	2	ACC0130	402-06-118P	Area-based Risk Screening

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Residential Sampling Summary by Area
Iron King Mine Site
Dewey-Humboldt, Arizona
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SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RSE-017	1517	1517	2	ACC0122	402-06-118K	Area-based Risk Screening
RSE-018	1518	1518	2	ACC0013	402-06-118L	Area-based Risk Screening
RSE-019	1519	1519	2	ACC0106	402-06-118F	Area-based Risk Screening
RSE-020	1520	1520	2	ACC0106	402-06-118G	Area-based Risk Screening
RSE-022	1522	1522	2	ACC0106	402-06-118J	Area-based Risk Screening
RSE-027	1527	1527	2	ACC0133	402-06-124B	Area-based Risk Screening
RSE-028	1528	1528	2	ACC0153	402-06-117N	Area-based Risk Screening
RSE-030	1530	1530	2	ACC0123	402-06-121B	Area-based Risk Screening
RSE-031	1531	1531	2	ACC0108	402-06-121C	Area-based Risk Screening
RSE-032	1532	1532	2	ACC0132	402-06-124F	Area-based Risk Screening
RSF-001	1601	1601	2	ACC0014	402-06-015Z	Area-based Risk Screening
RSF-002	1602	1602	2	ACC0167	402-06-120	Area-based Risk Screening
RSF-003	1603	1603	2	ACC0159	402-06-125	Area-based Risk Screening
RSF-004	1604	1604	3	ACC0024	402-06-116B	Area-based Risk Screening
RSF-005	1605	1605	2	ACC0159	402-06-125A	Area-based Risk Screening
RSF-008	1608	1608	2	ACC0158	402-06-015N	Area-based Risk Screening
RSF-010	1610	1610	2	ACC0162	402-06-015Q	Area-based Risk Screening
RSF-011	1611	1611	2	ACC0272	402-06-015P	Area-based Risk Screening
RSF-012	1612	1612	2	ACC0164	402-06-015T	Area-based Risk Screening
RSF-013	1613	1613	2	ACC0164	402-06-015U	Area-based Risk Screening
RSF-018	1618	1618	2	ACC0160	402-06-011A	Area-based Risk Screening
RSF-019	1619	1619	2	ACC0163	402-06-010B	Area-based Risk Screening
RSF-020	1620	1620	2	ACC0008	402-06-010	Area-based Risk Screening
RSF-021	1621A	1621A	2	ACC0112	402-06-009	Area-based Risk Screening
RSF-022	1621B	1621B	2	ACC0112	402-06-108	Area-based Risk Screening
RSF-024	1624	1624	2	ACC0024	402-06-015A	Area-based Risk Screening
RSG-003	1703	1703	5	ACC0030	402-07-097C	Area-based Risk Screening
RSG-004	1704	1704	3	ACC0139	402-07-098	Area-based Risk Screening
RSG-005	1705	1705	3	ACC0044	402-07-099	Area-based Risk Screening

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Residential Sampling Summary by Area
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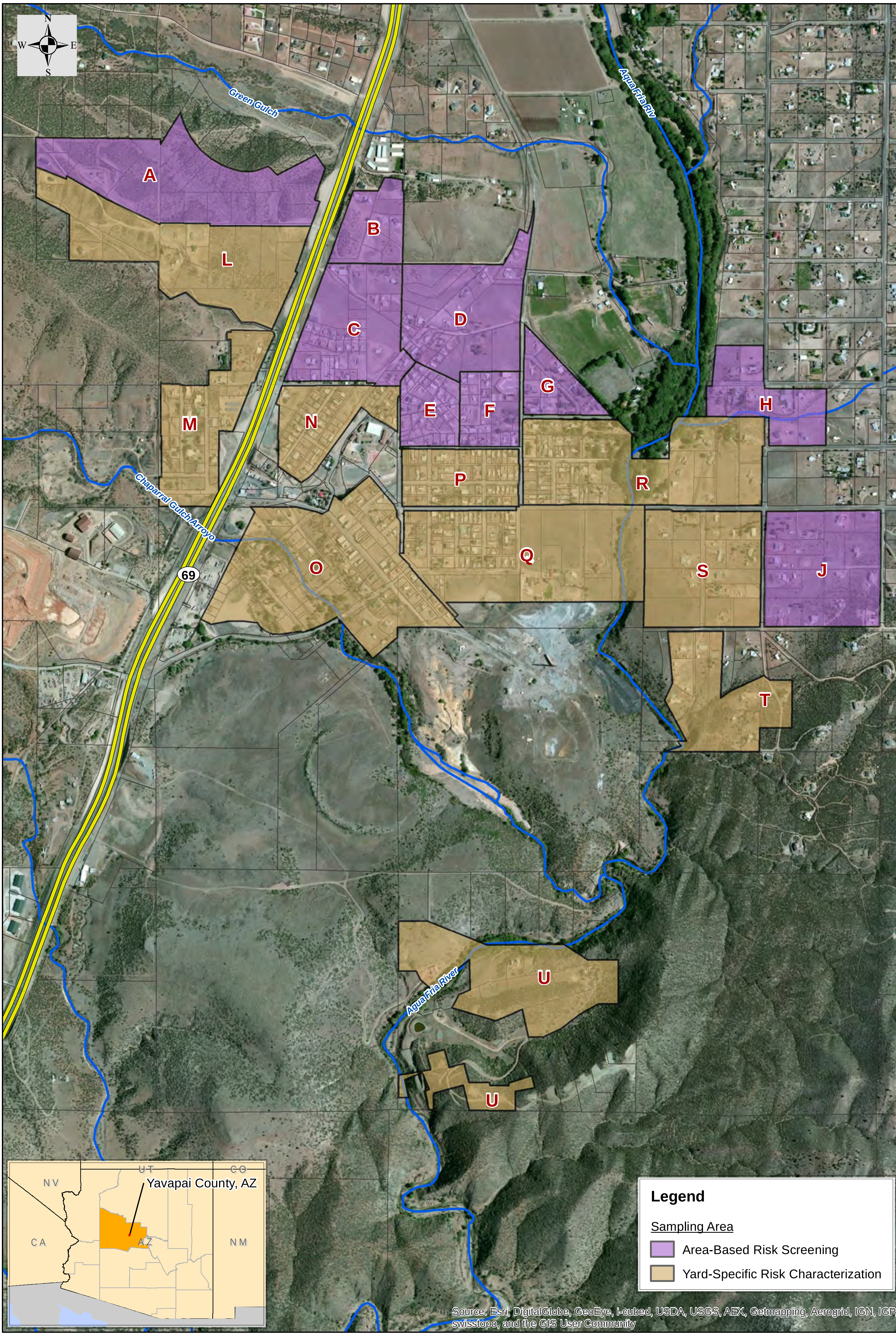
SERAS Property ID	EA Number	Correct EA Number	Number of Samples	ACC Number	Parlabel	Comments
RSG-006	1706	1706	3	ACC0063	402-07-100	Area-based Risk Screening
RSG-010	1710	1710	3	ACC0135	402-07-104	Area-based Risk Screening
RSH-001	1801	1801	4	ACC0009	402-24-057	Area-based Risk Screening
RSH-004	1804	1804	3	ACC0194	402-24-060	Area-based Risk Screening
RSH-006	1806	1806	4	ACC0169	402-05-006C	Area-based Risk Screening
RSH-007	1807	1807	4	ACC0072	402-05-008B	Area-based Risk Screening
RSH-009	1809	1809	4	ACC0021	402-05-008A	Area-based Risk Screening
RSJ-017	1917	1917	4	ACC0129	402-05-083	Area-based Risk Screening

TABLE 11-3
In Vitro Bioaccessibility (IVBA) Summary Data
Iron King Mine Site
All Concentrations in Milligrams per Kilogram (mg/kg)
Dewey-Humboldt, Arizona
December 2014

Sample Number	Location		Sample Date	Arsenic Total (unsieved)	Arsenic Total (sieved prior to digestion)	Arsenic IVBA	Lead Total (unsieved)	Lead Total (sieved prior to digestion)	Lead IVBA
417	417	1	4/30/2013	2,500	2,700	375 J+	3,580	3,820	7.1
431	431	2	4/30/2013	280	450	107 J+	390	580	102
442	442	3	4/30/2013	3,960	3,000	39 J+	6,290	5,740	17
451	451	4	4/30/2013	642	591	138 J+	838	710	84.4
467	467	5	4/30/2013	1,480	1,500	170 J+	2,860	2,960	2 U
477	477	6	4/30/2013	3,740	3,720	88.3 J+	3,270	2,990	42
485	485	7	4/30/2013	4,100	4,290	273 J+	3,760	4,300	7.8
486	486	8	4/30/2013	1,750	1,800	110 J+	4,180	3,840	12.4
513	513	9	4/29/2013	840	890	187 J+	250	220	2 U
515	515	10	4/29/2013	4,920	4,080	2420 J+	228	220	2 U
527	527	11	4/29/2013	5,100	8,820	330 J+	6,730	12,000	5.5
621	621	12	4/30/2013	180	310	13 J+	105	125	22
669	669	13	5/1/2013	226	310	32 J+	149	186	27
701	701	14	5/2/2013	603	860	127 J+	369	494	18
820	820	15	5/1/2013	751	680	116 J+	1,300	1,200	2 U
861	861	16	5/1/2013	338	502	29 J+	480	726	3.3
865	865	17	5/1/2013	497	650	65 J+	888	1,110	2 U
873	873	18	5/1/2013	572	704	78.8 J+	770	896	4.7
879	879	19	5/1/2013	920	894	120 J+	2,000	1,670	2.9 U
106-04	106-04	1	2/26/2014	214	254	23	32	22	6.2
108-03	108-03	2	2/24/2014	242	447	110	520	770	280
109-11	109-11	3	2/19/2014	169	170	47	249	230	140
126-14	126-14	4	2/27/2014	170	180	13	31	22	8.8
2014-08	2014-08	5	1/31/2014	190	310	46	230	305	19
2216-02	2216-02	6	3/5/2014	140	290	17.2	300	355	196
2324-03	2324-03	7	2/5/2014	214	230	45	200	170	59
2328-02	2328-02	8	2/5/2014	530	810	138	400	528	204
2408-01	2408-01	9	3/10/2014	160	220	24	649	841	77
2410-03	2410-03	10	3/10/2014	260	294	28	1,700	2,100	160
2426-09	2426-09	11	2/5/2014	360	340	18	49	66	26.2
2519-10	2519-10	12	3/10/2014	125	160	20	38	47	24
2523-05	2523-05	13	2/19/2014	140	170	31.4	220	223	77.4
2602-09	2602-09	14	2/13/2014	350 J	147	24	9,490	15,000	15000
2615-03	2615-03	15	2/20/2014	760	1,200	51	34	16	3
2743D-11	2743D-11	16	2/24/2014	503	650	41	30	11	3.3 U
2755-07	2755-07	17	2/22/2014	130	150	11	49	37	16.5
2808-15	2808-15	18	2/21/2014	340	420	15	20 J	19	6
2901-06	2901-06	19	2/26/2014	150	163	16	28	15	5.7
3004-08	3004-08	20	3/3/2014	152	260	52	510	650	480
3005-18	3005-18	21	3/4/2014	240	230	58	470	459	310
GAL-01	GAL-01	1	2/28/2014	NA	1,300	41.8	NA	1,710	59
GAL-02	GAL-02	2	2/28/2014	NA	170	7.4	NA	184	47
GAL-03	GAL-03	3	2/28/2014	NA	723	26	NA	1,900	478
GAL-04	GAL-04	4	2/28/2014	NA	2,700	970	NA	518	9.5
GAL-05	GAL-05	5	2/28/2014	NA	650	69	NA	823	33
GAL-06	GAL-04	6	2/28/2014	NA	2,500	930	NA	490	12
MTP-01	MTP-01	1	2/27/2014	NA	5,390	174	NA	2,550	23
MTP-02	MTP-02	2	2/27/2014	NA	4,340	410	NA	3,060	2100
MTP-03	MTP-03	3	2/27/2014	NA	312	62.7	NA	780	122
MTP-04	MTP-04	4	2/27/2014	NA	1,900	349	NA	1,910	21
MTP-05	MTP-05	5	2/27/2014	NA	1,300	400	NA	1,290	27
MTP-06	MTP-06	6	2/27/2014	NA	2,270	267	NA	1,300	28
MTP-07	MTP-07	7	2/27/2014	NA	1,030	231	NA	1,000	12.2
MTP-08	MTP-08A	8	2/27/2014	NA	1,500	363	NA	1,630	28.1
MTP-09	MTP-09	9	2/27/2014	NA	2,850	660	NA	1,350	14
MTP-10	MTP-10	10	2/27/2014	NA	892	112	NA	585	24



Base map created using ESRI World Imagery data,
parcel data fromYavapai county.

Map Creation Date: 05 December 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

0 1,000 2,000
Feet

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Figure 11-1
Residential Sampling Area
Iron King Mine Site
Dewey-Humboldt, Arizona

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area
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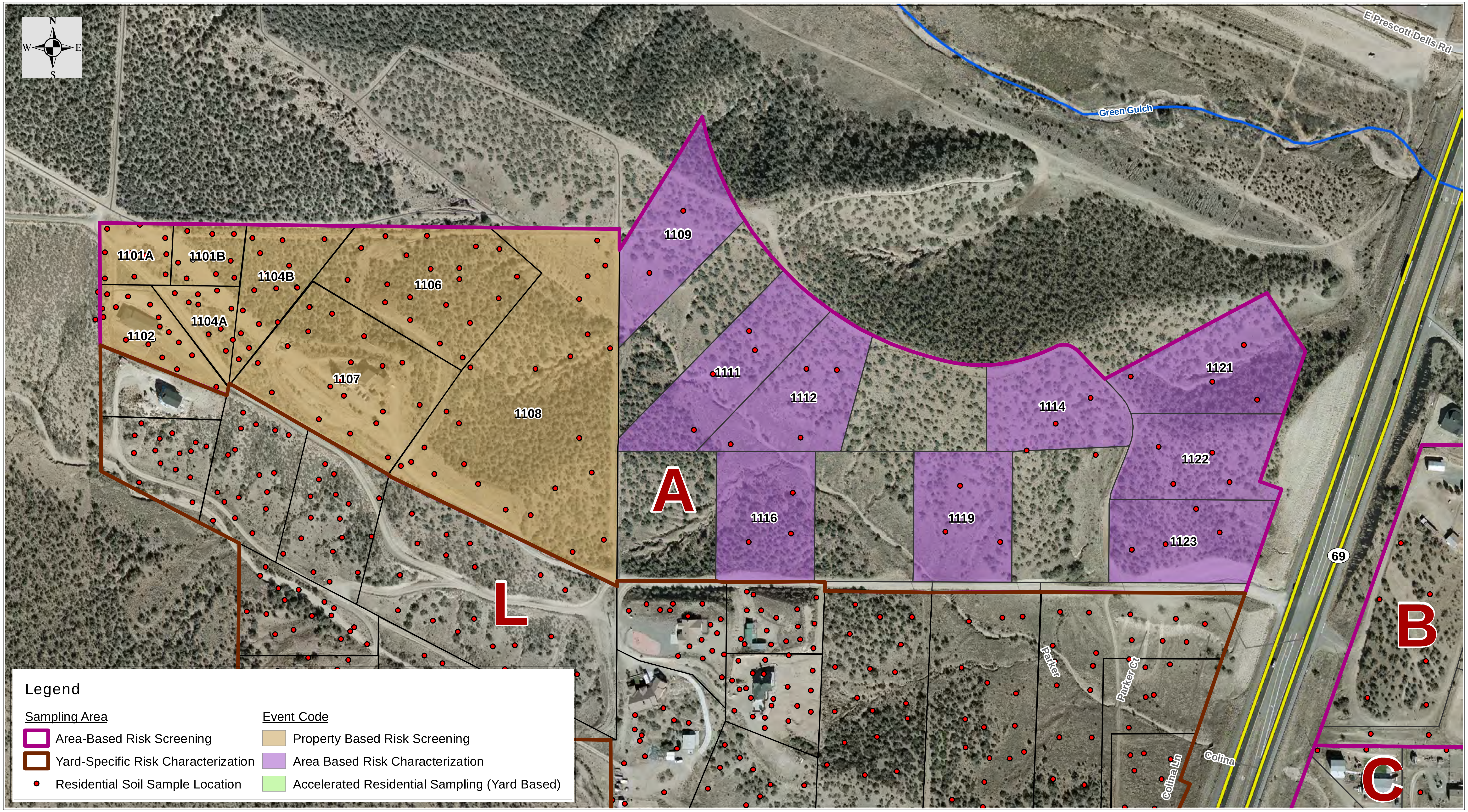

Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

0 240 480 Feet

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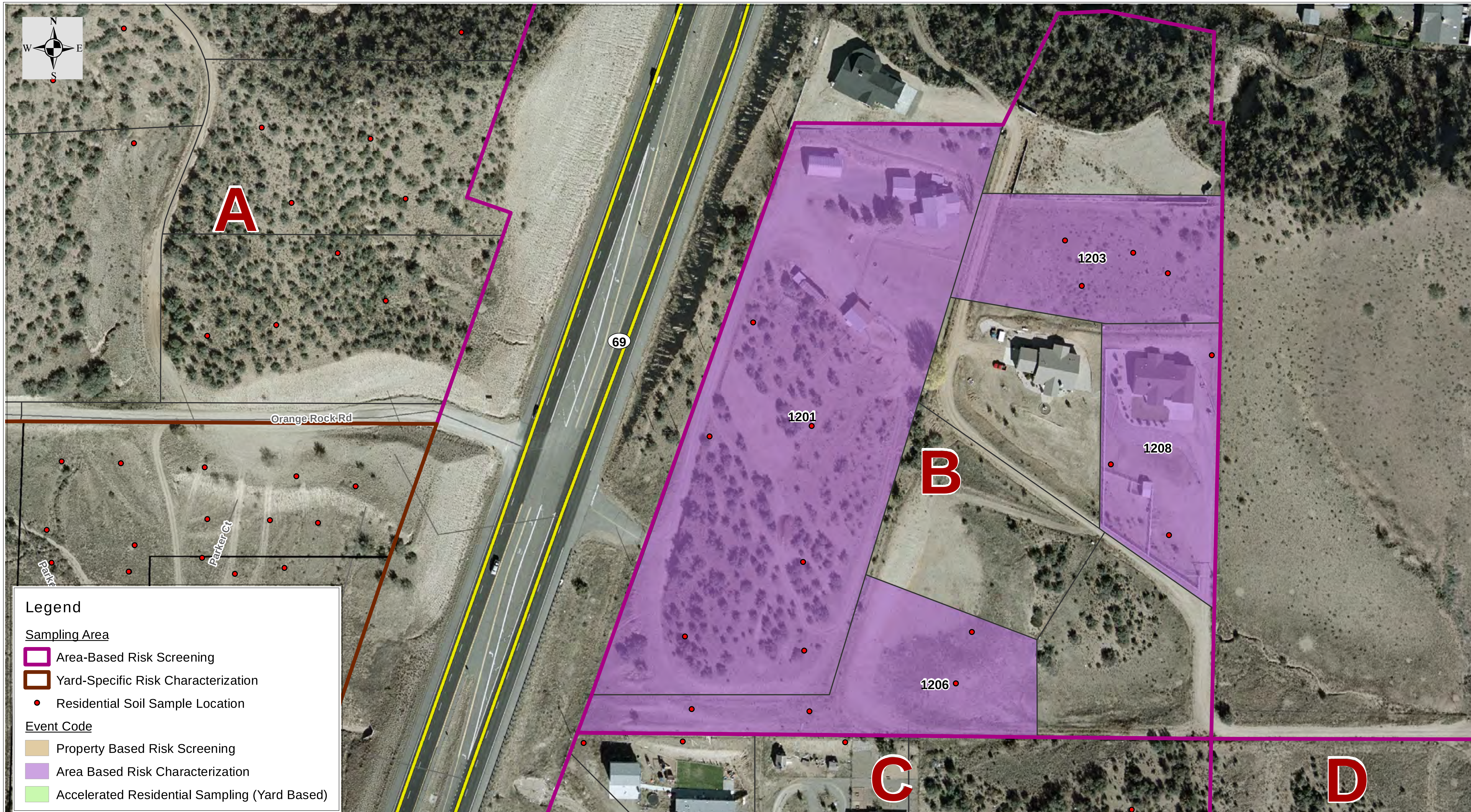
Figure 11-2A
Residential Sampling Area A
Iron King Mine Site
Dewey-Humboldt, Arizona

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_A_f11-2A



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_ARea\146_SEC11_Residential_Sampling_Area_B_f11-2B

0 120 240
Feet

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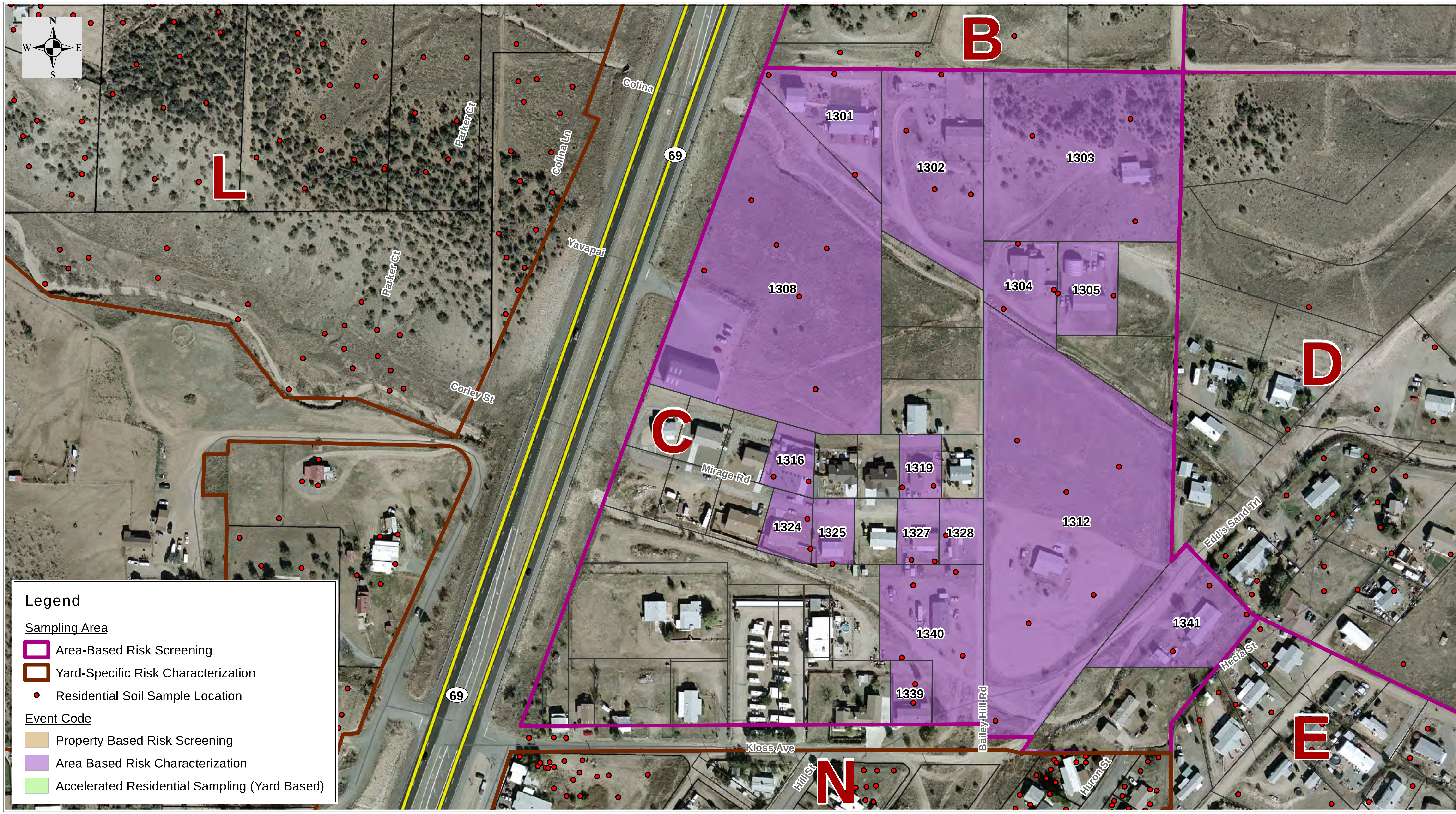
Figure 11-2B
Residential Sampling Area B
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_C_f11-2C

0 180 360 Feet

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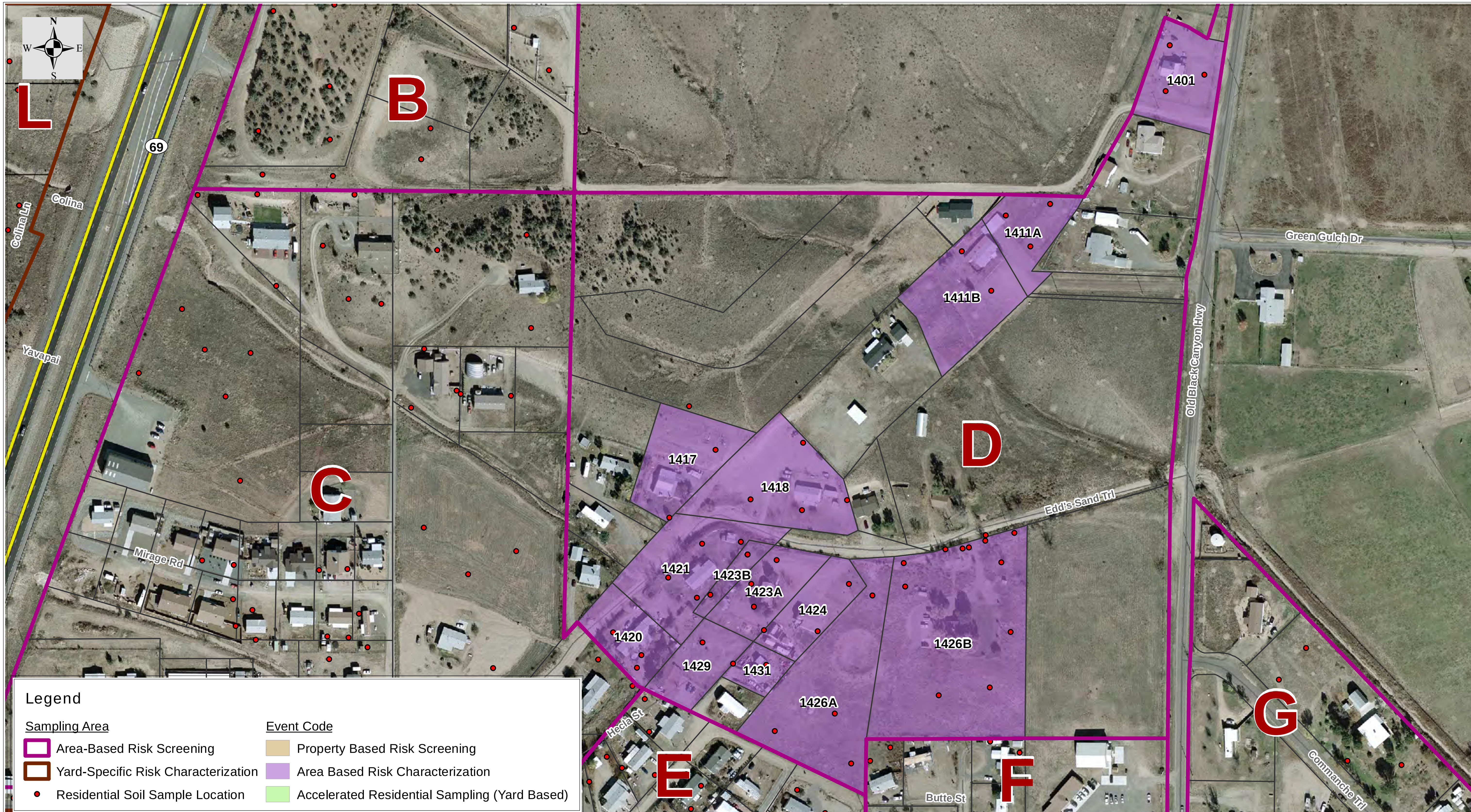
Figure 11-2C
Residential Sampling Area C
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 December 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_D_f11-2D

0 200 400
Feet

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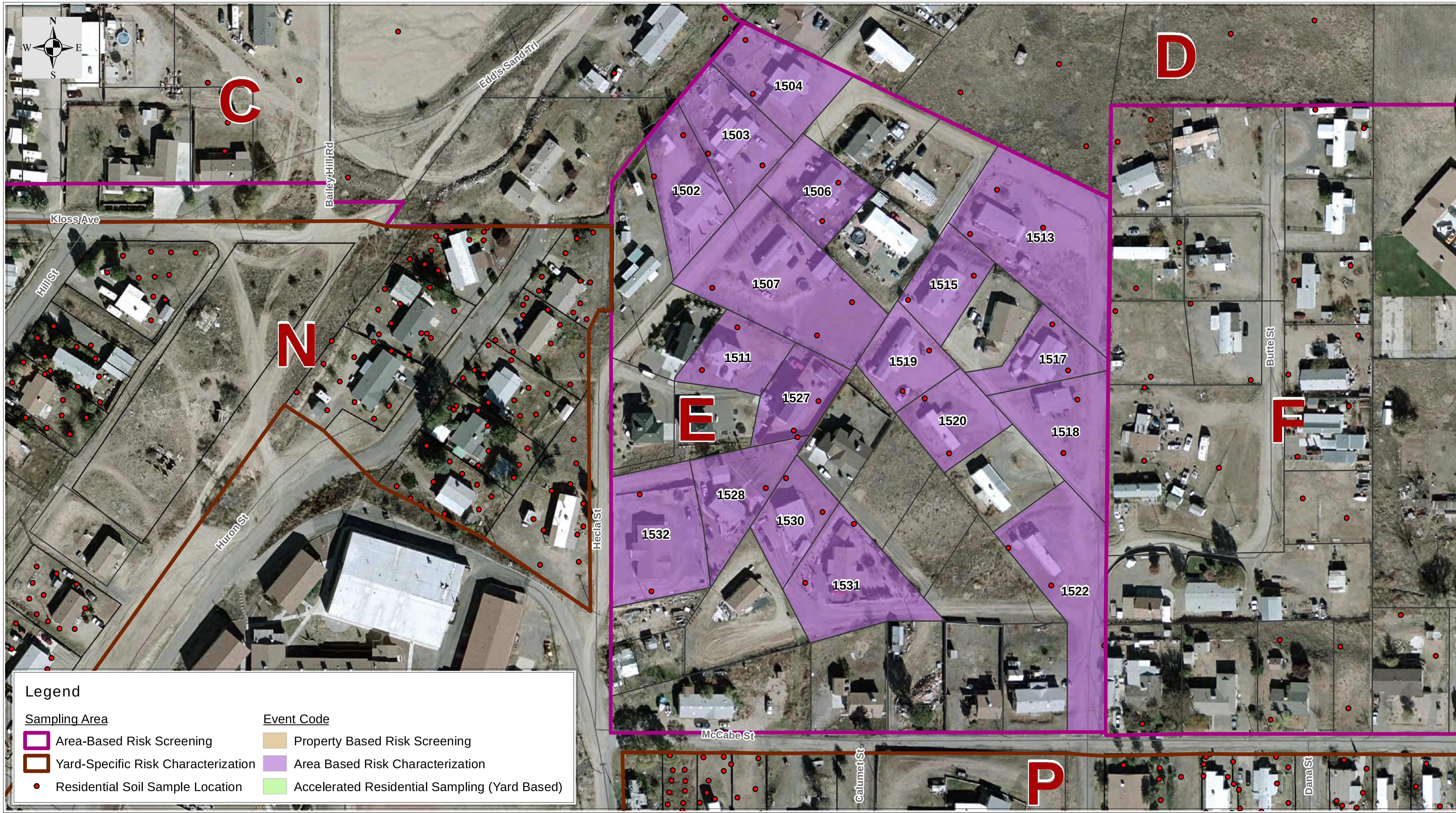
Figure 11-2D
Residential Sampling Area D
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_E_f11-2E

0 120 240 Feet

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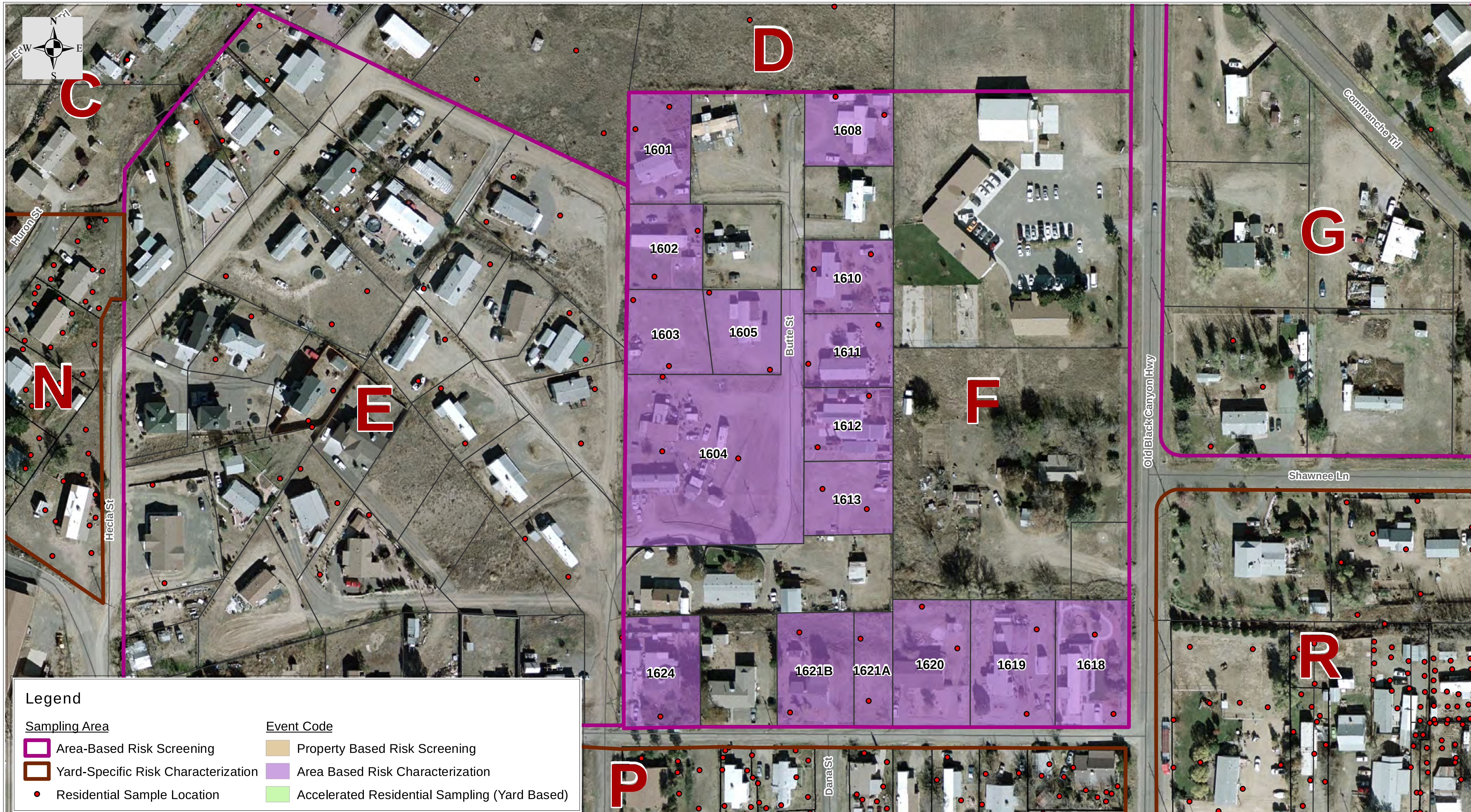
Figure 11-2E
Residential Sampling Area E
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_F_f11-2F

0 120 240 Feet

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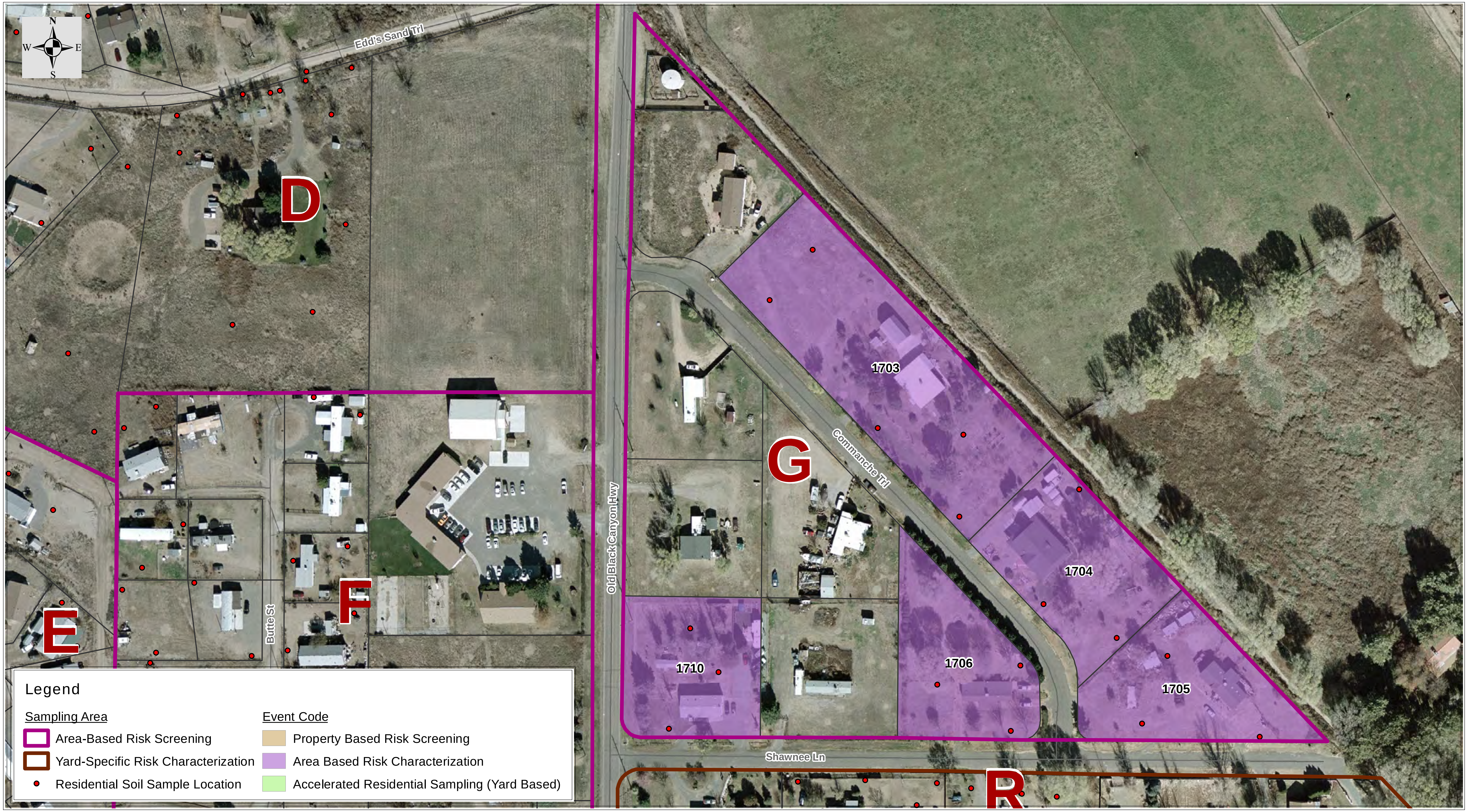
Figure 11-2F
Residential Sampling Area F
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_G_f11-2G

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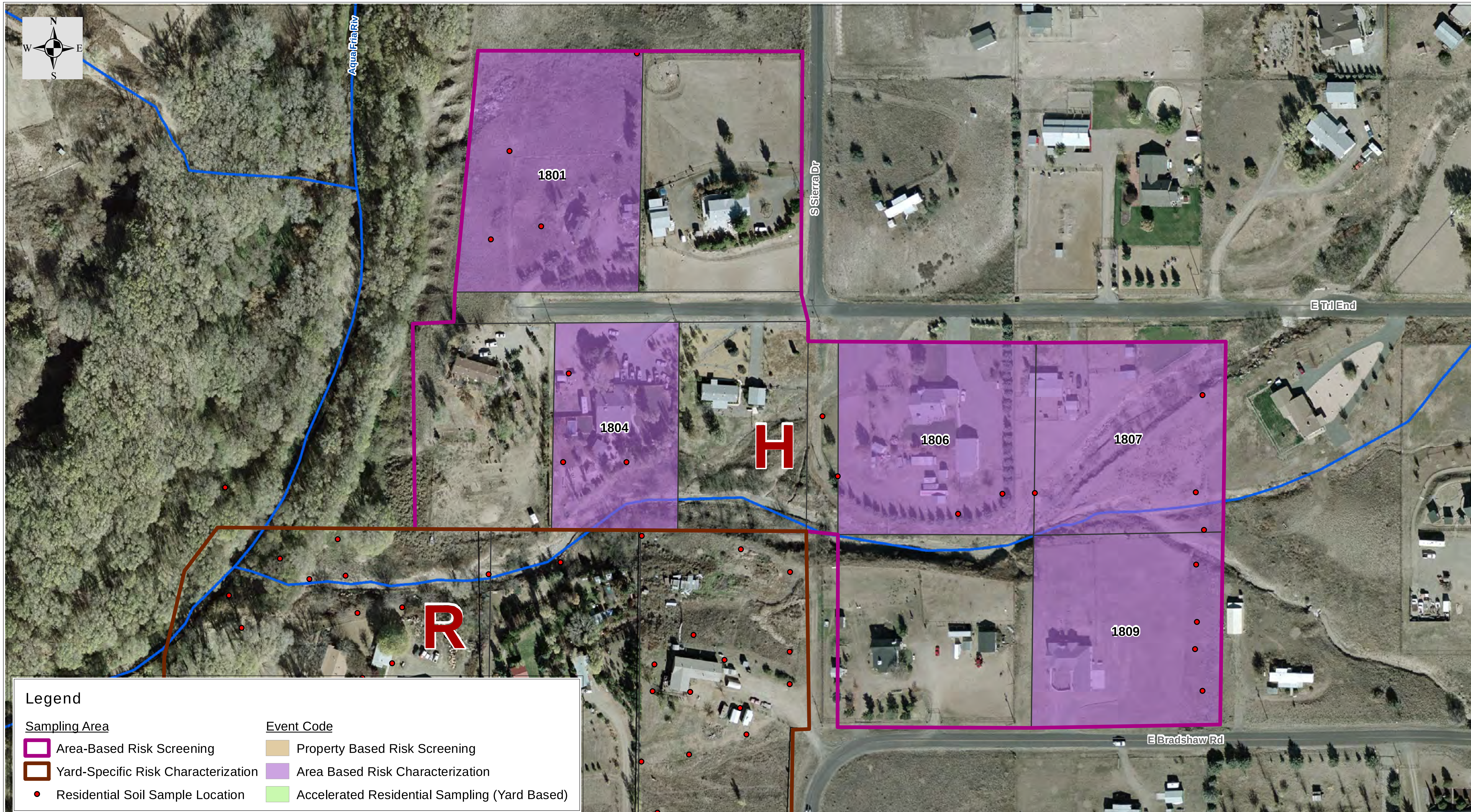
Figure 11-2G
Residential Sampling Area G
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, parcel data from Yavapai county,
sampling Information by 2014.

Map Creation Date: 08 December 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

0 150 300
Feet

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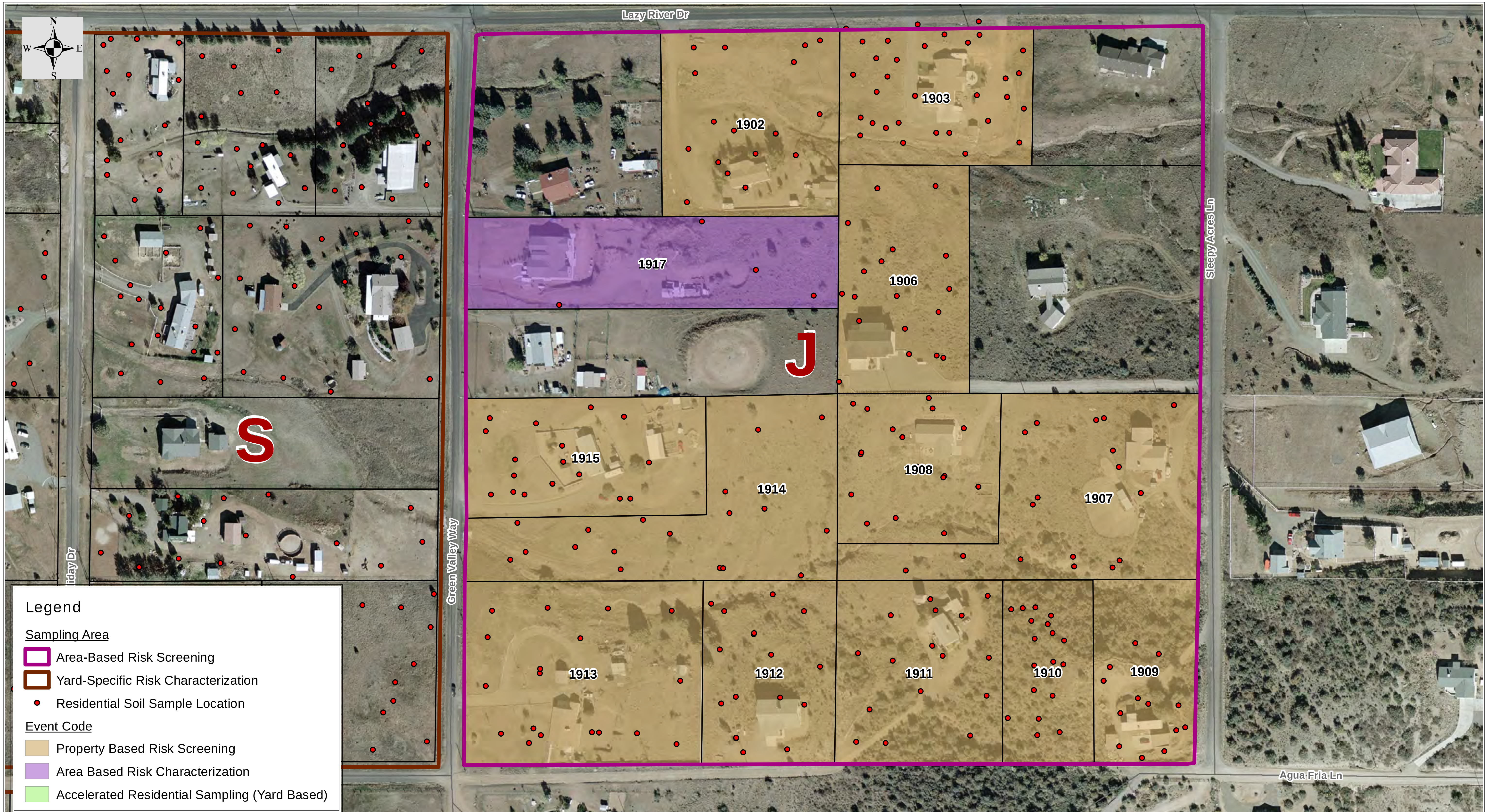
Figure 11-2H
Residential Sampling Area H
Iron King Mine Site
Dewey-Humboldt, Arizona

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_H_f11-2H



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Note:
Assess removed after area based sampling and prior to yard based sampling

0 160 320 Feet

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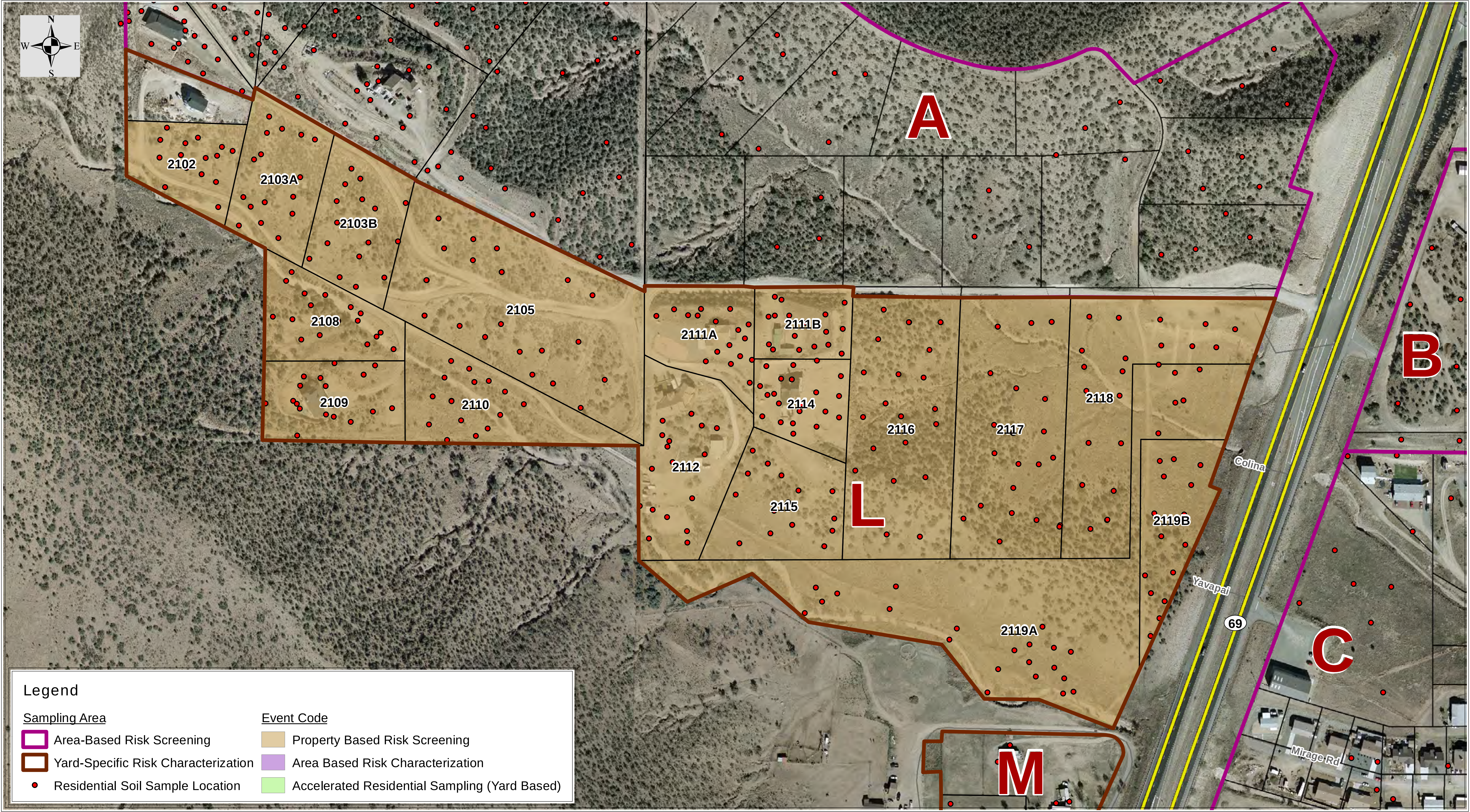
Figure 11-2J
Residential Sampling Area J
Iron King Mine Site
Dewey-Humboldt, Arizona

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_J_f11-2J



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sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_L_f11-2L

0 240 480
Feet

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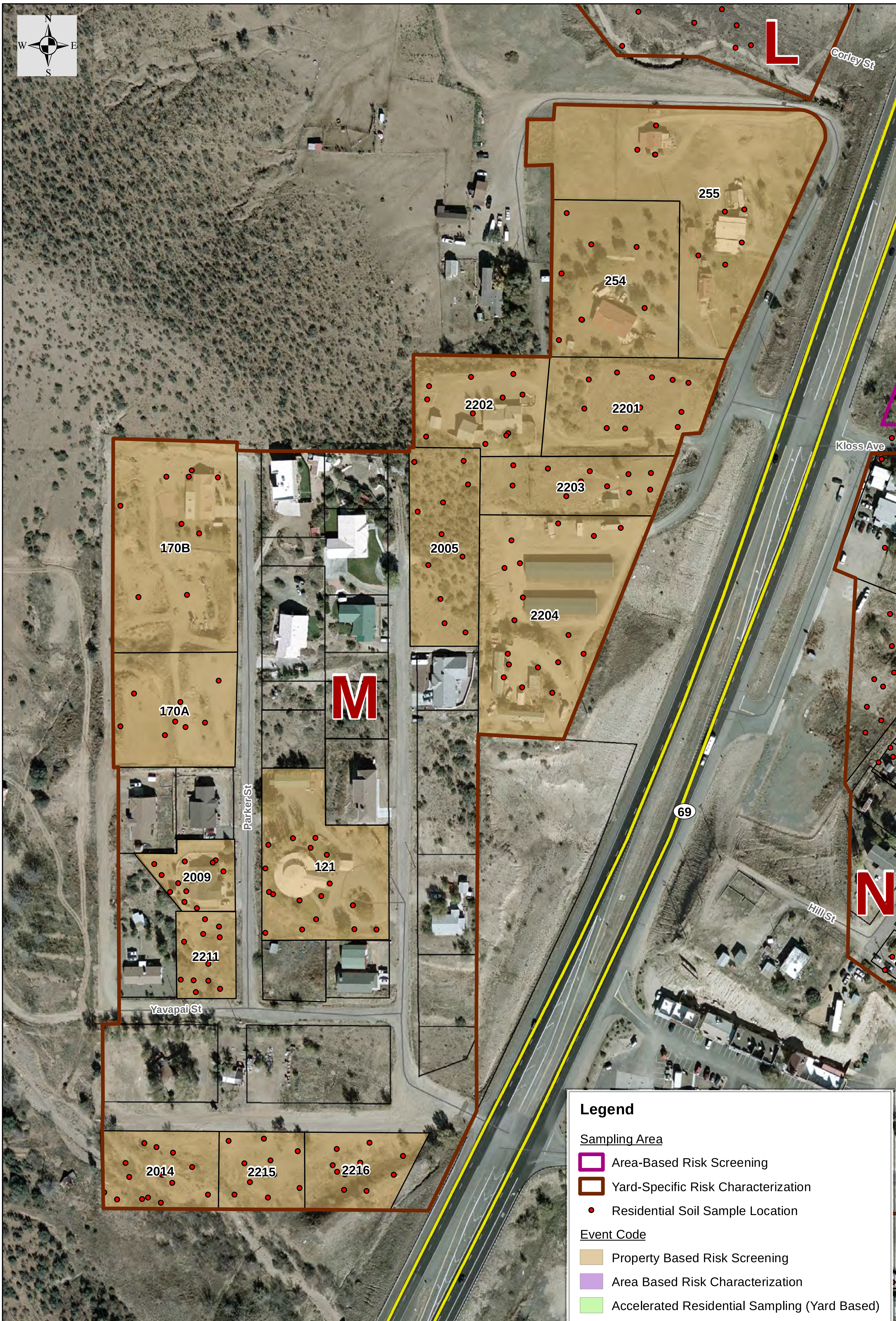
Figure 11-2L
Residential Sampling Area L
Iron King Mine Site
Dewey-Humboldt, Arizona



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Map Creation Date: 10 December 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

0 160 320 Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_M_f11-2M

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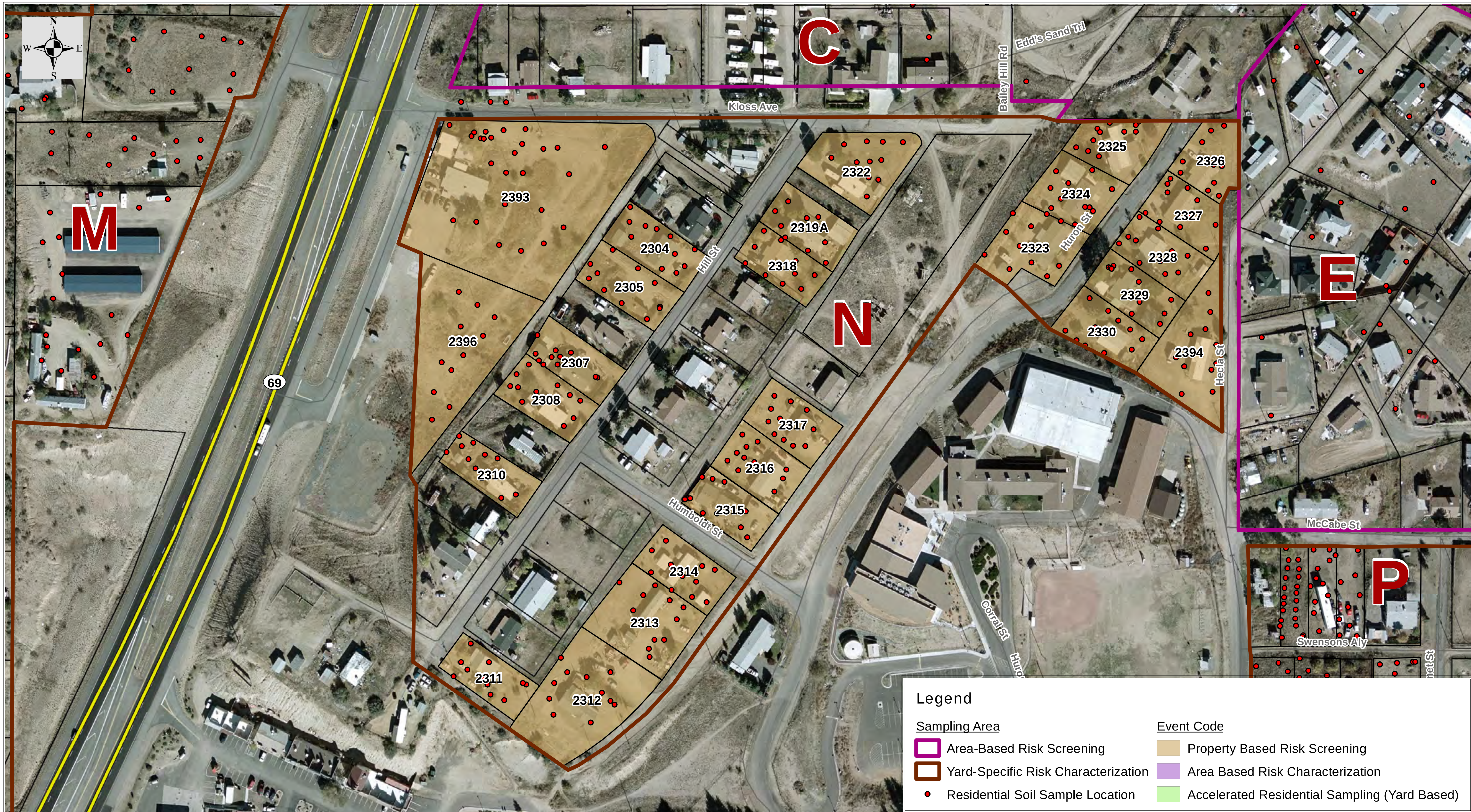
Figure 11-2M
Residential Sampling Area M
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_N_f11-2N

0 150 300
Feet

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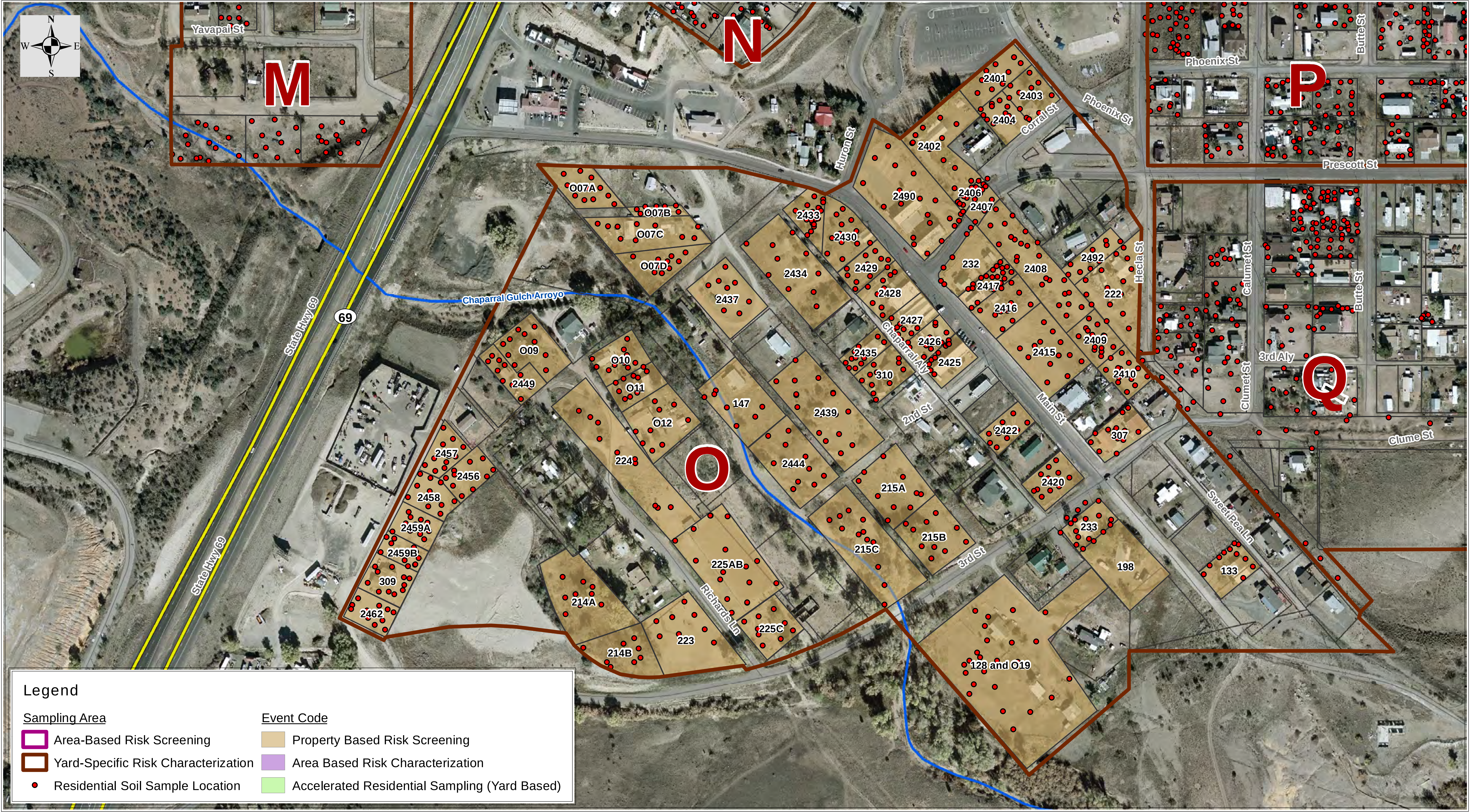
Figure 11-2N
Residential Sampling Area N
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 December 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

0 250 500
Feet

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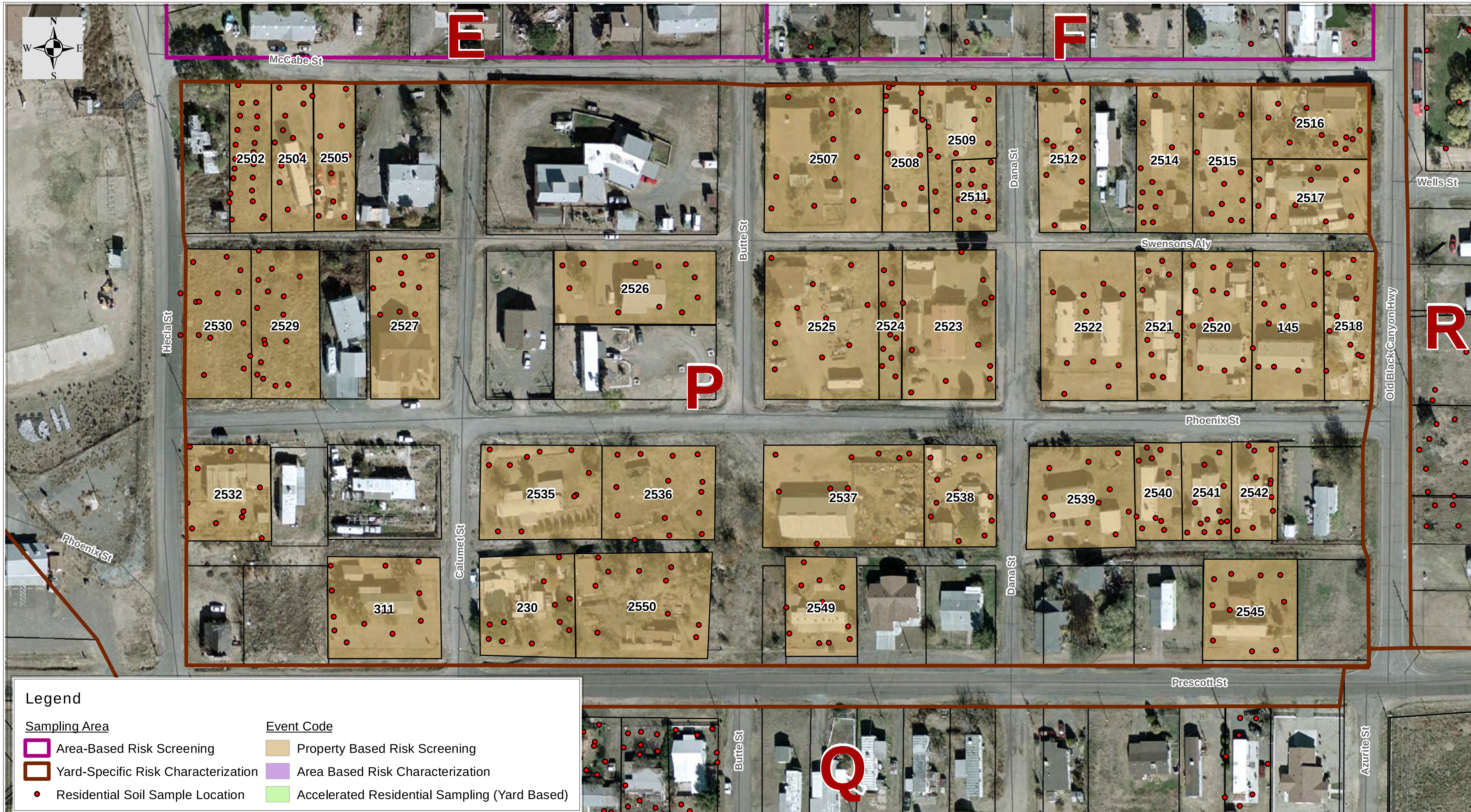
Figure 11-2O
Residential Sampling Area O
Iron King Mine Site
Dewey-Humboldt, Arizona

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_ResidentialArea\146_SEC11_Residential_Sampling_Area_O_f11-2O



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_P_f11-2P

0 100 200
Feet

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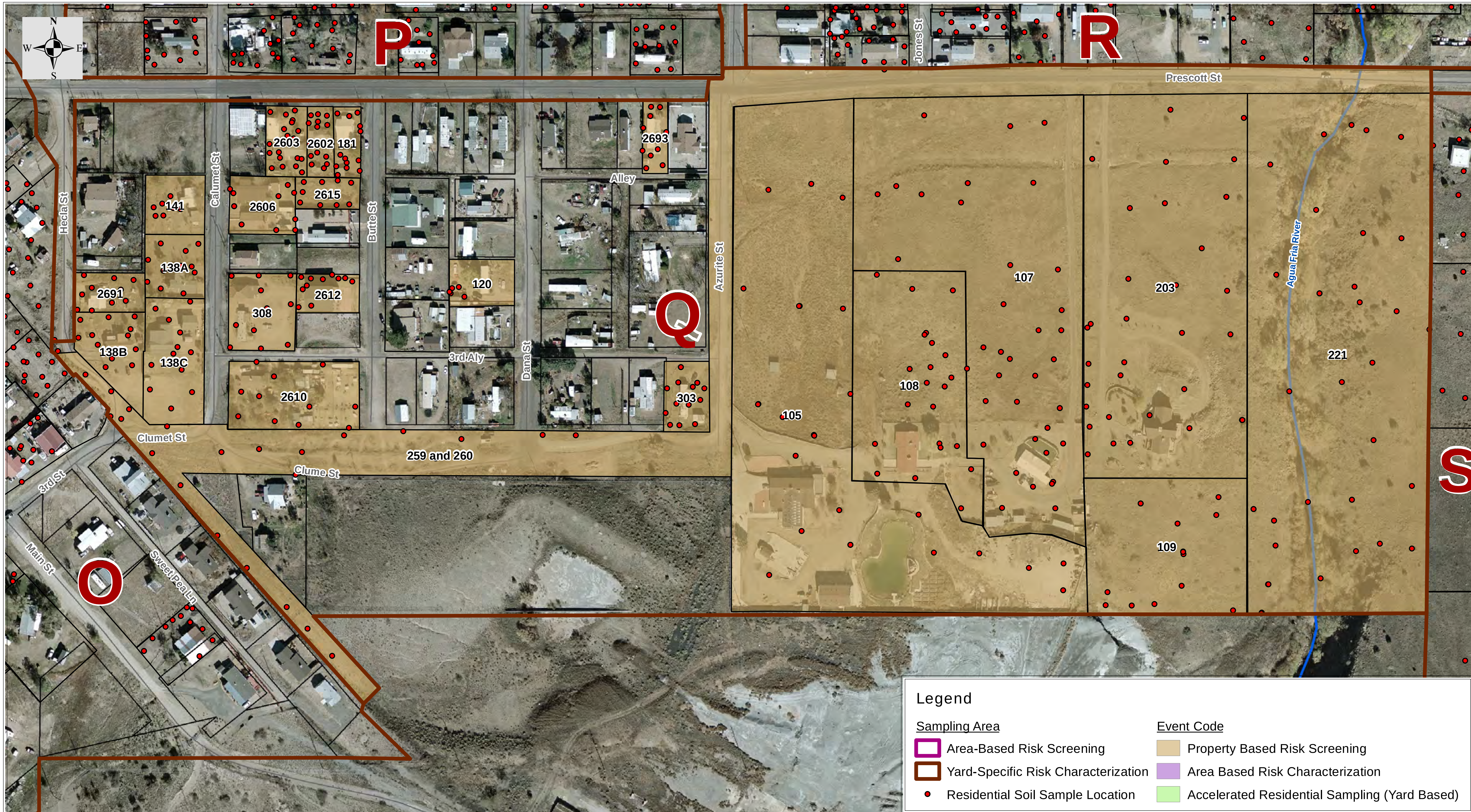
Figure 11-2P
Residential Sampling Area P
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

0 180 360
Feet

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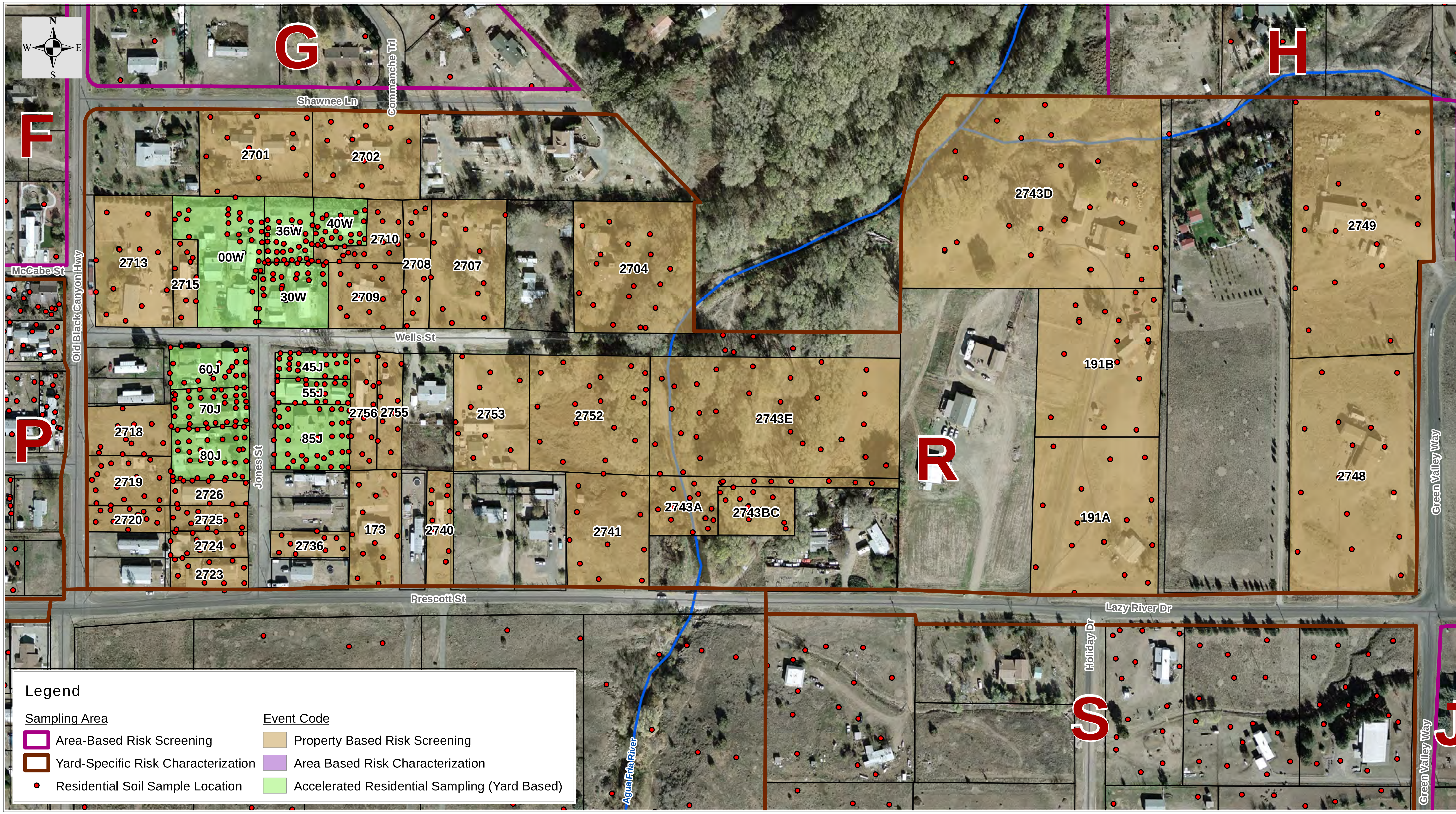
Figure 11-2Q
Residential Sampling Area Q
Iron King Mine Site
Dewey-Humboldt, Arizona

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_Q_f11-2Q



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 December 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\ResidentialArea\146_SEC11_R_Residential_Sampling_Area_R_f11-2R

0 180 360 Feet

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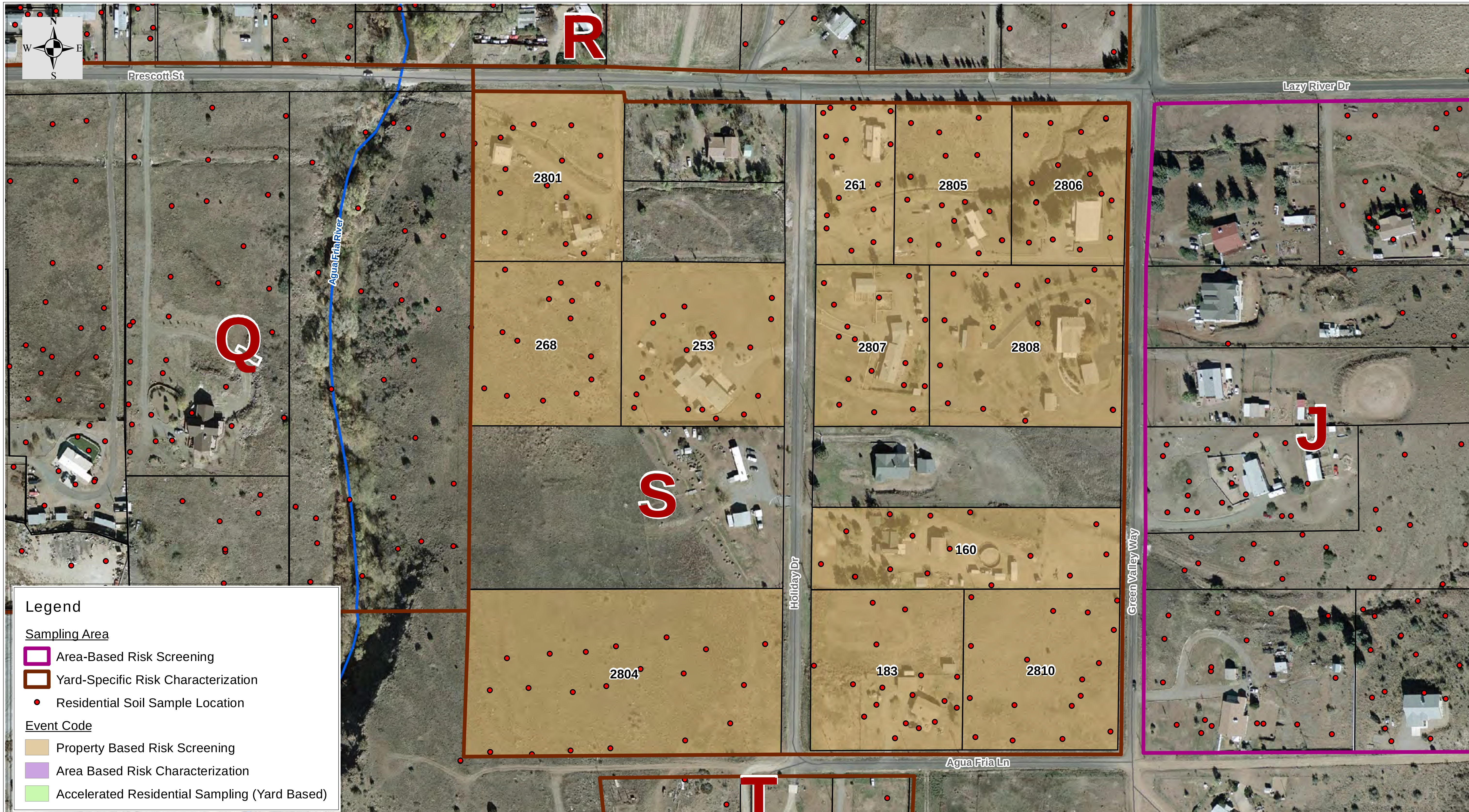
Figure 11-2R
Residential Sampling Area R
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, parcel data from Yavapai county,
sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

0 180 360 Feet

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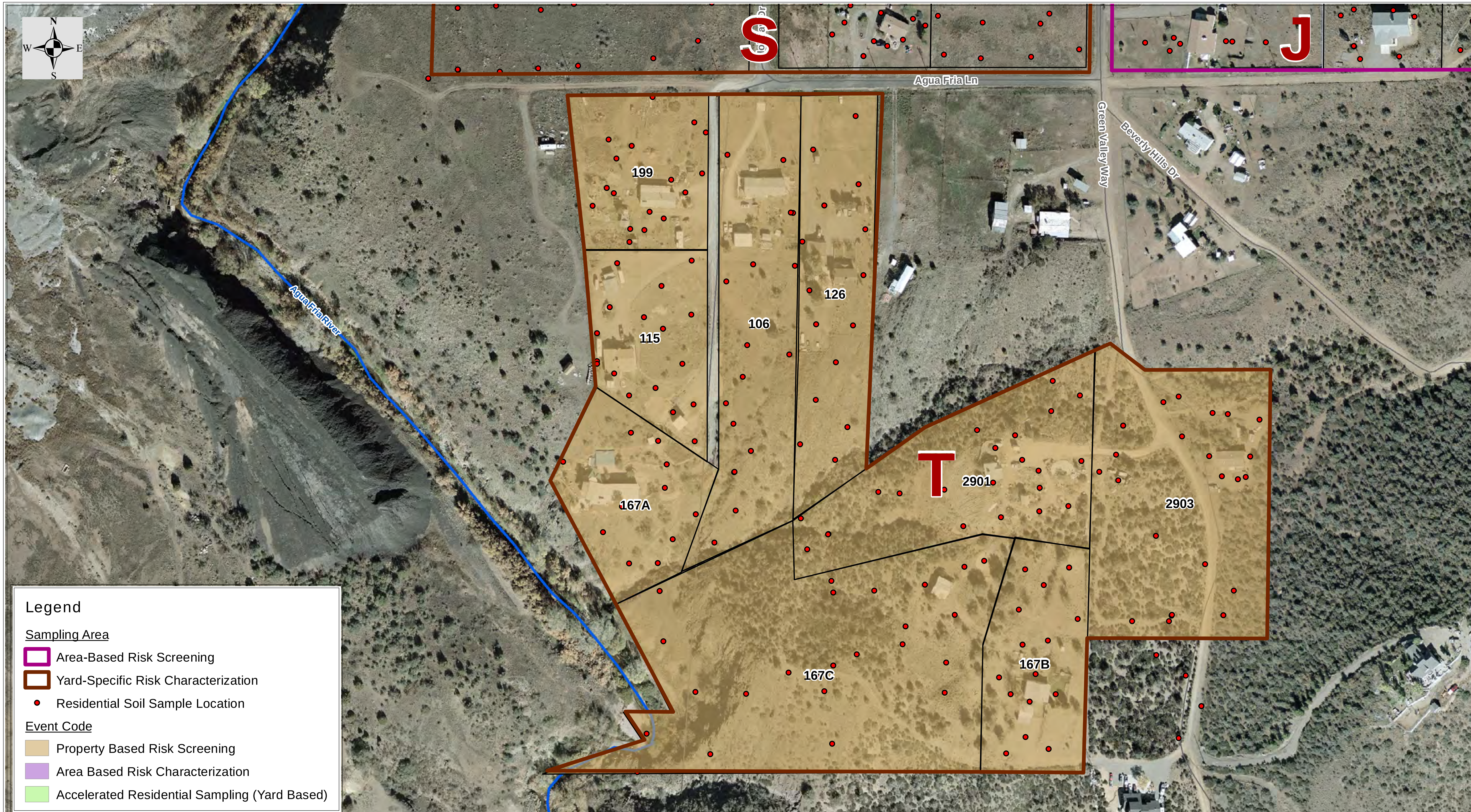
Figure 11-2S
Residential Sampling Area S
Iron King Mine Site
Dewey-Humboldt, Arizona

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_S_f11-2S



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 Decembert 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC11_Residential_Area\146_SEC11_Residential_Sampling_Area_T_f11-2T

0 180 360 Feet

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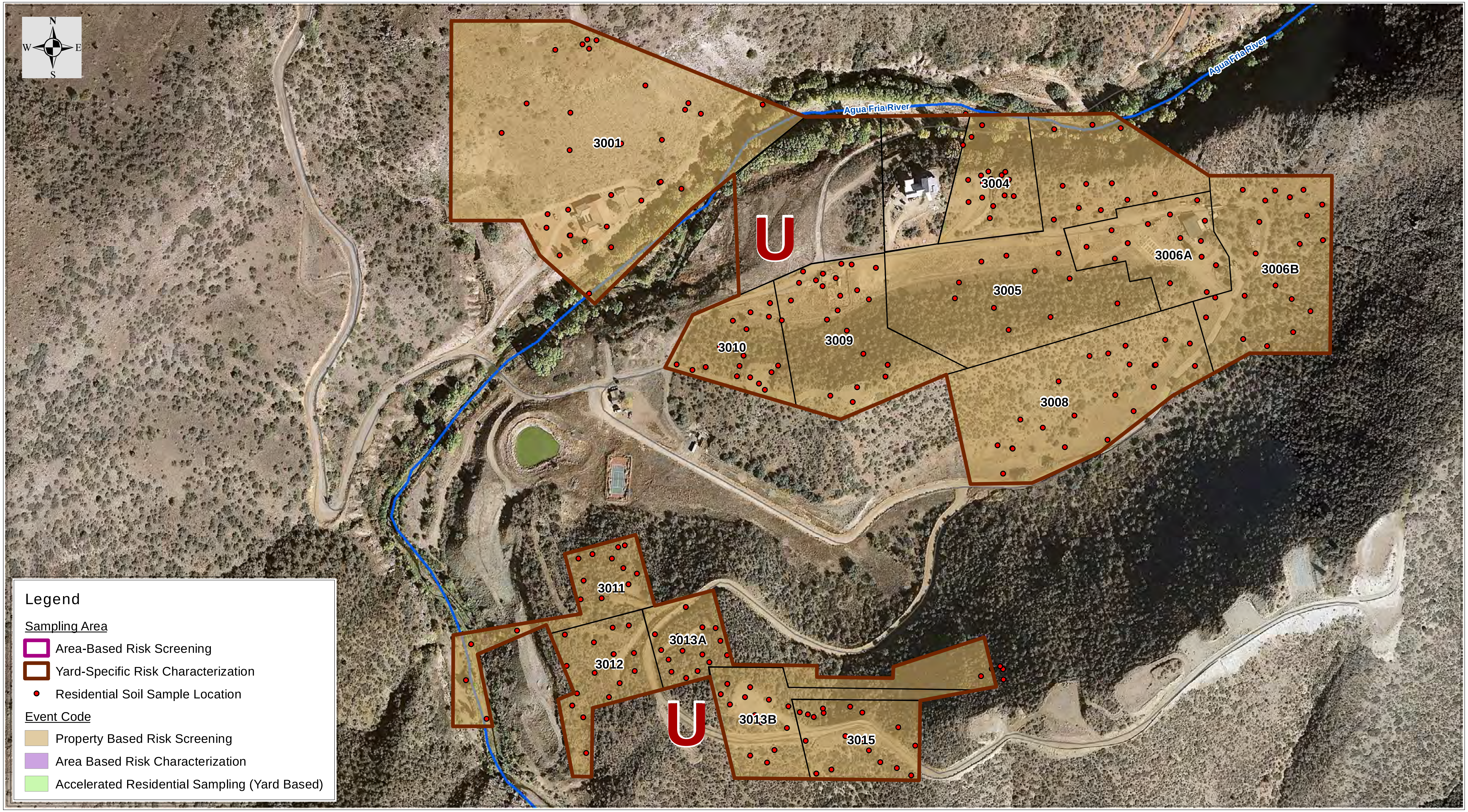
Figure 11-2T
Residential Sampling Area T
Iron King Mine Site
Dewey-Humboldt, Arizona



Base map created using 2010 orthoimagery, parcel data from Yavapai county, sampling Information by 2014.

Map Creation Date: 08 December 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

0 250 500 Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\ResidentialArea\146_SEC11_Residential_Sampling_Area_U_f11-2U

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Figure 11-2U
Residential Sampling Area U
Iron King Mine Site
Dewey-Humboldt, Arizona

Section 12 - Surface Soil Sampling: Non-Residential Areas

12.1 INTRODUCTION

The primary objective of the non-residential surficial sampling effort was to evaluate metal contaminants, particularly arsenic and lead, in areas surrounding the Iron King Mine Site (IKM). Previous investigations had focused on areas immediately around the mine and smelter, but movement and distribution of contaminants into the surrounding landscape had not been thoroughly evaluated. Non-residential areas can potentially have elevated levels of soil contaminants due to deposition of contaminated soil by wind, water, or previous human activities. This sampling effort occurred to better understand the distribution of contaminants in the non-residential areas surrounding the Site.

12.2 METHODOLOGY

At all sampling locations, a soil sample was collected at the soil surface (0 to 2 inches below ground surface). A second, deeper soil sample was also collected at most locations, from a hand-augered boring, which usually extended to a maximum depth of one foot below ground surface (bgs). A third, deeper sample (below one foot) was collected from a few locations.

The soil conditions at most sampling locations were hard and very rocky, making it challenging to collect samples at depth. After sampling, the borings were backfilled with native soil to match the existing grade. Surface and subsurface soil samples were collected in accordance with SERAS SOP #2012, *Soil Sampling*. All observations during field and subsequent laboratory efforts were documented in accordance with SERAS SOP #4001, *Logbook Documentation* and SERAS SOP #2002, *Sample Documentation*.

The number of samples collected per area by analyses and depth are listed in Tables 12-1 and 12-2 respectively. A total of 341 samples were collected for x-ray fluorescence (XRF) analysis. Eighteen of these were also analyzed for target analyte list (TAL) metals for confirmation. Of the 341 samples 304 were in IKM peripheral areas, 29 were in the vicinity of Galena Gulch and 8 were in undeveloped areas. The number of samples and their location/distribution locations were selected by EPA personnel on an aerial map of the Site. Using the marked aerial map, Lockheed Martin/SERAS personnel generated unique Global Positioning System (GPS) coordinates for each sampling location. Each sample coordinate was then located in the field using a Trimble differential GPS receiver. Sample locations were named in accordance with the specific site area, followed by "HA" (for all hand-augered samples), and then by a consecutive sample number (as collected in the field). Note that the majority of the non-residential locations have the prefix "IKM" (for Iron King Mine) although a few are associated with specific areas (e.g. "GAL" for the samples collected near Galena Gulch and "UND" for undeveloped areas; Section 13.5). In most areas, there were no roads or paths that led to the location of interest; thus, sampling involved carrying all necessary equipment over barren terrain. The majority of the non-residential samples were located north of the MTP as wind carries dust from the mine primarily in that direction.

Each collected soil sample was broken up and homogenized in a decontaminated stainless steel bowl and then placed in a clear, plastic Ziploc bag. Large rocks and other debris were also removed from the

samples prior to filling the bags. All samples were transferred to a temporary on-site laboratory for metals analysis using a field portable XRF analyzer
Upon completion of the XRF analyses, five percent (%) of the soil samples were selected for later laboratory confirmation (TAL metals).

Sample locations and the resultant As and Pb soil values are presented in Figure 12-1. Elevated levels of Pb and As were noted in many locations, particularly immediately west and just north of the MTP. Elevated levels were also found in samples collected from Galena Gulch. In general, elevated levels (where present) were higher at ground surface than at depth, although there were some exceptions. Elevated levels occasionally occurred at some of the northern sampling locations (e.g., IKM-HA131). However, locations furthest from the Site (in all directions) generally contained only background levels of As and Pb, even at ground surface.

All analytical results can be found in the Scribe database (Appendix A).

Photograph 12-1

A Lockheed Martin/SERAS Environmental Technician Assisting with the Non-residential Sampling Effort at Iron King Mine. February 2014.

TABLE 12-1
Number of Non-Residential Sample Locations by Analysis
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

Analysis	IKM IKM Peripheral Areas	GAL Galena Gulch	UND Undeveloped Areas	TOTALS
Field XRF	304	29	8	341
TAL Metals and Mercury	16	2	0	18
Total	320	31	8	359

XRF = X-ray Fluorescence
TAL = Target Analyte List

TABLE 12-2
Number of Non-Residential Sample Locations by Depth
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

Depth Interval (inches)	IKM IKM Peripheral Areas		GAL Galena Gulch		UND Undeveloped Areas		TOTALS
	XRF	TAL Metals	XRF	TAL Metals	XRF	TAL Metals	
0 to 2	148	9	18	2	4	0	181
4 to 8	2	0	0	0	0	0	2
10 to 14	140	7	11	0	4	0	162
22 to 26	4	0	0	0	0	0	4
28 to 32	1	0	0	0	0	0	1
34 to 36	9	0	0	0	0	0	9
Total	304	16	29	2	8	0	359

XRF = X-ray Fluorescence
TAL = Target Analyte List

Base map created using 2010 orthoimagery, sample location and sampling data in April 2014.

Map Creation Date: 16 October 2014

Coordinate system: Arizona State Plane Central
FIPS: 0202
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-146
MXD file: g:\arcinfoprojects\SERAS01\SER00146_IronKingMineSite\SEC12_Non-Residential_Area\146_SEC12_XRF_Results_in_NonResidentialArea_Esize_f12-1.mxd

U.S. EPA Environmental Response Team
Scientific Engineering Response and Analytical Services
EP-W-09-031
W.A.# 0-146

Figure 12-1
XRF Results in Non-Residential Areas (Arsenic & Lead)
Iron King Mine Site
Dewey-Humboldt, Arizona

Section 13 - Analysis, Validation and Data Management

13.1 INTRODUCTION

The following section provides a summary of analyses (field and laboratory), validation and data management used for the Iron King Mine (IKM) site assessment. The information contained in this section is applicable to all data presented throughout this report in Sections 1 through 12. Additional information, not specified in this section, relating to analysis, validation and data management is contained in the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) Iron King Mine Site, Dewey-Humboldt, Arizona (Amendment 3).

13. 2 FIELD MEASUREMENTS

Water quality parameters (conductivity, dissolved oxygen [DO], oxygen reduction potential [ORP], pH, salinity, total dissolved solids [TDS], temperature and turbidity), ferrous iron (Fe^{2+}), sediment pH, depth to groundwater and soil thickness were measured in the field and recorded in field logbooks or field datasheets. This data was transcribed from the field notes and imported to the "Monitoring" table of the Scribe database (Appendix A).

13.3 FIELD ANALYSIS

Soil samples were analyzed in the field for metals using a field portable (FP) X-ray Fluorescence (XRF) instrument in a laboratory trailer set up onsite. Metals analyzed by XRF initially included arsenic (As) and lead (Pb) but were extended to include analysis of copper (Cu), chromium (Cr), zinc (Zn), manganese (Mn), and iron (Fe) per the request of EPA Region 9. All samples were analyzed by either a NITON XLt792YW XRF in accordance with Scientific, Engineering, Response and Analytical Services (SERAS) Standard Operating Procedure (SOP) #1720, *Operation of the NITON XLt792YW* or an INNOV-X 4000SL XRF in accordance with SOP #1740, *Operation of the INNOV-X 4000 SL XRF* for Zn, Cu, Fe, Mn, Cr, Pb, and As. Response checks using National Institute for Standards and Technology (NIST) standard reference materials (SRMs) were done to ensure the instrument and application were working properly prior to analysis. Demonstrations of capability (DOCs) were run by each XRF operator in accordance with The NELAC (National Environmental Laboratory Accreditation Conference) Institute (TNI) standard. Both XRFs analyzers were setup to use measurement times (instrument live times) of 120 seconds for measurement condition 1 and 30 seconds for measurement condition 2. Sample preparation, analysis, and quality assurance/quality control (QA/QC) measures documented in the SOPs were followed by the XRF operators for both instruments.

Each sample was analyzed twice by XRF, once on the front and once on the back of the bag. An "A" was added as a suffix to the sample ID for the front of the bag analysis and a "B" was added as a suffix to the sample ID for the back of the bag analysis. The individual measurements were included in the "XRF_Data" table in the Scribe database. Final XRF data (average of the "A" and "B") measurements are included in the "LabResults" table of the Scribe database.

13.4 LABORATORY ANALYSIS

Table 13-1 summarizes the number of samples analyzed by parameter and by laboratory. All sampling preparations and laboratory methods are summarized by analysis, matrix and laboratory in Table 13-2.

13.4.1 Target Analyte List (TAL) Metals

For all 2014 sampling, 10 percent (%) of the residential and 5% of the non-residential soil samples analyzed in the field by XRF were also submitted for target analyte list (TAL) metals confirmation analysis using inductively-coupled (ICP) methodology. TAL metals include: aluminum (Al), antimony (Sb), As, barium (Ba), beryllium (Be), cadmium (Cd), calcium (Ca), Cr, cobalt (Co), Cu, Fe, Pb, magnesium (Mg), Mn, mercury (Hg), nickel (Ni), potassium (K), selenium (Se), silver (Ag), thallium (Tl), vanadium (V) and Zn. Confirmation samples were packaged on wet ice and shipped under chain-of-custody overnight to a Region 9 Contract Laboratory Program (CLP) laboratory (Bonner Analytical) coordinate by the EPA Region 9 Regional Sample Control Coordinator. The analytical results reported by the CLP laboratory were provided as electronic data deliverables (EDDs). The EDDs contained unvalidated data from the laboratory that were imported to the Scribe database (Appendix A). The Analytical Reports provided by the Contract Laboratory Program (CLP) laboratory are included in Appendix B.

13.4.2 Other Analyses

The EPA Region 9 laboratory and SERAS subcontract laboratories were used to perform all of the remaining analyses as specified in Tables 13-1 and 13-2. All laboratory data were provided in electronic format as EDDs. The Region 9 laboratory EDDs were imported directly into the Scribe database; all SERAS subcontract data was reviewed as per Section 13.5 and then imported to the Scribe database (Appendix A). The Final Analytical Reports are included in Appendix B.

13.5 DATA VALIDATION

CLP TAL metals data from Bonner Analytical received an EPA Region 9 Tier 2 automated validation which produced an automated summary reflecting whether contract required QC criteria and/or generic measurement quality objectives had been met. A Tier 3 validation is currently being performed by EPA Region 9, but the validated data is not included in the Scribe file.

Analyses conducted by the EPA Region 9 Laboratory (IVBA and SPLP) received a Region 9 internal review according to USEPA Regional 9 Laboratory SOP #845, *Analytical Data Review*. This data did not receive an external validation.

XRF data are considered field screening data and were not validated.

Geotechnical measurements are considered screening data and have not been validated. These measurements/data include: Atterberg Limits, moisture density, specific gravity, saturated hydraulic conductivity (Ksat), consolidation, direct shear, consolidated-undrained triaxial shear, and soil-water characteristic curves.

All of the remaining analytical data obtained from SERAS subcontracted laboratories was validated as per Stage 4 Manual Validation (S4VM) as specified in the Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use by SERAS QA/QC Chemists..

Copies of all analytical reports are included in Appendix B.

13.6 DATA MANAGEMENT

All field measurements, geospatial data (GPS data), well sampling data and analytical results were imported to the Scribe database (Appendix A). Scribe (http://www.ertsupport.org/Scribe) is a software tool developed by the EPA ERT to assist in the process of managing environmental data which is stored in a Microsoft Access database. Data in the Scribe database may be utilized directly through Scribe or through database management software such as Microsoft Access.

13.6.1 Sample Identifiers (IDs)

Sample identifiers (IDs) were generated using the symbols in Table 13-3. Generally, sample IDs consisted of the sample area, followed by the sample type and a sequential number. For example CHF-SB01 would be the first soil boring collected in the Chaparral Gulch Floodplains.

Property access (Residential and Non-residential) was managed in the Access Database. This database links the access identifier (ACC) ID, SERAS Property ID, EA Number, Correct EA Number and Parlabel ID (see Section 11). The Access Database contained in Section 11, Appendix 11-C, should be used instead of the AccessDB table in Scribe (Appendix A) for obtaining links between ACC IDs, EA numbers, parlabels and SERAS Property IDs.

13.6.2 Database Fields

Data field definitions used in the database were standard Scribe defined fields and should be intuitive to the user of the database. The table below is a summary of key fields and fields that were used for data that was not consistent with the field name. The "Activity", "PropertyID" and "LocationZone" fields were also used to group as described below.

Table	Field	Description
Location	Location	Sample Location ID for Residential and Non-residential Samples
Location	PropertyID	SERAS Property ID for Residential Sampling) and Sample ID Symbol (see Table 13-3) for Non-residential Sampling.
Location	LocationDescription	Sample ID Description (see Table 13-3)
Location	LocationZone	Report Section
Location	Comment	Correct EA Number
Location	GeoScale	Type of Residential Sampling (1 = Yard-Specific Risk Characterization Property, 2 = Off Property Sample, 3 = Accelerated Residential Sampling, 4 = Area-based Risk Screening Property)
Samples	Activity	EA Number assigned by sampling teams based on which property was intended to be sampled. The correct EA Number is in the Location Table and Comment Field (see above).
Samples	Sub_Location	Sample Depth (top of interval)

13.6.3 Database Tables

Below is a summary of the primary tables in the Scribe (Access) database and the data contained within the table:

Table	Data Included
Access DB	Table is not updated and should not be used. The Access Database (Section 11, Appendix C) should be used for obtaining links between ACC IDs, EA numbers, Correct EA

Table	Data Included
	numbers, Parlabels and SERAS Property IDs.
IKM_Monitor_Wells2	Site monitor well data (new and historic) , and 3 rounds of water level measurements
LabResults	All analytical data for the project. Includes IVBA samples collected by EPA in 2013 and residential soils data from ERT/SERAS 2013 accelerated residential sampling event.
Location	Geospatial data for all sampling locations. PropertyID, LocationZone and LocationDescription fields provide additional data for grouping/sorting data. The comments field contains the Correct EA Number.
Monitoring	All field measurements
Samples	Contains field data (sample time, date, depth, samplers, etc.) for all field samples
XRF_data	All raw field XRF results for field samples for 2014 sampling event. An "A" or "B" suffix was added to the sample id for the front and back of the bag measurement. The averaged data for both measurement is included in the "LabResults" table

13.6.4 Database Events

All samples were grouped into fourteen Event IDs in the Scribe database based on the sampling objective and the time of the sampling (Table 13-4). Events are used to further organize the samples within the database.

13.7 ANALYTICAL REFERENCES

Analysis of Alkalinity, Bicarbonate and Carbonate by SM 2320B, "Alkalinity -Titration Method", Standard Methods for the Examination of Water and Wastewater", 15th through 20th editions, 1980 through 1999.

Analysis of Chloride by Method 325.2, "Chloride (Colorimetric, Automated)", Methods for the Determination of Inorganic Substances in Environmental Samples", EPA 600/R-93/100, August 1993.

Analysis of Dissolved Organic Carbon by SM 5310B, "High-Temperature Combustion Method", Standard Methods for the Examination of Water and Wastewater", 15th through 20th editions, 1980 through 1999.

Analysis of Fluoride by Method 300.0, "Inorganic Anions by Ion Chromatography", Methods for the Determination of Inorganic Substances in Environmental Samples", EPA 600/R-93/100, August 1993.

Analysis of Nitrate-Nitrite by Method 353.2, "Nitrate-Nitrite, Colorimetric, Automated Cadmium Reduction", Methods for the Chemical Analysis of Water and Wastes (MCAWW), EPA 600/4-79-020, 1979, revised 1983.

Analysis of Phosphorus by Method 365.4, "Phosphorus, Colorimetric, Automated, Block Digestor, AAII", Methods for the Chemical Analysis of Water and Wastes (MCAWW), EPA 600/4-79-020, 1979, revised 1983.

Analysis of Silica by Method 3020A/6010C, "Inductively Coupled Plasma-Atomic Emission Spectrometry", Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods, SW-846, 2nd and 3rd Editions, Updates I through IIIB, 1996 through 2004.

Analysis of Sulfate by Method 375.4, "Sulfate (Turbidimetric)", Methods for the Chemical Analysis of Water and Wastes (MCAWW), EPA 600/4-79-020, 1979, revised 1983.

Analysis of Total Dissolved Solids by SM 2540C, "Total Dissolved Solids Dried at 180 Deg C", Standard Methods for the Examination of Water and Wastewater", 15th through 20th editions, 1980 through 1999.

Analysis of Hexavalent Chromium by EPA Method SW846 3060A, "Alkaline Digestion for Hexavalent Chromium" and SW846 7196A, "Chromium, Hexavalent (Colorimetric)".

Analysis of Dioxin/Furans by EPA Method SW846 3540C, "Soxhlet Extraction" and SW846 8290A "Polychlorinated Dibenzo-p-Dioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (HRGC/HRMS)".

Analysis of Lead and Arsenic (solids and IVBA) by SW846 6020 Method, "Inductively Coupled Plasma-Mass Spectrometry".

In Vitro RBA and In Vivo RBA were calculated by EPA Method 9200.1-86, "Standard Operating Procedure for an In Vitro Bioaccessibility Assay for Lead in Soil".

Analysis of Metals by EPA Method SW846 3050B, "Acid Digestion of Sediments, Sludges and Soils" and SW846 6020A, "Inductively Coupled Plasma-Mass Spectrometry".

Analysis of Lead and Arsenic (solids and IVBA) by SW846 6020 Method, "Inductively Coupled Plasma-Mass Spectrometry".

Analysis of Metals in Soil by SERAS SOP# 1811, "Digestion and Analysis of Metals by Inductively Coupled Plasma/Atomic Emission Spectrometry (ICP-AES)".

Analysis of Mercury in Soil by SERAS SOP# 1832, "Digestion and Analysis Of Mercury By Cold-Vapor Atomic Absorption (CVAA)".

Analysis of Mercury by EPA Method SW846 7471A, "Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)".

Acid-Base Accounting by EPA Method EPA-600/2-78-054, "Field and Laboratory Methods" and ASTM Method E1915 "Standard Test Methods for Analysis of Metal Bearing Ores and Related Materials by Combustion Infrared-Absorption Spectrometry".

"Standard Test Methods for Analysis of Metal Bearing Ores and Related Materials by Combustion Infrared-Absorption Spectrometry".

Analysis of Total Organic Carbon by EPA Method SW846 9060A, "Total Organic Carbon".

ISM01.3. USEPA Contract Laboratory Program Statement of Work for Multi-Media, Multi-Concentration Inorganic Analysis, December 2006.

Environmental Protection Agency R9 Standard Operating Procedure 254, Bioaccessibility SPLP Extraction; 03/01/11, Rev. 1.

Environmental Protection Agency R9 Standard Operating Procedure 407, Preparation of Leachate Procedure Extracts for Metals Analysis; 10/10/11, Rev. 2.

Environmental Protection Agency R9 Standard Operating Procedure 503 Standard Operating Procedure 503, Standard Determination of Trace Elements in Solids and Leachate Procedure Extracts by ICP-AES; 12/14/12 Rev. 5.

Environmental Protection Agency R9 Standard Operating Procedure 515, Determination of Mercury in Water by CVAA Spectrometry; 7/98, Rev. 8.

Environmental Protection Agency R9 Standard Operating Procedure 256, Bioaccessibility Extraction; 06/03/11, Rev. 1.

ASTM D2216-10 Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

ASTM D2937 ASTM D2937-10, Standard Test method for Density of Soil in Place by the Drive-Cylinder Method.

ASTM D5084-10, Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

ASTM D6836 - 02(2008)e2, Standard Test Methods for Determination of the Soil Water Characteristic Curve for Desorption Using a Hanging Column, Pressure Extractor, Chilled Mirror Hygrometer, and/or Centrifuge.

ASTM D422 - 63(2007) Standard Test Method for Particle-Size Analysis of Soils.

ASTM D4318 - 10 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

ASTM D2435 / D2435M - 11 Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading.

ASTM D3080 / D3080M - 11 Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions.

ASTM D4767 - 11 Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils.

ASTM D6836 - 02(2008)e2, Standard Test Methods for Determination of the Soil Water Characteristic Curve for Desorption Using a Hanging Column, Pressure Extractor, Chilled Mirror Hygrometer, and/or Centrifuge.

ASTM D854-14, Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

TABLE 13-1
Number of Samples Analyzed by Parameter and Laboratory
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

Subcontract Laboratory	Analyses	Number of Samples*
ACZ Laboratories	*In Vitro* Bioaccessibility (IVBA;As & Pb)	19
ALS Laboratory Group (subcontracted by Katahdin Analytical Services)	Acid Base Accounting (ABA)	39
Bonner Analytical	TAL Metals	757
Cape Fear (subcontracted by Katahdin Analytical Services)	Dioxin/Furans	8
ChemTech Consulting Group	TAL Metals (August 2013 - Accelerated Residential Sampling Event)	30
ERT SERAS Laboratory	TAL Metals (Collected in conjunction with EPA 2013 IVBA Samples)	19
GeoSystems Analysis Inc.	Soil-Water Characteristic Curves/Ksat	3
Katahdin Analytical Services	Dissolved Organic Carbon	67
	Hexavalent Chromium	35
	Phosphorus	67
	Nitrate/Nitrite	67
	Silicon	66
	TAL Metals & Hg (Plant Tissue)	11
	TOC	6
	Water Quality (Alkalinity/Carb/Bicarb, Chloride, Sulfate, Fluoride, TDS)	67
Speedie & Associates, Inc.	Atterberg Limits	59
	Consolidation	3
	Consolidated-Undrained Triaxial Shear/Ksat	3
	Direct Shear	3
	Grain Size	59
	Ksat (hydraulic conductivity)	5
	Moisture	38
	Moisture - Density	18
	Specific Gravity	25
U.S. EPA Region 9 Laboratory	IVBA (As & Pb)	37
	Synthetic Precipitation Leaching Procedure (SPLP) – RCRA 8 metals[§] and aluminum (Al), Cu, Fe, Mn, and Zn	39

*Number of samples including duplicate samples and blanks

[§]RCRA 8 – Resource Conservation and Recovery Act metals: arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), selenium (Se), silver (Ag)

TABLE 13-2
Analytical Methods, Containers and Sample Preparation
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

Analysis	Matrix	Laboratory	Laboratory Method	Preparation
In Vitro Bioaccessibility (IVBA) for As and Pb	Soil	ACZ Laboratories[a]	*SW 846 6020 and EPA Method 9200.1-86*	None
		EPA Region 9 Laboatory	EPA R9 SOP 256 / EPA R9 SOP 407 and EPA R9 SOP 515	None
Synthetic Precipitation Leach Procedure (SPLP)	Soil		EPA R9 SOP 254 and EPA R9 SOP 503	None
Acid Base Accounting (ABA)	Soil	ALS Environmental	EPA-600/2-78-054 and ASTM E1915	None
TAL Metals and Mercury, total[b]	Soil	ERT/SERAS Laboratory	Metals/SERAS SOP# 1811 & 1832	Preserved w/HNO3 to pH < 2 (water) None (soils)
TAL Metals and Mercury, total	Soil and Water	Bonner Analytical	ISM01.3	Preserved w/**HNO_3** to pH < 2 (water) None (soils)
TAL Metals and Mercury, dissolved				
TAL Metals and Mercury (Plants)	Plant Tissue	Katahdin Analytical Services	SW 846 3050B/6020A and 7471A	None
Hexavalent Chromium	Soil		SW 846 3060A and 7196A	None
Synthetic Precipitation Leach Procedure (SPLP)	Soil	U.S. EPA Region 9	EPA R9 SOP 254 and EPA R9 SOP 503	None
Dioxin/Furans	Soil	Cape Fear Analytical	SW846 3540C/8290A	None

TABLE 13-2
Analytical Methods, Containers and Sample Preparation
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

Analysis		Matrix	Laboratory	Laboratory Method	Preparation
Water Quality	Alkalinity	Water	Katahdin Analytical Services	SM 2320B	Unfiltered; no preservative
	Bicarbonate				
	Carbonate				
	Chloride			EPA Method 325.2	
	Fluoride			EPA Method 300.0	
	Sulfate			EPA Method 375.4	
	Solids-Filterable Residue (TDS)			SM 2540C	
	Silica			EPA Method 6010C	Unfiltered; preserved w/**HNO_3** to pH < 2
	Dissolved Phosphorus as P			EPA Method 365.4	*Filtered; preserved w/**H_2SO_4** to pH < 2
	Nitrate+Nitrite as N			EPA Method 353.2	
	Dissolved Organic Carbon			SM 5310B	*Filtered; preserved w/**H_2SO_4** to pH < 2 (water)
TOC		Soil	Cape Fear Analytical	SW 846 9060A	None
Soil-Water Characteristic Curves/Ksat		Soil	Speedie & Associates, Inc.	ASTM D6836	None
Atterberg Limits				ASTM D4318	None
Consolidation				ASTM D2435	None
Consolidated-Undrained Triaxial Shear/Ksat				ASTM D4767	None
Direct Shear				ASTM D3080	None
Grain Size					None
Ksat (hydraulic conductivity)				ASTM D5084	None
Moisture				ASTM 2216	None
Moisture - Density				ASTM D2937	None
Specific Gravity				ASTM D854	None
Moisture Characteristic Curves		Soil	GeoSystems Analysis, Inc.	ASTM D6836	None

TABLE 13-2
Analytical Methods, Containers and Sample Preparation
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

Analysis	Matrix	Laboratory	Laboratory Method	Preparation
Field Measurements (pH; Eh(redox); Specific Conductivity; Temp; DO; Turbidity)	Water	SERAS Field Team	Horiba Multi-parameter Water Quality Meter Operations Manual	Field Test
Ferrous iron (test kit)	Water		CHEMetrics Iron VACUettes Kit K-6210D Operations Manual	Field Test

* NOTE - add acid AFTER filtration process for samples that require filtration

[a]Samples collect by EPA in 2013

[b]Samples collected during Accelerated Residential Sampling Event (August 2013)

TABLE 13-3
Sample Identifiers
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

Description	Symbol
Area	
Residential: Risk Property-based Assessment Screening	RA*
IKM Main Tailings Pile	MTP
Waste rock	WR
IKM Peripheral Areas	IKM
Galena Gulch	GAL
Undeveloped Areas	UND*
Dross material	ASH
Slag	SL
Plateau soils	PS
Smelter Tailings Swale	STS
Chaparral Gulch (upstream of floodplain)	CH/CHU
Chaparral Gulch Floodplain	CHF
Dam/Area behind the Dam	DAM
Chaparral Gulch (downstream of dam)	CHD
Agua Fria River	AG
Monitor Wells (groundwater samples)	MW
Sample Type	
Soil - Surface/Near Surface (provide approx. depth if > 0.2 ft)	SS
Soil - Borings (provide approx. depth or depth interval)	SB
Soil (collected) with Hand Auger	HA
Sediment	SED
Surface Water	SW
Storm Water Sampling Device	SWD
Plant Matter	PL
Bioaccessibility Samples, Soil	IVBA
Bioaessessment Samples, Soil	BIOSS
Bioaessessment Samples, Sediment	BIOSED
Bioaessessment Samples, Plant	BIOPL
Bioaessessment Samples, Invertebrate	BIOINV

TABLE 13-4
Event Identifiers
Iron King Mine Site
Dewey-Humboldt, Arizona
December 2014

Event ID	Dates	Number of Samples	Comments
Accelerated Residential Soil Sampling	August 13 to 15, 2013	314	Final Data only; individual XRF measurements were not imported to Scribe
AUGUST SW Sampling	August 15, 2014	29	Surface water samples collected during August 2014 sampling event.
Bio Samples	February 27 to May 9	205	All bioassessment/biological survey samples
Bio SamplesIVBA	February 27 to 28, 2014	32	All IVBA samples that were not collected on residential properties
Deep Borings	April 2 to 8, 2014	141	All samples collected from deep borings
Dross Sampling	February 10 to May 9, 2014	365	All samples collected from the "Dross" area
Hand Boring	February 19 to May 9, 2014	398	Surface soil and shallow hand boring samples collected on non-residential portions of the site (Galena Gulch, IKM Mail Tailings Pile, IKM Peripheral Areas, Slag, Undeveloped Areas, Waste Rock)
JULY GW/SW Sampling	July 28 to August 4, 2014	177	Groundwater and surface water (storm water) samples collected during the July/August sampling event
OCT GW Sampling	October 21 to 23, 2014	141	Groundwater samples collected during the October sampling event.
OCT SW Sampling	October 2, 2014	2	Surface water (storm water) samples collected during the October sampling event
Risk Assessment	January 30 to May 8, 2014	4265	Residential (property based) risk assessment samples.
Risk Screening	January 22 to March 5, 2014	322	Residential (Area-Based) risk assessment samples. Some samples for areas that were elevated to property based risk assessment are included in this event.
Shallow Borings	February 2 to 28, 2014	759	Shallow soil borings
Spring 2013 IVBA	April 29 to May 2, 2013	19	IVBA samples collected by EPA in 2013

SECTION 14 – Survey Report

14.1 INTRODUCTION

Between April and July 2014, a Lockheed Martin SERAS subcontractor (Granite Basin Engineering, Inc., Prescott, Arizona) performed ground survey work in and around the Iron King Mine (IKM) and Humboldt Smelter (HS), in Dewey-Humboldt, Yavapai County, Arizona (AZ). The objectives of this work were as follows:

- Obtain horizontal and vertical measurements of new monitor wells that were installed throughout the study area by Scientific, Engineering, Response and Analytical Services (SERAS) personnel;
- Obtain measurements for monitoring the movement of existing cracks on the slag pile to the east of the HS;
- Gather and map out topographic and subsurface data around the Chaparral Gulch Dam to assist with a subsequent stability assessment;
- Gather topographic data throughout the smelter tailings swale (adjacent to the Chaparral Gulch floodplain) to estimate the volume of tailings within this area; and
- Survey channel cross sections and a longitudinal profile in an area downstream of the Chaparral Gulch Dam to assist with a hydraulic analysis

Monitor Well Survey

Horizontal coordinates and ground elevations were determined for all new monitor wells installed during 2014. Additional elevation data were recorded at the well locations to document the top of outer protective casings (either above ground or flush-mount) and top of inner polyvinyl chloride (PVC) well risers.

Slag Pile Stability Measurements

There are large cracks in the top of the main slag pile that may be the result of cooling rather than mass wasting. To determine if the cracks are widening, metal pins were installed at five locations, on each side of major cracks (a total of 10 pins). The horizontal coordinates and elevations of the pins were surveyed to sub-millimeter accuracy in April 2014 and will again be re-surveyed in April or May 2015 to determine if the slag cracks expanded or remained unchanged during the 12-month monitoring period.

Transects along cracks through the most critical sections of the slag pile were additionally surveyed and plotted on high resolution aerial imagery. The data were gathered at 50-foot intervals along major cracks that ran longitudinally across the pile, and encompassed a total length of approximately 2,000 feet.

Survey of the Chaparral Gulch Dam

At present, the concrete rubble dam is essentially a retaining wall for tailings and unconsolidated deposits on the upstream side. The downstream side of the dam is fully exposed; whereas the upstream side is completely obscured. While the dam is currently not showing any significant signs of structural fatigue, a stability analysis had been recommended to evaluate the long-term permanence of the structure.

In support of the stability analysis, the dimensions of the dam were surveyed and a number of scaled drawings were prepared. Borehole data from 2014 were additionally used to determine the slope of the concrete on the upstream side of the dam and character of the natural bedrock surface on either side of the dam.

Survey of Smelter Tailings Swale

The smelter tailings are located west and south of the HS stack within a tributary swale on the north side of the Lower Chaparral Gulch floodplain. The tailings are yellow in appearance and similar to the materials within the Main Tailings Pile on the Iron King Mine property, except being lighter in color. An old tailings dam, oriented east-west, is located at the southern end of the pile, which had been constructed in the natural swale to allow settling and containment of tailings. It appears that a coarse fraction of the tailings and native material were used for the dam embankment, as was common with the construction of tailings dams.

The tailings dam has two breaches (or slope failures), which over time has led to the upstream formation of two primary gullies (generally oriented north-south) across the pile. Periods of excessive rainfall and surface water runoff are the main factors contributing to gully formation, erosion, and downstream transport of materials. The two breaches are not recent as they are observed in 1940 aerial imagery.

Because the volume of tailings had not previously been quantified, a detailed delineation of material was required for this area. In late May 2014, a survey of the tailings swale was completed, which included surface topography of the tailings along with numerous survey shots of what was estimated as being the top of "natural ground" along the sides of eroded, gullied areas. These data were combined with 2014 borehole data to verify the approximate depth to natural ground beneath the tailings and ultimately estimate the volume of the tailings within this area.

Surveying Downstream of Dam

During July 2014, a survey was performed downstream of the Chaparral Gulch Dam. Channel cross-section measurements were performed at two locations where pressure transducers had been installed by SERAS to monitor changes in water height (or flow) over time. At both locations, survey data were gathered at an estimated perpendicular to the existing flow line of Chaparral Gulch. A longitudinal profile along the primary channel was also surveyed between the two cross sections, which extended an additional 16 feet beyond the sections, in both upstream and downstream directions.

Granite Basin's *Iron King Mine Survey Report*, along with supporting data, figures and tables follow this introduction.

Iron King Mine Survey Report

Iron King Mine, Dewey-Humboldt, Arizona

Presented to Lockheed Martin Information Systems and Global Services

Developed by Granite Basin Engineering, Inc.

November 20, 2014

tom@granitebasinengineering,com.com

Executive Summary

In April, May and June of 2014, Granite Basin Engineering, Inc. performed ground survey work in and around the Iron King Mine and Humboldt Smelter, in Dewey-Humboldt, Yavapai County, Arizona. The purpose for the work was to provide measurements of bore holes and monitoring wells that have been placed on the property by Lockheed Martin/SERAS, measurements for the monitoring of existing cracks on the slag pile to the east of the Humboldt Smelter, and gathering of topographic data for the existing tailings dam and the tailings piles adjacent to Chaparral Gulch as part of the ongoing analysis funded by the United States Environmental Protection Agency. Cross sections and profiles were performed in the area downstream of the dam on Chaparral Gulch to assist with a hydraulic analysis of the drainage area. The work was performed using existing control developed by Granite Basin Engineering, Inc. in October and November of 2010 for the Yavapai County Flood Control District. The datum used was as provided by the National Geodetic Survey, NAD 83 (2007 epoch) Arizona State Plane, Central Zone with the NAVD 88 vertical datum. Upon commencement of work in April of 2014, this control was densified throughout the project area. The Yavapai County Flood Control District developed aerial mapping and imagery that is being used by Lockheed Martin/SERAS as part of their project and the survey data being gathered matches that mapping both horizontally and vertically. The data when combined will provide a footprint for monitoring of earth movement and the local water table as well as being used to accurately approximate the amount of material that will need to be remediated from the site. This report is considered to be a living document and will be updated as required when subsequent work is performed on the site.

View from the Agua Fria River

Incorporated in 2004 by a 72% voting margin, the town of Dewey-Humboldt is nestled in an area between the Bradshaw and Mingus Mountain ranges. A population of fewer than 4,000, the town and its residents are a combination of self-employed and service workers that commute to nearby Prescott and Prescott Valley as well as Phoenix. The town and its history have been long associated with mining. From its humble beginnings in the late 1800's where its settlers sought gold to the modern day remnants of "big copper", the Town of Dewey-Humboldt continues to persevere.

Contents

I. Project Control

The control for the project is based on an existing control network that was previously developed by Granite Basin Engineering, Inc. for the Yavapai County Flood Control District. That control was developed in October and November of 2010. GBE densified the existing control within the project area on April 14, 15, and 16, 2014. The original control network was developed for aerial mapping for the Flood Control District and that mapping has been provided to LM/SERAS and is being used as a background and base map for all of their work. The work by GBE will match that mapping. The datum used was as provided by the National Geodetic Survey and densified throughout the project area. The North American Datum from 1983 (NAD 83 (2007 epoch)) Arizona State Plane, Central Zone is the horizontal reference for the work and the North American Vertical Datum 1988 (NAVD 88) is the vertical reference. Although these reference points have been established for many years, the most recent publications of these local control points were used in the 2010 network and perpetuated again in 2014 for our work. GBE utilized Trimble 5800 GPS total stations and 5600 Robotic total stations to execute this initial stage of the work. The main control points that were originally used were both primary NGS control points and their names are “Dewey” and “Texas”. Both points are a high order horizontal points while “Texas” was also a high order vertical point. The existing 2008 network for the nearby Town of Prescott Valley was also used to verify these positions. Both of these points were near the junction of Highways 169 and State Route 69 at the north end of Dewey-Humboldt. GBE verified that all of the original control points that were found were in agreement with these reported positions. Using Global Positioning total stations, GBE increased the amount of control points in an around the site. Once the control was brought into a closer range, GBE then used the Robotic total stations to gather point data. The Global Positioning survey data was developed with sub-centimeter accuracy while the robotic work is performed in the millimeter range. The information as published by the National Geodetic Survey for these points is contained on the following pages.

Project Overview

I.a NGS Control Point "DEWEY"

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
PROGRAM = datasheet95, VERSION = 8.4
1        National Geodetic Survey,   Retrieval Date = MAY 13, 2014
 ET0862 ***********************************************************************
 ET0862  DESIGNATION -  DEWEY
 ET0862  PID         -  ET0862
 ET0862  STATE/COUNTY-  AZ/YAVAPAI
 ET0862  COUNTRY     -  US
 ET0862  USGS QUAD   -  HUMBOLDT (1973)
 ET0862
 ET0862                         *CURRENT SURVEY CONTROL
 ET0862
 ET0862* NAD 83(1992) POSITION- 34 31 49.10511(N) 112 13 55.44243(W)   ADJUSTED
 ET0862* NAVD 88 ORTHO HEIGHT -  1397.6    (meters)    4585.    (feet) VERTCON
 ET0862
 ET0862  GEOID HEIGHT    -        -26.14  (meters)                     GEOID12A
 ET0862  LAPLACE CORR    -          1.59  (seconds)                    DEFLEC12A
 ET0862  HORZ ORDER      -  SECOND
 ET0862
 ET0862.The horizontal coordinates were established by classical geodetic methods
 ET0862.and adjusted by the National Geodetic Survey in August 1993.
 ET0862.
 ET0862.The NAVD 88 height was computed by applying the VERTCON shift value to
 ET0862.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 ET0862
 ET0862.The Laplace correction was computed from DEFLEC12A derived deflections.
 ET0862
 ET0862. The following values were computed from the NAD 83(1992) position.
 ET0862
 ET0862;                    North         East     Units Scale Factor Converg.
 ET0862;SPC AZ C     -   391,518.601   184,406.937   MT  0.99991033   -0 10 43.6
 ET0862;SPC AZ C     - 1,284,509.85    605,009.64   iFT  0.99991033   -0 10 43.6
 ET0862;UTM  12      - 3,821,647.086   386,930.026   MT  0.99975758   -0 41 54.5
 ET0862
 ET0862!             -  Elev Factor  x  Scale Factor =   Combined Factor
 ET0862!SPC AZ C     -   0.99978476  x   0.99991033  =   0.99969511
 ET0862!UTM  12      -   0.99978476  x   0.99975758  =   0.99954239
 ET0862
 ET0862:                Primary Azimuth Mark                        Grid Az
 ET0862:SPC AZ C     -  ROUND                                       105 16 37.2
 ET0862:UTM  12      -  ROUND                                       105 47 48.1
 ET0862
 ET0862|---------------------------------------------------------------------|
 ET0862| PID    Reference Object                     Distance      Geod. Az  |
 ET0862|                                                           dddmmss.s |
 ET0862| ET0866 ROUND                               APPROX. 4.2 KM 1050553.6 |
 ET0862| CH3044 DEWEY RM 1                           14.176 METERS 17037     |
 ET0862| ET0919 HUMBOLDT SMOKE STACK                APPROX. 3.6 KM 1802627.0 |
 ET0862| CH3045 DEWEY RM 2                           13.445 METERS 27856     |
 ET0862|---------------------------------------------------------------------|
 ET0862
 ET0862                          SUPERSEDED SURVEY CONTROL
```

```
ET0862
ET0862  NAD 83(1986)-  34 31 49.10126(N)    112 13 55.44054(W) AD(       ) 2
ET0862  NAD 27      -  34 31 49.01237(N)    112 13 52.85943(W) AD(       ) 2
ET0862  NGVD 29 (07/19/86) 1396.8    (m)         4583.     (f) VERT ANG
ET0862
ET0862.Superseded values are not recommended for survey control.
ET0862
ET0862.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
ET0862.See file dsdata.txt to determine how the superseded data were derived.
ET0862
ET0862_U.S. NATIONAL GRID SPATIAL ADDRESS: 12SUD8693021647(NAD 83)
ET0862
ET0862_MARKER: DD = SURVEY DISK
ET0862_SETTING: 15 = METAL ROD DRIVEN INTO GROUND. SEE TEXT FOR ADDITIONAL
ET0862+WITH SETTING: INFORMATION.
ET0862_SP_SET: PREFABRICATED CONCRETE POST
ET0862_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
ET0862+SATELLITE: SATELLITE OBSERVATIONS - July 11, 2008
ET0862
ET0862  HISTORY     - Date     Condition        Report By
ET0862  HISTORY     - 1969     MONUMENTED       USGS
ET0862  HISTORY     - 1980     GOOD             USGS
ET0862  HISTORY     - 19971112 GOOD             USPSQD
ET0862  HISTORY     - 20080517 GOOD             GEOCAC
ET0862  HISTORY     - 20080711 GOOD             GEOCAC
ET0862
ET0862                         STATION DESCRIPTION
ET0862
ET0862'DESCRIBED BY US GEOLOGICAL SURVEY 1969 (FLA)
ET0862'LOCATED ABOUT 13 MI. E. OF PRESCOTT.  0.6 MI. E. OF DEWEY.  ON LEVEL
ET0862'GROUND AT A FENCE CORNER.
ET0862'
ET0862'TO REACH FROM THE JUNCTION OF STATE HIGHWAY 69 AND RD. E. TO DEWEY,
ET0862'DRIVE E. ACROSS THE RR. TRACKS FOR 0.6 MI. TO A N.-S. FENCE, TURN
ET0862'LEFT AND DRIVE N. ALONG THE W. SIDE OF THE FENCE FOR 300 FT. TO A
ET0862'FENCE CORNER AND STATION MARK.
ET0862'
ET0862'STATION MARK--A STANDARD USGS TABLET STAMPED DEWEY ET 1969 CRIMPED
ET0862'ON THE END OF A COPPERWELD ROD THAT HAS BEEN DRIVEN TO REFUSAL,
ET0862'LEVEL WITH THE GROUND.
ET0862'
ET0862'REFERENCE MARK NO. 1--A STANDARD USGS REFERENCE MARK TABLET STAMPED
ET0862'1 1969, CRIMPED ON THE END OF A COPPERWELD ROD THAT HAS BEEN DRIVEN
ET0862'TO REFUSAL, LEVEL WITH THE GROUND, AND 2 FT. BELOW THE STATION
ET0862'MARK.
ET0862'
ET0862'REFERENCE MARK NO. 2--A STANDARD USGS REFERENCE MARK TABLET STAMPED
ET0862'2 1969, CRIMPED ON THE END OF A COPPERWELD ROD THAT HAS BEEN DRIVEN
ET0862'TO REFUSAL, LEVEL WITH THE GROUND, AND 1 FT. ABOVE THE STATION.
ET0862'
ET0862'HUMBOLDT SMOKE STACK--A TALL MASONRY SMELTER STACK ABOUT 2.0 MI.
ET0862'FROM THE STATION MARK.
ET0862
ET0862                         STATION RECOVERY (1980)
ET0862
ET0862'RECOVERY NOTE BY US GEOLOGICAL SURVEY 1980 (GH)
ET0862'THE STATION MARK AND REFERENCE MARK 2 WERE RECOVERED AS DESCRIBED.
ET0862'REFERENCE MARK 1 HAS BEEN DESTROYED.  A NEW ROUTE TO THE
ET0862'STATION FOLLOWS.
ET0862'
```

```
ET0862'TO REACH THE STATION FROM THE POST OFFICE IN DEWEY, TRAVEL EAST ALONG
ET0862'ARIZONA HIGHWAY 169 FOR 0.7 MILE TO A SIDE ROAD LEFT.  TURN LEFT
ET0862'CROSSING OVER A CATTLE GUARD AND THEN BEAR LEFT ON A BLADED ROAD FOR
ET0862'0.18 MILE TO THE STATION ON THE LEFT, JUST PAST A RIGHT HAND CURVE IN
ET0862'THE ROAD.
ET0862
ET0862                          STATION RECOVERY (1997)
ET0862
ET0862'RECOVERY NOTE BY US POWER SQUADRON 1997
ET0862'RECOVERED IN GOOD CONDITION.
ET0862
ET0862                          STATION RECOVERY (2008)
ET0862
ET0862'RECOVERY NOTE BY GEOCACHING 2008 (RFC)
ET0862'RECOVERED IN GOOD CONDITION.
ET0862
ET0862                          STATION RECOVERY (2008)
ET0862
ET0862'RECOVERY NOTE BY GEOCACHING 2008 (JM)
ET0862'RECOVERED STATION MARK AND REFERENCE MARK 2 IN GOOD CONDITION AS
ET0862'DESCRIBED WITH THE FOLLOWING UPDATE TO THE DESCRIPTION - THE BLADED
ET0862'ROAD IS CUTBACK ROAD.

*** retrieval complete.
Elapsed Time = 00:00:05
```

I.b NGS Control Point "TEXAS"

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
PROGRAM = datasheet95, VERSION = 8.4
1        National Geodetic Survey,   Retrieval Date = MAY 13, 2014
 ET0869 ***********************************************************************
 ET0869  DESIGNATION -  TEXAS
 ET0869  PID         -  ET0869
 ET0869  STATE/COUNTY-  AZ/YAVAPAI
 ET0869  COUNTRY     -  US
 ET0869  USGS QUAD   -  HUMBOLDT (1973)
 ET0869
 ET0869                         *CURRENT SURVEY CONTROL
 ET0869
 ET0869* NAD 83(1992) POSITION- 34 31 59.60106(N) 112 14 35.61907(W)   ADJUSTED
 ET0869* NAVD 88 ORTHO HEIGHT -  1398.19   (+/-2cm)    4587.2   (feet) VERTCON
 ET0869
 ET0869  GEOID HEIGHT    -        -26.14  (meters)                     GEOID12A
 ET0869  LAPLACE CORR    -          0.96  (seconds)                    DEFLEC12A
 ET0869  HORZ ORDER      -   SECOND
 ET0869  VERT ORDER      -   THIRD ? (See Below)
 ET0869
 ET0869.The horizontal coordinates were established by classical geodetic methods
 ET0869.and adjusted by the National Geodetic Survey in August 1993.
 ET0869.
 ET0869.The NAVD 88 height was computed by applying the VERTCON shift value to
 ET0869.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 ET0869
 ET0869.The vertical order pertains to the NGVD 29 superseded value.
 ET0869
 ET0869.The Laplace correction was computed from DEFLEC12A derived deflections.
 ET0869
 ET0869. The following values were computed from the NAD 83(1992) position.
 ET0869
 ET0869;                   North         East     Units Scale Factor Converg.
 ET0869;SPC AZ C     -   391,845.250   183,383.499   MT  0.99991107   -0 11 06.4
 ET0869;SPC AZ C     - 1,285,581.53    601,651.90   iFT  0.99991107   -0 11 06.4
 ET0869;UTM  12      - 3,821,982.954   385,909.748   MT  0.99976044   -0 42 17.4
 ET0869
 ET0869!             -  Elev Factor  x  Scale Factor =  Combined Factor
 ET0869!SPC AZ C     -   0.99978467  x   0.99991107  =  0.99969576
 ET0869!UTM  12      -   0.99978467  x   0.99976044  =  0.99954516
 ET0869
 ET0869:                Primary Azimuth Mark                     Grid Az
 ET0869:SPC AZ C     -  ESTATE                                   338 33 07.0
 ET0869:UTM  12      -  ESTATE                                   339 04 18.0
 ET0869
 ET0869|---------------------------------------------------------------------|
 ET0869| PID    Reference Object                     Distance      Geod. Az  |
 ET0869|                                                           dddmmss.s |
 ET0869| CH3500 TEXAS RM 1                           12.027 METERS 07853     |
 ET0869| ET0874 ESTATE                             APPROX. 2.8 KM 3382200.6 |
 ET0869| CH3501 ROUTE 69 MP 281.35                   21.907 METERS 34849     |
 ET0869|---------------------------------------------------------------------|
```

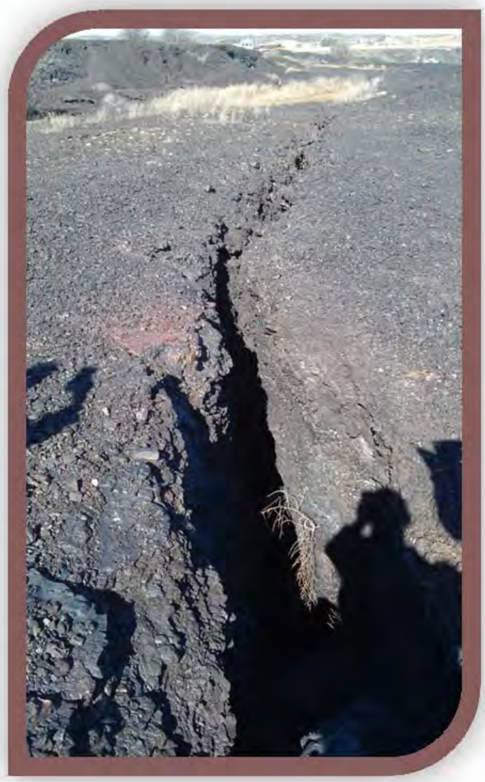
```
ET0869
ET0869                          SUPERSEDED SURVEY CONTROL
ET0869
ET0869  NAD 83(1986)-  34 31 59.59730(N)    112 14 35.61722(W) AD(       ) 2
ET0869  NAD 27      -  34 31 59.50775(N)    112 14 33.03286(W) AD(       ) 2
ET0869  NGVD 29 (07/19/86) 1397.39   (m)         4584.6    (f) LEVELING    3
ET0869
ET0869.Superseded values are not recommended for survey control.
ET0869
ET0869.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
ET0869.See file dsdata.txt to determine how the superseded data were derived.
ET0869
ET0869_U.S. NATIONAL GRID SPATIAL ADDRESS: 12SUD8590921982(NAD 83)
ET0869
ET0869_MARKER: DD = SURVEY DISK
ET0869_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
ET0869_SP_SET: SET IN TOP OF CONCRETE MONUMENT
ET0869_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
ET0869+STABILITY: SURFACE MOTION
ET0869_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
ET0869+SATELLITE: SATELLITE OBSERVATIONS - July 11, 2008
ET0869
ET0869  HISTORY     - Date     Condition        Report By
ET0869  HISTORY     - 1980     MONUMENTED       AZDT
ET0869  HISTORY     - 19971112 GOOD             USPSQD
ET0869  HISTORY     - 20040821 GOOD             USPSQD
ET0869  HISTORY     - 20080711 GOOD             GEOCAC
ET0869
ET0869                          STATION DESCRIPTION
ET0869
ET0869'DESCRIBED BY ARIZONA DEPARTMENT OF TRANSPORTATION 1980 (GH)
ET0869'THE STATION IS LOCATED 13 MILES EAST OF PRESCOTT, 1/4 MILE NORTH OF
ET0869'DEWEY AND ALONG THE EAST RIGHT OF WAY OF ARIZONA HIGHWAY 69.
ET0869'
ET0869'THE STATION MARK IS AN ADOT DISK STAMPED TEXAS 1980.  IT IS SET IN TOP
ET0869'OF A CONCRETE MONUMENT 121 FEET EAST OF THE CENTERLINE OF THE HIGHWAY
ET0869'AND 4.3 FEET WEST OF THE WITNESS POST.
ET0869'
ET0869'REFERENCE MARK 1 IS AN ADOT DISK STAMPED TEXAS RM 1 1980.  IT IS SET
ET0869'IN TOP OF A CONCRETE MONUMENT.
ET0869'
ET0869'REFERENCE MARK 2 IS AN AHD DISK STAMPED P AND M 1345 MP 281.35 1973.
ET0869'IT IS SET IN A DRILL HOLE IN A ROCK.
ET0869'
ET0869'TO REACH THE STATION FROM THE POST OFFICE IN DEWEY, TRAVEL NORTH ALONG
ET0869'ARIZONA HIGHWAY 69 FOR 0.27 MILE TO THE STATION ON THE RIGHT ON A
ET0869'SMALL RISE.
ET0869
ET0869                          STATION RECOVERY (1997)
ET0869
ET0869'RECOVERY NOTE BY US POWER SQUADRON 1997
ET0869'RECOVERED IN GOOD CONDITION.
ET0869
ET0869                          STATION RECOVERY (2004)
ET0869
ET0869'RECOVERY NOTE BY US POWER SQUADRON 2004 (CP)
ET0869'RECOVERED AS DESCRIBED. MARK 2
ET0869
ET0869                          STATION RECOVERY (2008)
ET0869
```

```
ET0869'RECOVERY NOTE BY GEOCACHING 2008 (JM)
ET0869'RECOVERED STATION MARK AND REFERENCE MARK 2 IN GOOD CONDITION AS
ET0869'DESCRIBED.
ET0869'
ET0869'A DESTROYED MONUMENT WHERE REFERENCE MARK 1 SHOULD HAVE BEEN LOCATED
ET0869'WAS FOUND DESTROYED, THE DISK WAS NOT FOUND AMONG THE MONUMENT DEBRIS.
ET0869'

*** retrieval complete.
Elapsed Time = 00:00:02
```

II. Slag Pile Survey

The slag pile has been in its current location since the closure of the Humboldt Smelter in early part of the 20th Century. The slag being the waste from the smelting operations was dumped on the east slope of the property above the Agua Fria River. Upon cooling, the slag has sat in its current state for almost a century. This passing of time and exposure to wind, rain, freeze and thaw have caused the development of longitudinal cracking in the slag that are now being impacted by environmental conditions that may be causing them to separate at an increased rate and could potentially create a dangerous situation. The top of the slag pile sits several hundred feet above the Agua Fria River and with this continued decay, can eventually collapse into the river bottom below. The Agua Fria is subject to mainly underground flow with seasonal surface flow as a result of snow melt and summer monsoon rains. The 2014 monsoon season, however, generated the most rainfall seen in recent years. The Prescott Area that in part feeds the Agua Fria River Basin accumulated over 20 inches of rainfall while the area immediate to the site in Mayer reported an excess of 11 inches. On April 14, and 15, 2014, GBE began the process of data acquisition for the area of the slag that is subject to the longitudinal cracking. The data for the crack monitoring was gathered at 50-foot intervals with data points taken on each edge and our best effort to obtain a depth. GBE gathered 10 observations of ten different points for continued monitoring using a Trimble 5600 Robotic Total Station. We also performed differential leveling across the ten individual points as a redundant check. The 10 observations of each point were subjected to a weighted average and the results reported after this visit and again on our subsequent visit for your review and consideration. This exercise will be performed again on a separate visit within a 12 month period. The crack mapping is based on



Slag Pile Cracking

cross sections of the existing cracking that included 3 shots at various locations along the cracking. The 3 shots are located at each edge and the center of the crack. The depth at each location was approximated by GBE by extending down into the crack until we felt refusal. This data has been gathered at 50-foot intervals along the cracks and encompassed a total of 2000 feet with single observations. The cracks that were surveyed ran longitudinally along the slag pile after being reviewed with a representative of LM/SERAS. The data for the intermediate positions is provided in table format for review and will be provided separately in CAD format for analysis. The positions of the ten monitoring points are reported as follows in tables "II.a" through "II.j" and graphically represented in figure "II.k". Please note that we have removed any outlier values that were obtained in the field measurement process and that can be demonstrated below. Our purpose for doing the reporting in this manner was to minimize the amount of error in the data that is reported. The positions are being reported using a random point number for each series of measurements with the northing, easting, and elevation all being averaged. The positions were averaged and then a standard deviation for each point is reported. These positions will be utilized 12-months from now when the second data gathering session takes place.

II.a Monitoring Point "A"

Point #	Northing	Easting	Elevation
2000	1272537.460	605508.801	4532.235
2001	1272537.472	605508.781	4532.231
2002	1272537.463	605508.788	4532.238
2003	1272537.473	605508.788	4532.238
2004	1272537.461	605508.783	4532.238
2005	1272537.465	605508.785	4532.240
2006	1272537.458	605508.795	4532.240
2009	1272537.466	605508.781	4532.235
Average	1272537.465	605508.788	4532.237
Std. Dev	0.005	0.007	0.003

II.b Monitoring Point "B"

Point #	Northing	Easting	Elevation
3000	1272537.235	605505.960	4531.855
3001	1272537.260	605505.947	4531.863
3002	1272537.242	605505.960	4531.861
3003	1272537.253	605505.956	4531.862
3004	1272537.243	605505.949	4531.866
3005	1272537.246	605505.953	4531.864
3006	1272537.228	605505.951	4531.866
3009	1272537.279	605505.935	4531.857
Average	1272537.248	605505.951	4531.861
Std. Dev	0.016	0.008	0.004

II.c Monitoring Point "C"

Point #	Northing	Easting	Elevation
4000	1272451.284	605552.059	4531.542
4001	1272451.282	605552.050	4531.543
4002	1272451.277	605552.074	4531.552
4003	1272451.279	605552.069	4531.546
4004	1272451.276	605552.068	4531.548
4005	1272451.270	605552.060	4531.553
4006	1272451.268	605552.052	4531.554
4009	1272451.280	605552.051	4531.555
Average	1272451.277	605552.060	4531.549
Std. Dev	0.006	0.009	0.005

II.d Monitoring Point "D"

Point #	Northing	Easting	Elevation
5000	1272448.803	605550.249	4531.594
5001	1272448.810	605550.243	4531.594
5002	1272448.788	605550.251	4531.597
5003	1272448.800	605550.253	4531.595
5004	1272448.794	605550.258	4531.598
5005	1272448.793	605550.251	4531.597
5006	1272448.788	605550.243	4531.599
5009	1272448.806	605550.239	4531.597
Average	1272448.798	605550.248	4531.596
Std. Dev	0.008	0.006	0.002

II.e Monitoring Point "E"

Point #	Northing	Easting	Elevation
6000	1272333.933	605615.487	4531.617
6001	1272333.948	605615.482	4531.617
6002	1272333.922	605615.499	4531.623
6003	1272333.934	605615.497	4531.620
6004	1272333.922	605615.501	4531.625
6005	1272333.926	605615.500	4531.621
6006	1272333.921	605615.496	4531.625
6007	1272333.922	605615.488	4531.631
6009	1272333.941	605615.491	4531.629
Average	1272333.930	605615.493	4531.623
Std. Dev	0.010	0.007	0.005

II.f Monitoring Point "F"

Point #	Northing	Easting	Elevation
7000	1272332.041	605611.059	4531.923
7001	1272332.056	605611.058	4531.928
7002	1272332.031	605611.085	4531.932
7003	1272332.035	605611.086	4531.930
7004	1272332.035	605611.088	4531.932
7005	1272332.026	605611.094	4531.928
7006	1272332.023	605611.088	4531.931
7007	1272332.016	605611.096	4531.937
7009	1272332.041	605611.095	4531.931
Average	1272332.034	605611.083	4531.930
Std. Dev	0.012	0.015	0.004

II.g Monitoring Point "G"

Point #	Northing	Easting	Elevation
8000	1272279.277	605651.809	4531.761
8001	1272279.278	605651.816	4531.761
8002	1272279.268	605651.828	4531.765
8003	1272279.269	605651.820	4531.769
8004	1272279.277	605651.828	4531.771
8005	1272279.269	605651.834	4531.769
8006	1272279.255	605651.823	4531.777
8007	1272279.259	605651.822	4531.769
8009	1272279.285	605651.827	4531.773
Average	1272279.271	605651.823	4531.768
Std. Dev	0.010	0.008	0.005

II.h Monitoring Point "H"

Point #	Northing	Easting	Elevation
9001	1272276.868	605648.768	4531.634
9002	1272276.855	605648.780	4531.639
9003	1272276.859	605648.771	4531.640
9004	1272276.853	605648.780	4531.643
9005	1272276.854	605648.782	4531.642
9006	1272276.839	605648.774	4531.641
9007	1272276.846	605648.771	4531.646
9009	1272276.874	605648.775	4531.639
Average	1272276.856	605648.775	4531.640
Std. Dev	0.011	0.005	0.003

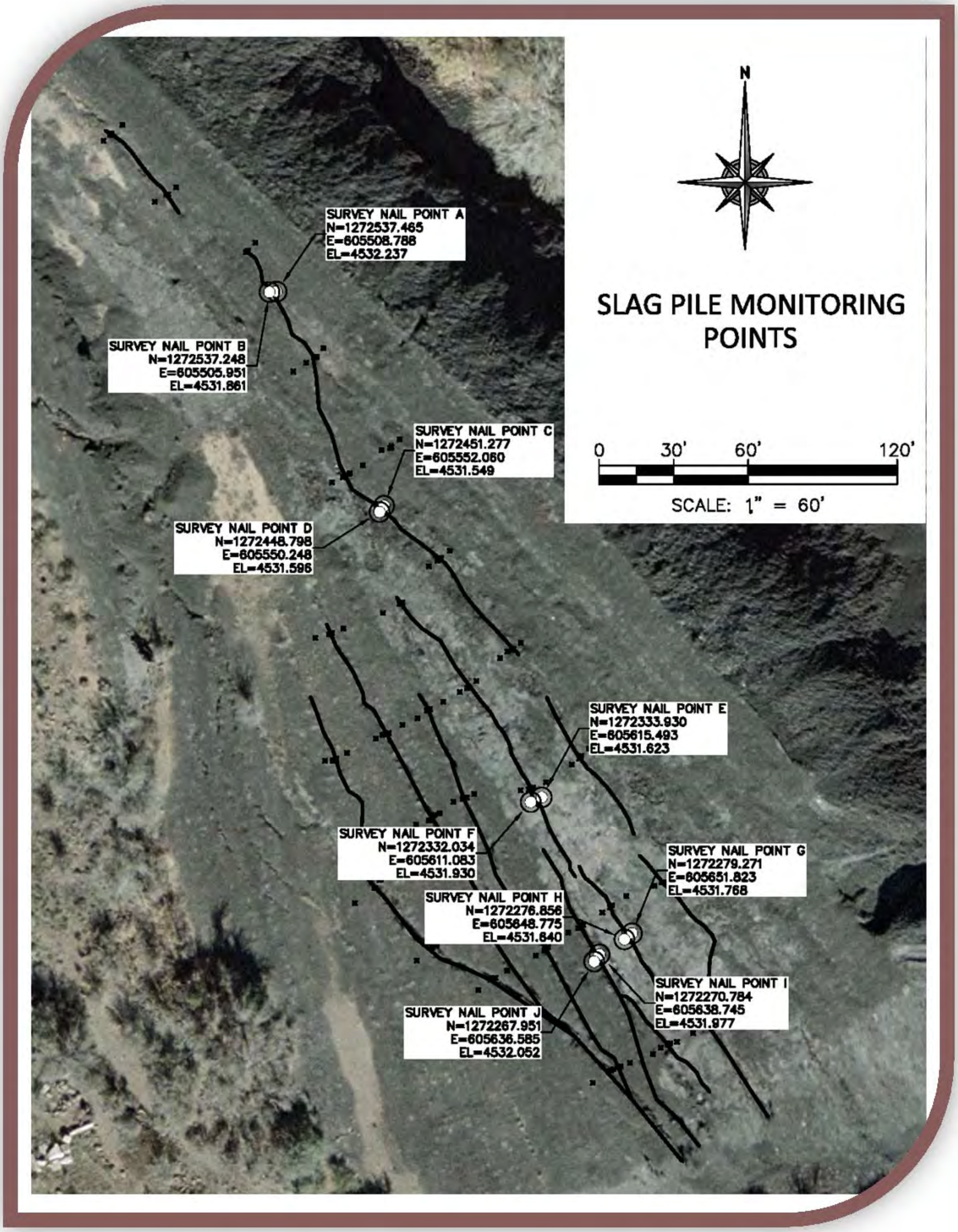
II.i Monitoring Point "I"

Point #	Northing	Easting	Elevation
10001	1272270.797	605638.740	4531.968
10002	1272270.783	605638.747	4531.976
10003	1272270.783	605638.746	4531.976
10004	1272270.781	605638.749	4531.979
10005	1272270.782	605638.753	4531.975
10006	1272270.778	605638.739	4531.982
10007	1272270.775	605638.737	4531.982
10009	1272270.794	605638.751	4531.977
Average	1272270.784	605638.745	4531.977
Std. Dev	0.008	0.006	0.004

II.j Monitoring Point "J"

Point #	Northing	Easting	Elevation
11000	1272267.960	605636.584	4532.043
11001	1272267.974	605636.573	4532.048
11002	1272267.956	605636.592	4532.053
11003	1272267.944	605636.589	4532.055
11004	1272267.948	605636.590	4532.050
11005	1272267.947	605636.594	4532.052
11006	1272267.932	605636.574	4532.058
11007	1272267.947	605636.577	4532.057
11009	1272267.951	605636.589	4532.056
Average	1272267.951	605636.585	4532.052
Std. Dev	0.012	0.008	0.005

II.k Slag Pile Monitoring Points



II.l Intermediate Slag Crack Delineation

Point #	Northing	Easting	Elevation
1	1272604.59	605446.82	4532.611
2	1272601.02	605442.38	4531.788
3	1272600.79	605442.18	4530.667
4	1272600.44	605441.78	4532.316
5	1272598.16	605439.11	4532.756
6	1272573.68	605459.86	4532.612
7	1272576.43	605464.36	4532.319
8	1272576.52	605464.47	4529.212
9	1272576.62	605465.11	4532.216
10	1272579.45	605468.40	4532.388
11	1272557.12	605500.28	4532.122
12	1272553.86	605497.15	4532.064
13	1272553.79	605497.08	4530.762
14	1272553.28	605496.49	4532.125
15	1272514.77	605527.74	4531.834
16	1272511.28	605524.93	4531.672
17	1272511.00	605524.43	4530.399
18	1272508.79	605520.67	4532.012
19	1272505.29	605515.49	4532.276
20	1272460.76	605531.11	4532.438
21	1272462.82	605535.50	4532.442
22	1272464.11	605537.98	4530.335
23	1272464.43	605538.43	4531.522
24	1272467.53	605543.47	4531.223
25	1272473.71	605551.10	4532.111
26	1272474.65	605554.62	4530.99
27	1272474.78	605554.95	4530.179
28	1272475.27	605554.93	4531.268
29	1272478.09	605558.37	4531.929
30	1272433.21	605578.52	4531.527
31	1272430.26	605574.94	4531.488
32	1272430.11	605574.79	4528.889
33	1272429.18	605573.50	4532.012
34	1272426.99	605570.07	4532.839
35	1272412.30	605559.31	4531.911
36	1272412.29	605559.32	4531.911
37	1272412.09	605559.01	4530.304
38	1272411.71	605558.18	4532.059
39	1272408.06	605551.57	4532.504
40	1272401.84	605535.59	4532.37
41	1272399.95	605531.00	4532.06
42	1272399.93	605530.76	4528.553
43	1272399.38	605529.93	4531.621

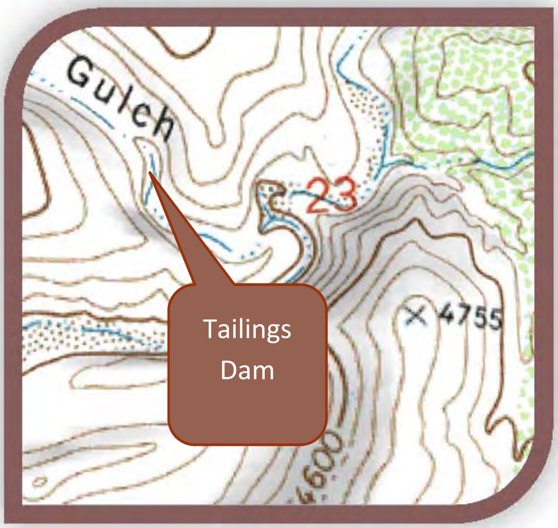
Point #	Northing	Easting	Elevation
44	1272398.04	605524.32	4532.159
45	1272348.59	605528.31	4533.536
46	1272348.58	605531.39	4533.164
47	1272348.80	605531.75	4526.546
48	1272349.32	605532.84	4533.047
49	1272351.69	605537.10	4533.463
50	1272357.50	605548.72	4533.785
51	1272359.12	605551.41	4532.883
52	1272359.19	605552.25	4522.22
53	1272359.74	605553.83	4533.051
54	1272363.02	605559.47	4533.155
55	1272365.69	605565.51	4533.008
56	1272368.75	605569.29	4532.432
57	1272369.04	605569.83	4528.797
58	1272369.52	605570.51	4531.933
59	1272372.40	605575.82	4531.552
60	1272376.20	605582.50	4531.416
61	1272377.91	605585.54	4531.227
62	1272378.09	605585.97	4530.228
63	1272378.18	605586.24	4531.275
64	1272380.62	605589.28	4531.508
65	1272389.83	605598.79	4531.356
66	1272392.43	605601.72	4531.561
67	1272393.20	605603.52	4530.017
68	1272393.67	605604.03	4530.937
69	1272396.03	605607.02	4531.38
70	1272353.42	605634.41	4531.652
71	1272350.56	605631.40	4531.24
72	1272349.96	605630.97	4530.455
73	1272349.53	605630.57	4531.559
74	1272347.11	605627.58	4531.701
75	1272340.06	605617.16	4531.403
76	1272337.82	605612.06	4531.456
77	1272337.56	605611.36	4525.107
78	1272337.08	605610.35	4531.723
79	1272336.71	605606.94	4531.807
80	1272335.24	605588.38	4532.286
81	1272333.95	605585.28	4532.208
82	1272333.87	605584.67	4525.576
83	1272333.25	605583.75	4532.759
84	1272332.09	605580.03	4533.957
85	1272327.49	605574.46	4534.918
86	1272326.80	605572.35	4534.432
87	1272326.60	605571.84	4519.007
88	1272324.67	605569.96	4534.552
89	1272322.97	605564.99	4535.022
90	1272304.57	605554.97	4535.392

Point #	Northing	Easting	Elevation
91	1272301.03	605550.57	4535.223
92	1272300.72	605550.27	4532.614
93	1272297.55	605548.51	4533.032
94	1272297.37	605548.26	4535.849
95	1272291.40	605540.23	4536.082
96	1272256.57	605589.89	4537.301
97	1272260.52	605594.79	4537.209
98	1272261.39	605595.17	4524.143
99	1272261.34	605596.90	4537.359
100	1272264.28	605601.60	4537.068
101	1272270.29	605613.05	4535.324
102	1272272.36	605616.49	4533.884
103	1272272.90	605617.36	4525.427
104	1272273.74	605617.97	4533.758
105	1272277.38	605619.57	4533.449
106	1272277.97	605620.18	4531.199
107	1272278.07	605621.06	4533.046
108	1272279.66	605626.23	4532.586
109	1272281.43	605630.25	4531.914
110	1272282.10	605631.32	4527.741
111	1272282.63	605632.26	4532.047
112	1272287.60	605639.88	4531.592
113	1272289.63	605642.99	4531.596
114	1272289.78	605643.30	4527.182
115	1272290.58	605643.85	4531.586
116	1272294.22	605649.45	4531.572
117	1272298.44	605660.91	4531.571
118	1272299.83	605663.73	4531.513
119	1272299.78	605664.25	4530.279
120	1272299.89	605664.73	4531.436
121	1272303.65	605669.65	4531.264
122	1272248.76	605686.47	4531.54
123	1272246.60	605683.12	4531.409
124	1272245.92	605682.63	4526.754
125	1272243.08	605681.21	4531.751
126	1272239.21	605676.33	4531.957
127	1272235.64	605669.89	4531.924
128	1272235.08	605667.22	4531.876
129	1272234.47	605666.22	4527.312
130	1272233.26	605663.38	4531.683
131	1272230.66	605660.15	4532.301
132	1272227.15	605650.91	4534.514
133	1272225.90	605647.35	4534.313
134	1272225.50	605646.42	4532.286
135	1272224.60	605644.42	4535.186
136	1272224.11	605643.58	4533.093
137	1272223.70	605642.44	4535.719

Point #	Northing	Easting	Elevation
138	1272219.25	605636.06	4537.271
139	1272278.03	605576.36	4536.409
140	1272274.94	605573.31	4536.235
141	1272274.52	605573.01	4526.217
142	1272273.38	605571.63	4536.628
143	1272268.40	605565.21	4536.898

III. Tailings Dam Survey

Running through the Humboldt Smelter property is Chaparral Gulch. It is a perennial stream that is subject to monsoon rains and snow melt. A dam was constructed just northwest of the confluence with Chaparral Gulch and the Agua Fria River. Not much is known about the time frame of the original construction. Through our research with the Dewey-Humboldt Historical Society and Sharlot Hall, we have been able to ascertain that the estimated date of the dam construction being the early 1900's. The dam was surveyed by GBE on April 14, and 15, 2014. The data was gathered using a robotic total station with control that was placed in the vicinity of the dam using Global Positioning units. Data points were gathered on the top and bottom of the dam as well as the rock sides of the canyon that contains the gulch. The exposed or downstream face of the dam has an angle break running horizontally across it and that was gathered in our data as well. The upstream face of the dam is silted to the top with a mixture of earth and tailings that have washed down to the dam over the years. LM/SERAS placed five bore holes at the upstream face of the dam in order for GBE to establish an approximate depth of the concrete. The dam has been modeled to reflect the actual hard survey points, and enhanced to include the speculation of what the buried areas of the dam would look like based on the information available. The top elevation of the dam is approximately 4462 feet (NAVD88) and the exposed bottom elevation of the dam is approximately 4443 feet (NAVD 88), thus leaving the exposed height of the dam at 19 feet. The



USGS Humboldt Quadrangle

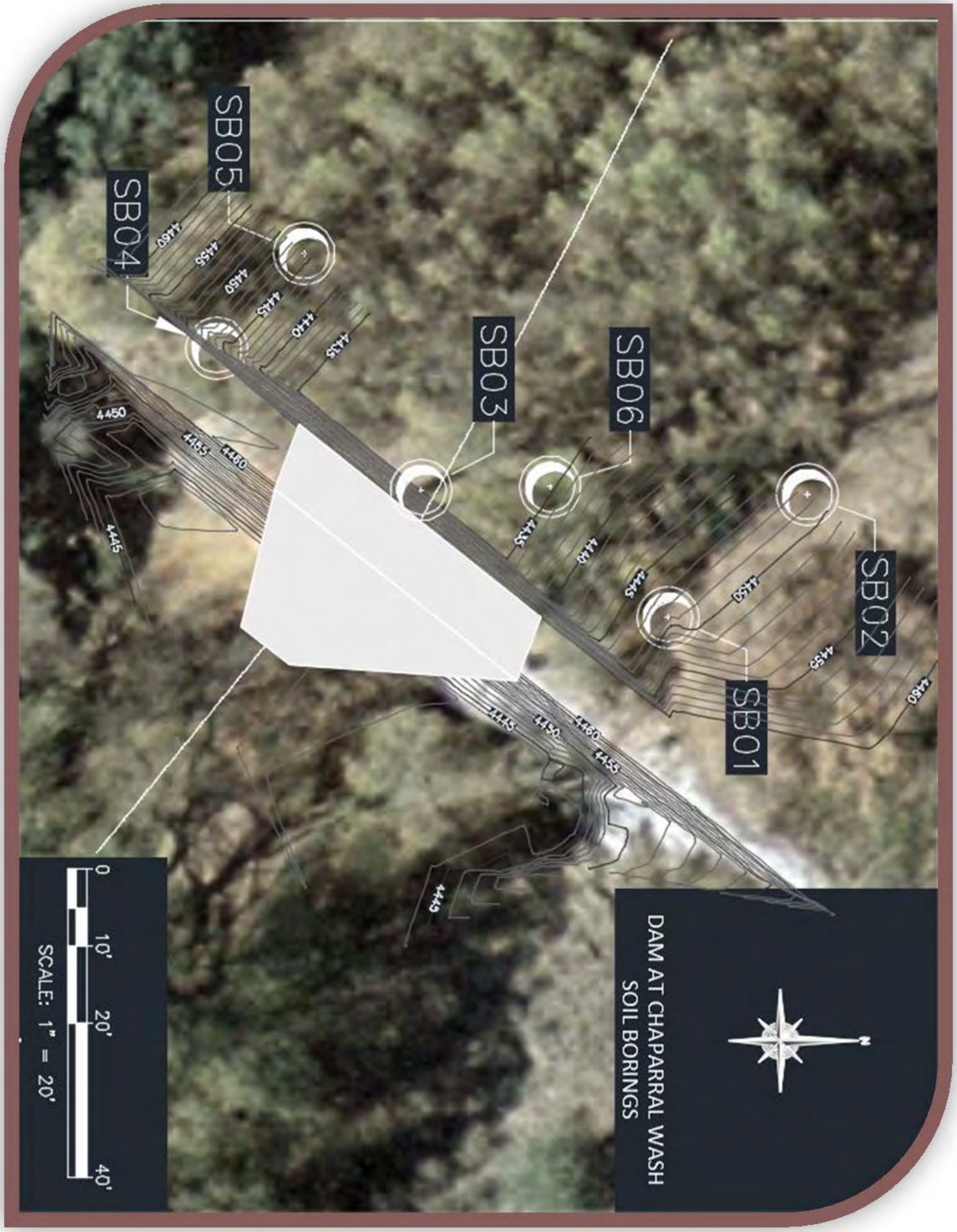

Isometric View of Dam

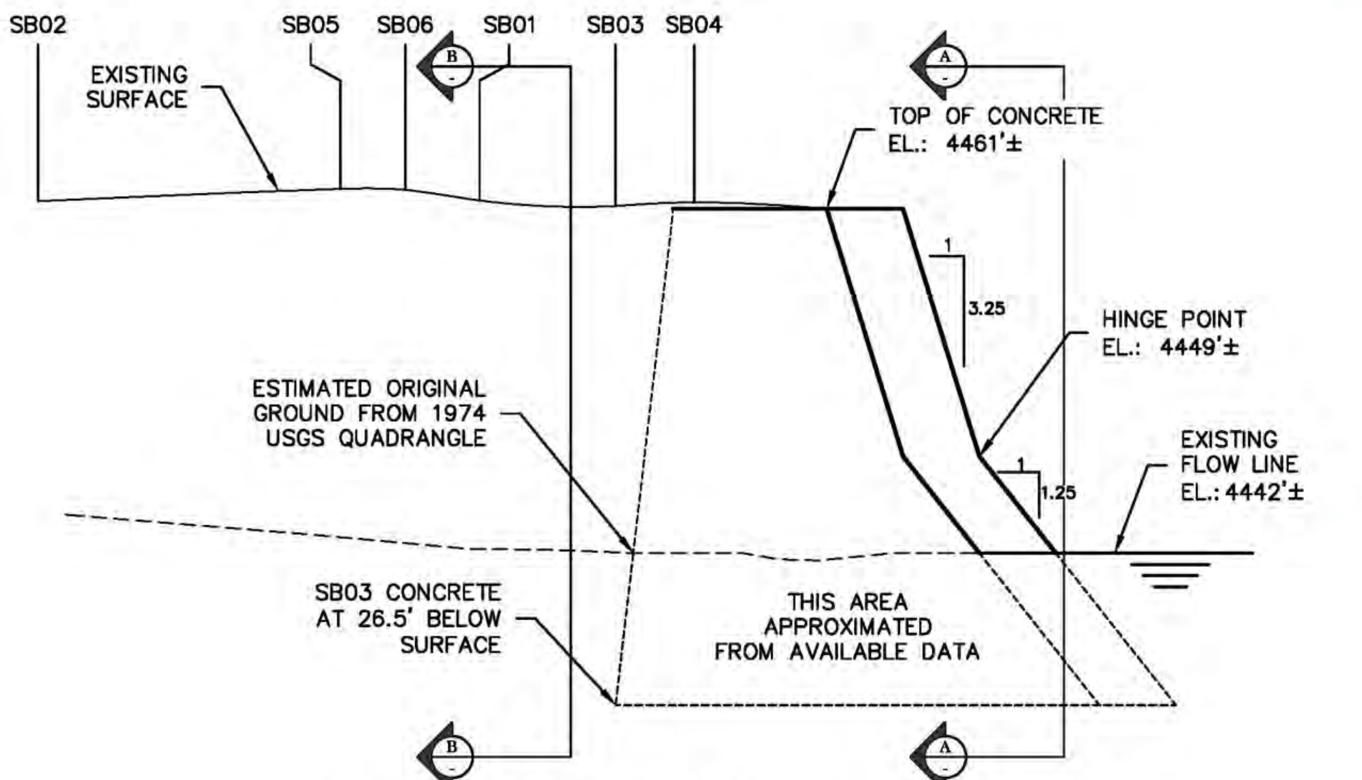
channel width at the bottom of the dam immediately at the face of concrete is approximately 60 feet and it narrows down as you move downstream. The lateral width of the concrete across Chaparral Gulch is approximately 130 feet and is firmly anchored into the rock walls of the canyon. The top cross-sectional width of the dam is approximately 8.2 feet. However, a central section of the dam flares downstream an addition 4.2 feet from the primary face of the dam, resulting in a maximum width of approximately 12.4 feet over 16 feet of lateral distance. From bore-hole data developed by LM/SERAS on the upstream side of the dam, concrete was hit at a depth of 26.5 feet along the estimated centerline of the channel at the centerline of the dam, leaving 7.5 feet of the downstream face of the dam buried under silt. Bedrock was hit on the north side of the channel at a depth of 13 feet and lying 36 feet from the centerline of the dam. Bedrock was hit on the south side of the channel at a depth of 15 feet and lying 32 feet from the dam centerline.

III.a Dam Soil Boring Data

Location	LM/SERAS Latitude	LM/SERAS Longitude	AZSPF Northing	AZSPF Easting	Ground Elevation	Depth/Material
SB01	34.49288034	-112.23319630	1270889.718	604632.4546	4461.565	13’ to Bedrock
SB02	34.49292919	-112.23325180	1270907.866	604616.4613	4461.676	13’ to Bedrock
SB03	34.49278592	-112.23325020	1270857.608	604615.8773	4461.125	26.5’ to Concrete
SB04	34.49271828	-112.23331400	1270830.989	604597.4283	4461.888	15’ to Bedrock
SB05	34.49274695	-112.23335600	1270842.353	604585.1342	4462.339	17.2’ to Bedrock
SB06	34.49284022	-112.23324750	1270874.381	604615.4735	4462.481	26.5’ to Bedrock

III.b Dam Soil Boring Plan



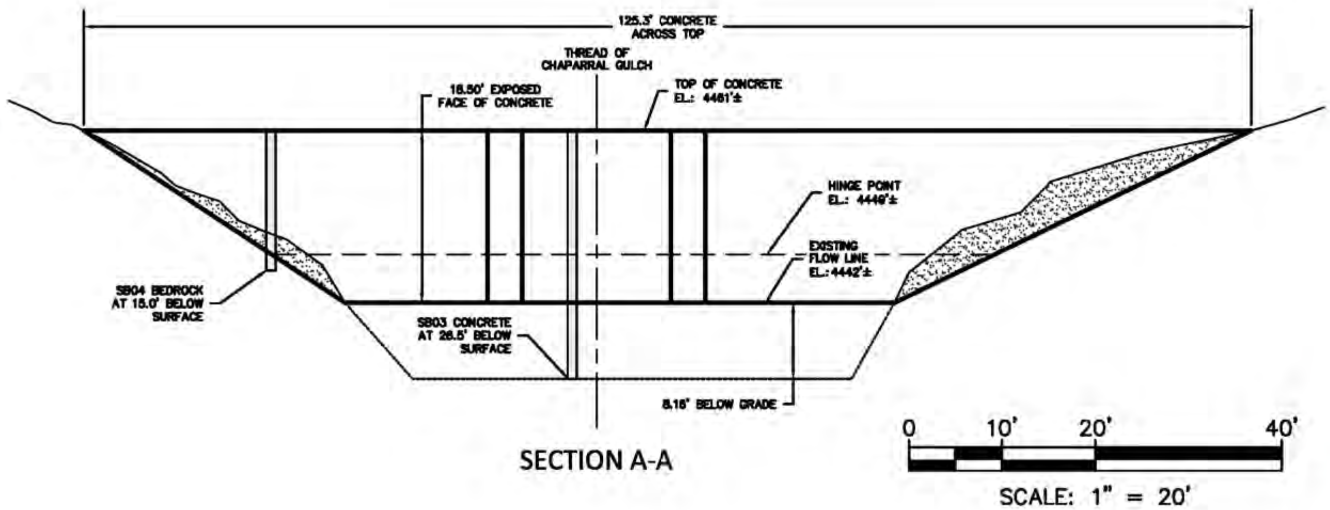


DAM AT CHAPARRAL WASH PROFILE

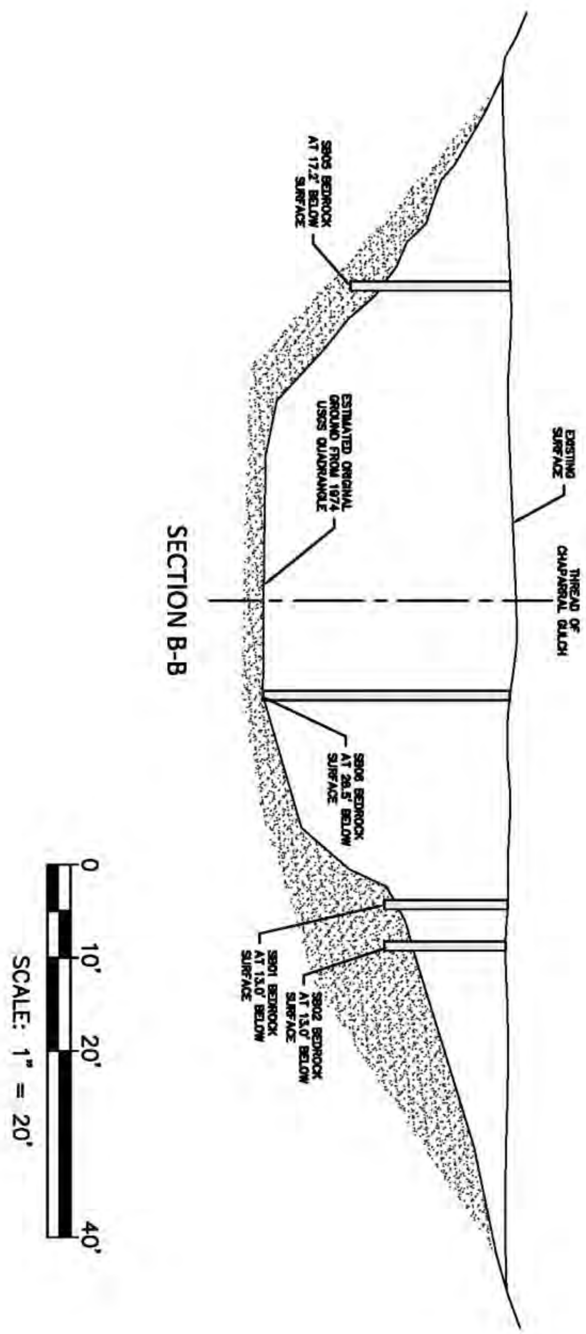
0 5' 10' 20'

SCALE: 1" = 10'

III.d Dam Cross Section A-A



III.e Dam Cross Section B-B



IV. Smelter Tailings Survey

Located on a plateau just southwest of the Humboldt smoke stack are the tailings from the retired smelting operations. Through the years and as a result of surface runoff these tailings have been washed down into Chaparral Gulch. From the effects of the erosion caused by the wind and rain, what remains is a landscape that resembles a barren wasteland. Dormant earth is capped with the golden tailings that wait for the next burst of nature to transport them further downstream into the gulch. The goal of this exercise was to develop an approximate quantity of the in-place tailings that require remediation. After detailed discussions between LM/SERAS and GBE, it was determined that by using the 2-foot contours as provided by the 2010 flood control mapping , a significant amount of estimation error would be introduced into the quantity. GBE was directed by LM/SERAS to develop 1-foot contours for the area of the tailings in order to narrow any potential margin of error as much as possible. GBE surveyed the area on May 27, 28, and 29, 2014 and this included the surface of all of the tailings fingers and gathered shots at what is estimated as being the top of natural ground on the sides of the eroded areas. This data was combined with bore-holes drilled by a LM/SERAS subcontractor on several of the tailings fingers to verify an approximate depth to natural ground that is under the tailings.

Tailings Area

Tailings Area

The area calculation for the tailings area is based upon several assumptions. GBE visually determined the bounding edge of existing ground versus the tailings by color matching. As discussed with LM/SERAS personnel at the site, the dark brown material would be classified as existing ground while the bright gold material would be classified as the tailings. Based on eight bore hole records (STS-SBO1 through STS-SB08) provided by LM/SERAS, the approximate depth of the tailings was added to the field data to aid in the approximation. Additional borings would be required in order to minimize the error in the approximation.

The surfaces were created using "Civil 3D" and compared to one another in order to develop this approximated quantity. No shrinkage or swell factors were added to the model since project-specific geotechnical data were not available for the material. The model for the base surface was based on the line located by GBE that represented the original ground. That surface was used as the base elevation to estimate the tailings quantity. Data points were then gathered from this line and above to develop the surface for the tailings themselves. Break lines were also used on both surfaces to aid in developing this approximation. When both of the surfaces were compared, the resultant quantity of the tailings that could be affected by remediation was 13,500 c.y.

IV.a Tailings Survey Plan

Tailings Looking Westerly

V. Monitoring Well Survey

A drilling subcontractor (retained by LM/SERAS) drilled exploratory bore-holes in the following areas: three bore-holes in the Chaparral Gulch floodplain (CHF), two bore-holes in a lower section of the smelter tailings - near the floodplain (STS), and three bore-holes on the Main Tailings Pile (MTP) at the Iron King Mine site. All of these bore-holes were converted to monitoring wells. During a later period, six additional monitoring wells (MW) were installed at key locations within the project study area. Horizontal coordinates and ground elevations were determined for all monitoring wells. Additional elevation data were recorded at the well locations to document the top of outer protective casings and top of inner PVC well risers

V.a Monitoring Well Data

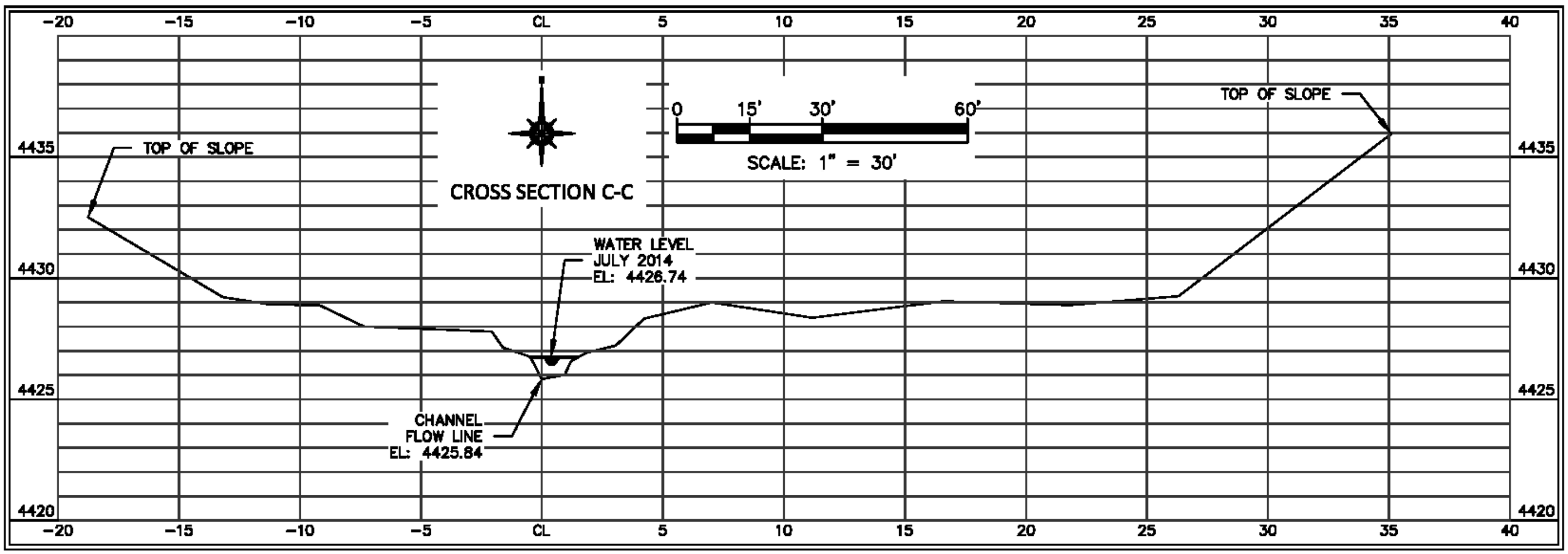
Point #	Northing	Easting	Elevation	Designation
1	1271004.236	604507.047	4464.282	CHF-SB28 MW 1 +4.03 TOP +3.44 TOP PVC SW SIDE
2	1271369.093	604002.209	4471.490	CHF-SB35/MW2 +3.52 TOP +3.11 PVC SW SIDE
3	1271672.063	603604.484	4477.472	CHF-SB38/MW3 +3.37 TOP +3.15 TO TOP PVC NE SIDE
4I	1271639.221	603810.740	4476.105	STS-SB15/MW4I +3.44 TOP +2.84 TO TOP PVC SW SIDE
4S	1271636.800	603808.812	4476.089	STS-SB15/MW4S +3.27 TOP +2.92 TO TOP PVC SW SIDE
1W	1273107.355	600177.427	4640.831	MTP-MW1 +3.13 TOP +2.59 TOP PVC NORTH SIDE
3W	1273698.392	599136.731	4747.037	MTP-MW3 +2.50 TOP +2.19 TOP PVC NORTH SIDE
2W	1273321.086	598707.822	4743.737	MTP-MW2 +3.37 TOP +2.935 TOP PVC NORTH SIDE
2D	1272206.03	603599.4	4515.13	MW 2D +2.28TOP +1.18 TO TOP PVC NORTH SIDE
11S	1273525.32	603185.2	4567.29	MW 11S TOP RIM -.30 TO TOP PVC NORTH SIDE
12S	1274665.73	603898.6	4512.54	MW 12S TOP RIM -0.67 TOP OF PVC SOUTH SIDE
12D	1274665.98	603903.7	4512.3	MW 12D TOP RIM -0.47 TOP OF PVC NORTH SIDE
10D	1274179.37	602102.7	4530.77	MW 10D TOP RIM -0.66 TO TOP PVC NORTH SIDE
10S	1274184.87	602098.4	4530.99	MW 10S TOP RIM -0.70 TO TOP PVC NORTH SIDE

VI. Downstream Cross Section Survey

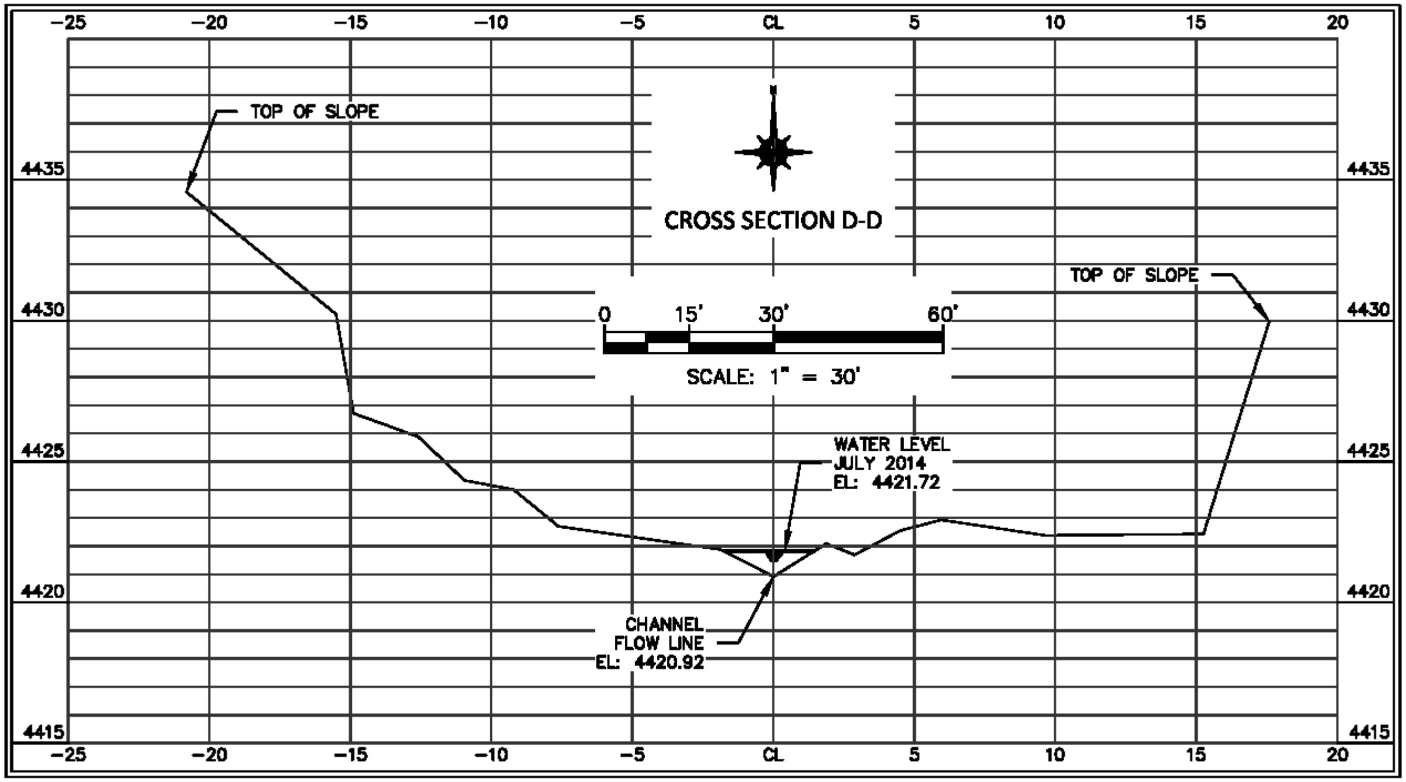
During the month of July 2014, GBE performed additional surveys downstream of the Chaparral Gulch Dam. The channel cross-section measurements were performed at two locations specified by LM/SERAS. GBE gathered the data at an estimated perpendicular to the existing flow line of Chaparral Gulch. These predetermined locations were below the dam in the vicinity where pressure transducers had been installed by LM/SERAS to monitor changes in water flow height over time. Cross-section C-C falls approximately 312 feet downstream (southeasterly) from the base of the dam. Cross-section D-D falls approximately 69 feet further downstream (southeasterly) from the Cross-section C-C. A longitudinal profile of the main channel was surveyed between the two cross-sections and also at approximately 17 feet upstream from cross-section (C-C), and approximately 16 feet downstream from cross-section (D-D). The longitudinal profile E-E is based on the existing flow line at the time of the survey. It does not show water depth. Subsequent to this survey and recording of the water surface elevation, the area received its summer monsoon rains which to date has dropped over 9 inches of rain in the Prescott and Dewey-Humboldt areas.

Agua Fria River

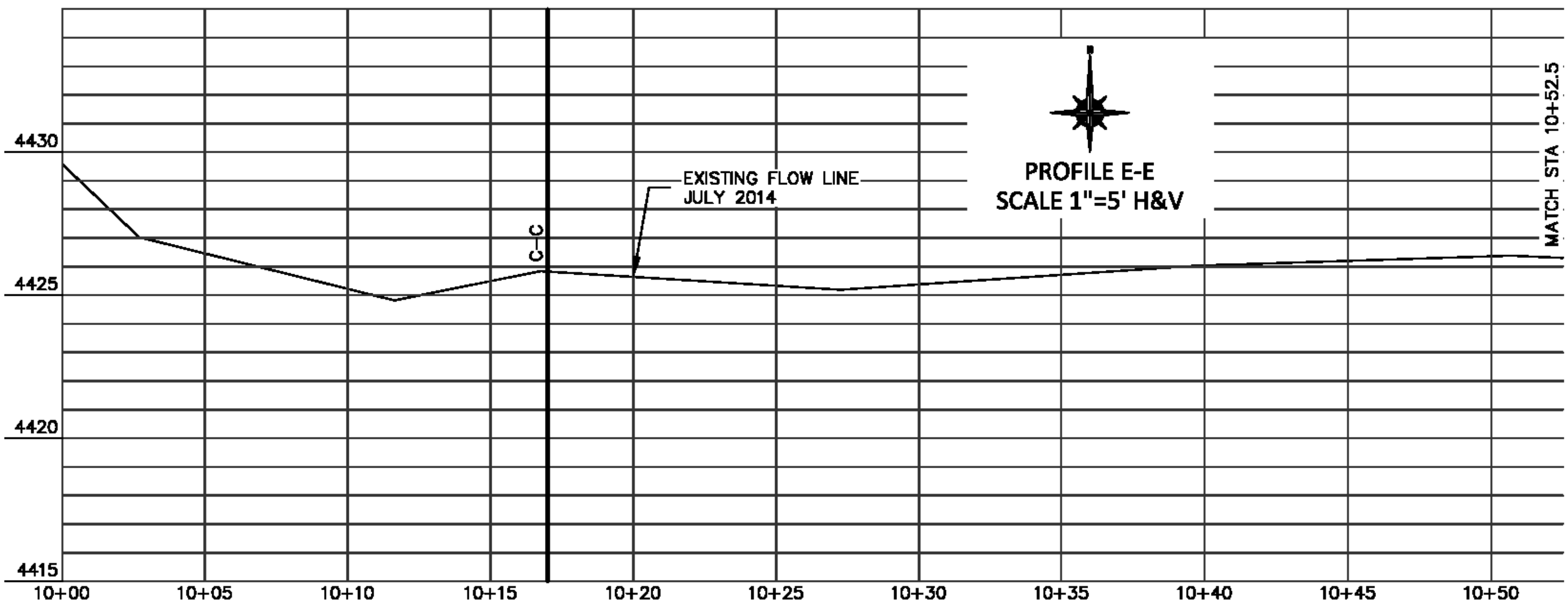
VI.a Downstream Cross Section C-C



VI.b Downstream Cross Section D-D



VI.c.1 Chaparral Gulch Profile E-E



VI.c.2 Chaparral Gulch Profile E-E