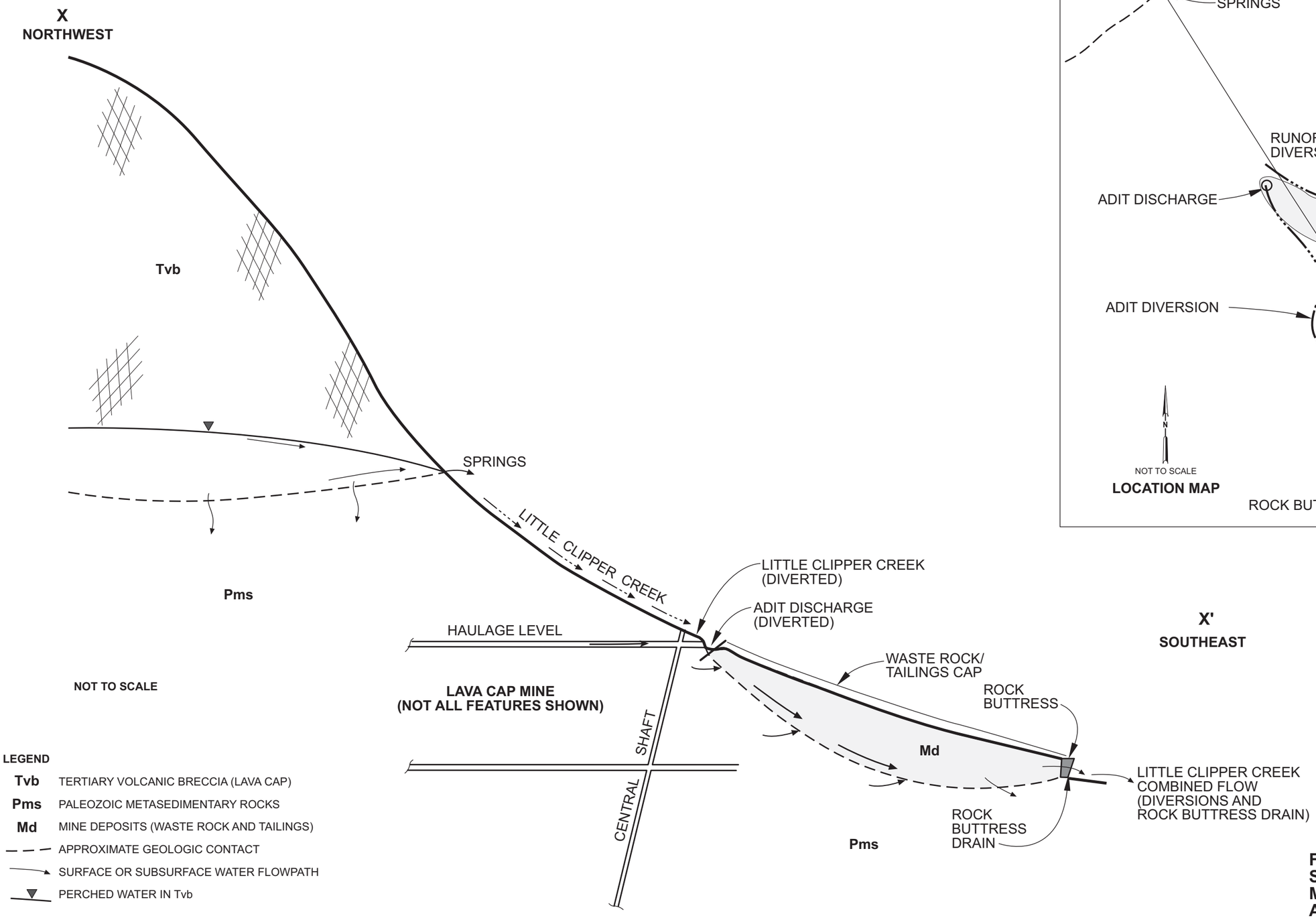
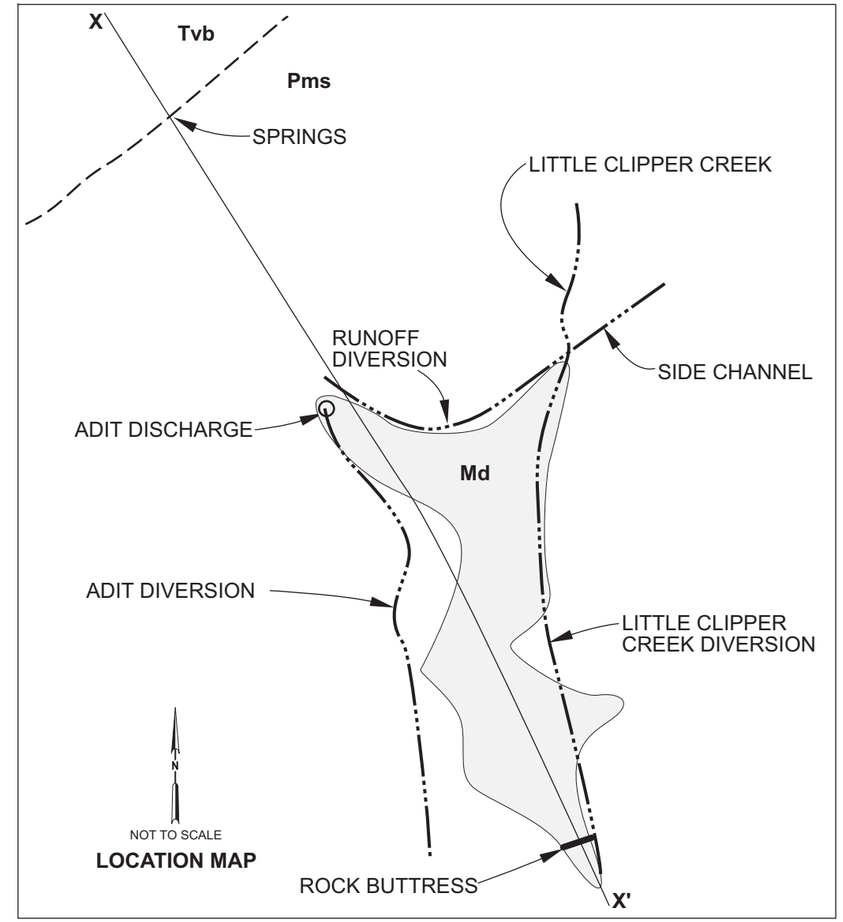




LEGEND

Tvb	TERTIARY VOLCANIC BRECCIA (LAVA CAP)
Pms	PALEOZOIC METASEDIMENTARY ROCKS
Md	MINE DEPOSITS (WASTE ROCK AND TAILINGS)
— — —	APPROXIMATE GEOLOGIC CONTACT
→	SURFACE OR SUBSURFACE WATER FLOWPATH
▼	PERCHED WATER IN Tvb

ES072007012RDD_42 (10/30/07)

FIGURE 5-1
SCHEMATIC CROSS SECTION OF MINE AREA GROUNDWATER AND SURFACE WATER CONDITIONS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

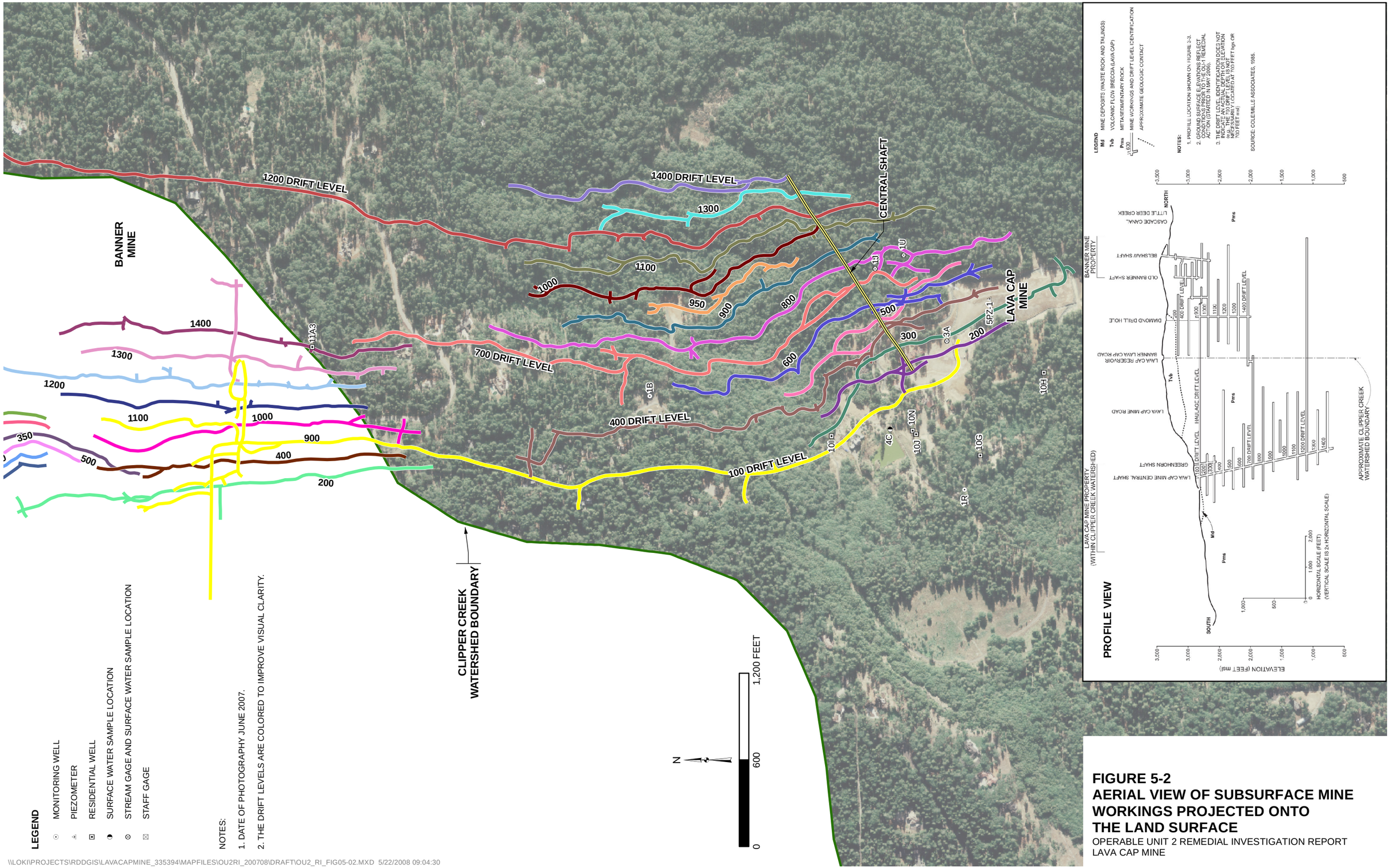


FIGURE 5-2
AERIAL VIEW OF SUBSURFACE MINE WORKINGS PROJECTED ONTO THE LAND SURFACE
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

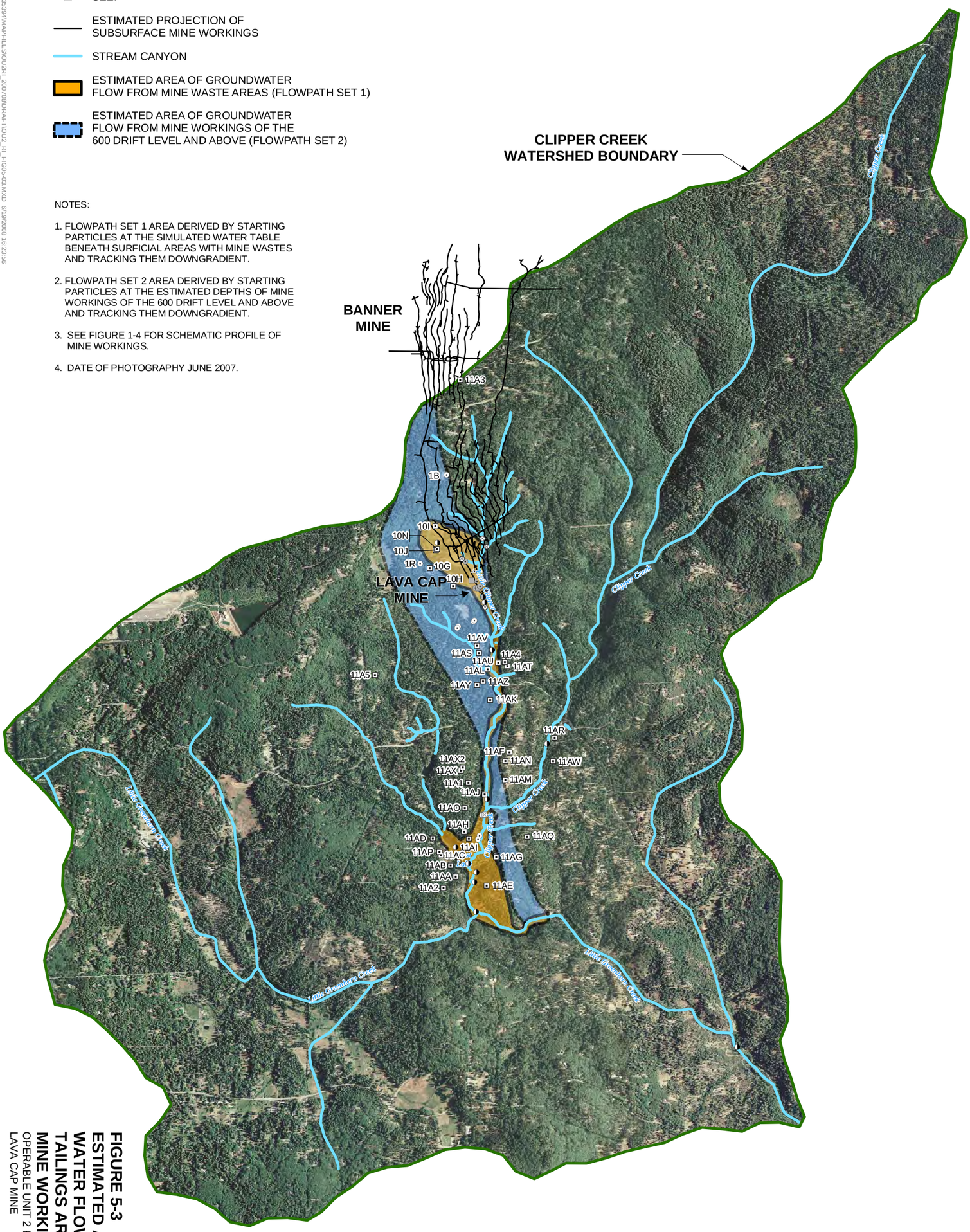
\\LOKI\PROJECTS\RDDGIS\LAVACAPMINE_335394\MAPFILES\OU2RI_200708\DRAFT\OU2_RI_FIG05-02.MXD 5/22/2008 09:04:30

LEGEND

- MONITORING WELL
- PIEZOMETER
- RESIDENTIAL WELL
- SURFACE WATER SAMPLE LOCATION
- STREAM GAGE AND SURFACE WATER SAMPLE LOCATION
- STAFF GAGE
- SEEP
- ESTIMATED PROJECTION OF SUBSURFACE MINE WORKINGS
- STREAM CANYON
- ESTIMATED AREA OF GROUNDWATER FLOW FROM MINE WASTE AREAS (FLOWPATH SET 1)
- ESTIMATED AREA OF GROUNDWATER FLOW FROM MINE WASTE AREAS OF THE 600 DRIFT LEVEL AND ABOVE (FLOWPATH SET 2)

NOTES:

1. FLOWPATH SET 1 AREA DERIVED BY STARTING PARTICLES AT THE SIMULATED WATER TABLE BENEATH SURFICIAL AREAS WITH MINE WASTES AND TRACKING THEM DOWNGRADIENT.
2. FLOWPATH SET 2 AREA DERIVED BY STARTING PARTICLES AT THE ESTIMATED DEPTHS OF MINE WORKINGS OF THE 600 DRIFT LEVEL AND ABOVE AND TRACKING THEM DOWNGRADIENT.
3. SEE FIGURE 1-4 FOR SCHEMATIC PROFILE OF MINE WORKINGS.
4. DATE OF PHOTOGRAPHY JUNE 2007.



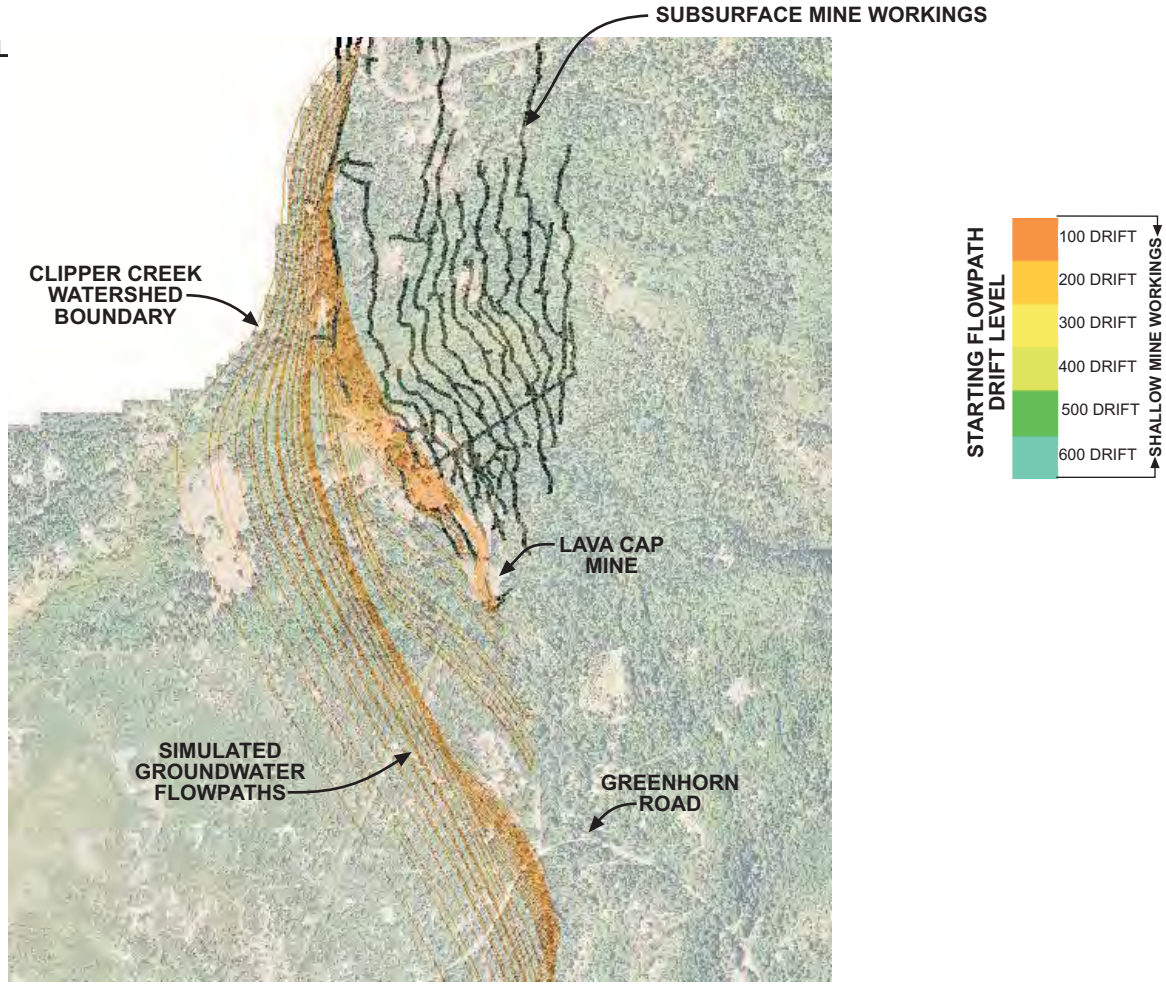
N

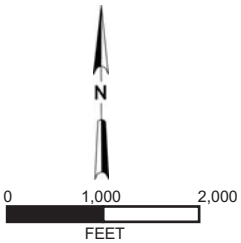
0 2,400 4,800 FEET

FIGURE 5-3
ESTIMATED AREA OF GROUND-WATER FLOW FROM SURFICIAL TAILINGS AREAS AND SHALLOW MINE WORKINGS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

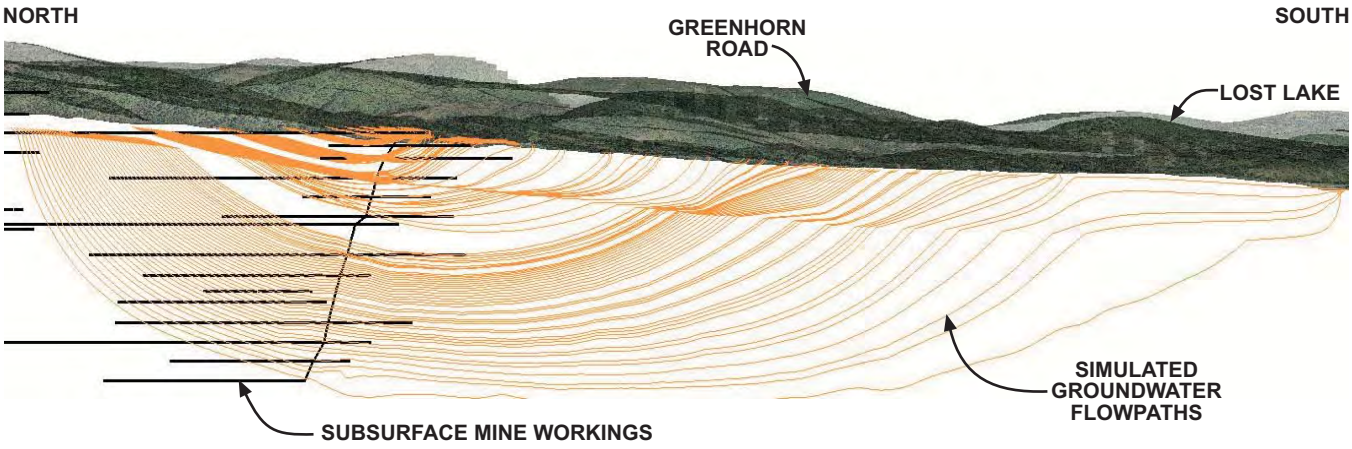
\\LOKI\PROJECTS\RDDG\SLAVACAPMINE_335394\MAPFILES\OU2\RI_2007\08\DRAFT\OU2_RI_FIG05-03.MXD 6/19/2008 16:23:56

100 DRIFT LEVEL AERIAL





100 DRIFT LEVEL PROFILE VIEW (LOOKING EAST)



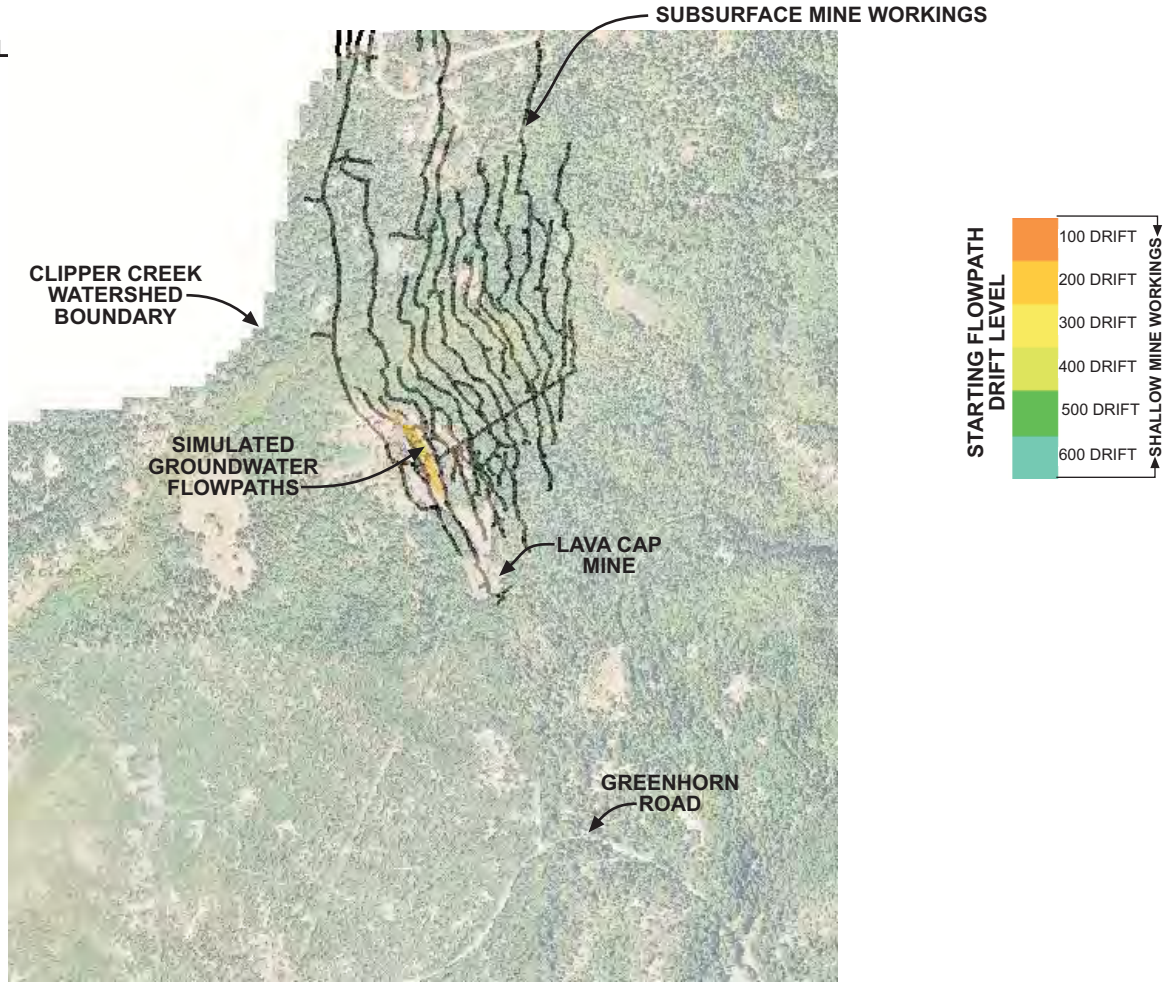
NOTE:

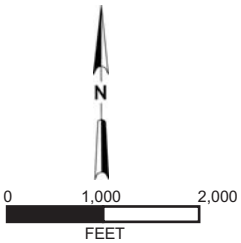
SHALLOW MINE WORKINGS INCLUDE THE 100 THROUGH 600 DRIFT LEVELS.

FIGURE 5-4 (PAGE 1 of 6)
AERIAL AND PROFILE VIEWS OF MODEL-DERIVED GROUNDWATER FLOWPATHS FROM SHALLOW MINE WORKINGS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

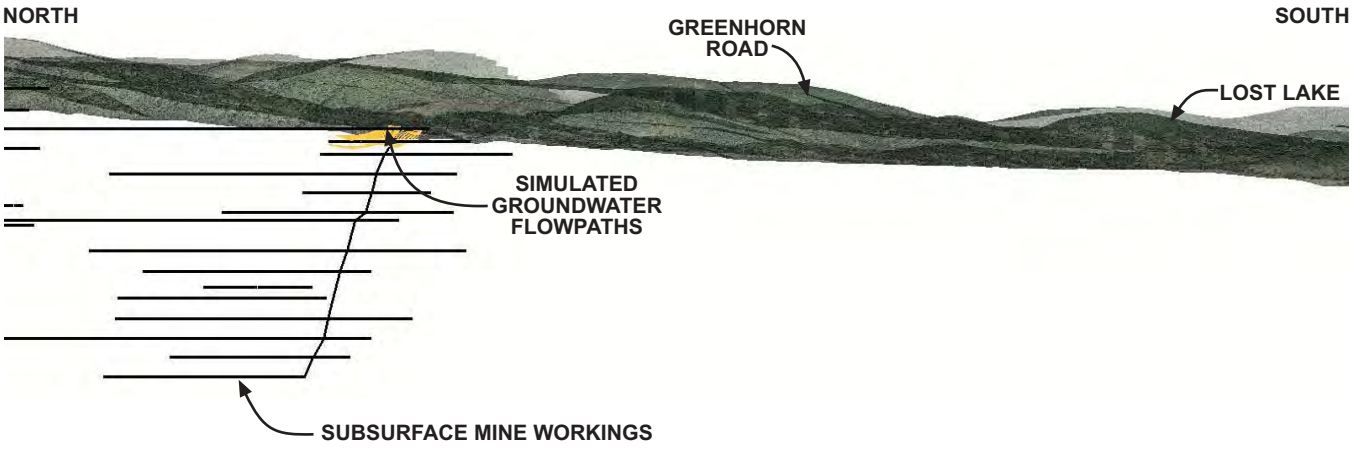
OU2_RI_FIG05-04.FH10

200 DRIFT LEVEL AERIAL





200 DRIFT LEVEL PROFILE VIEW (LOOKING EAST)



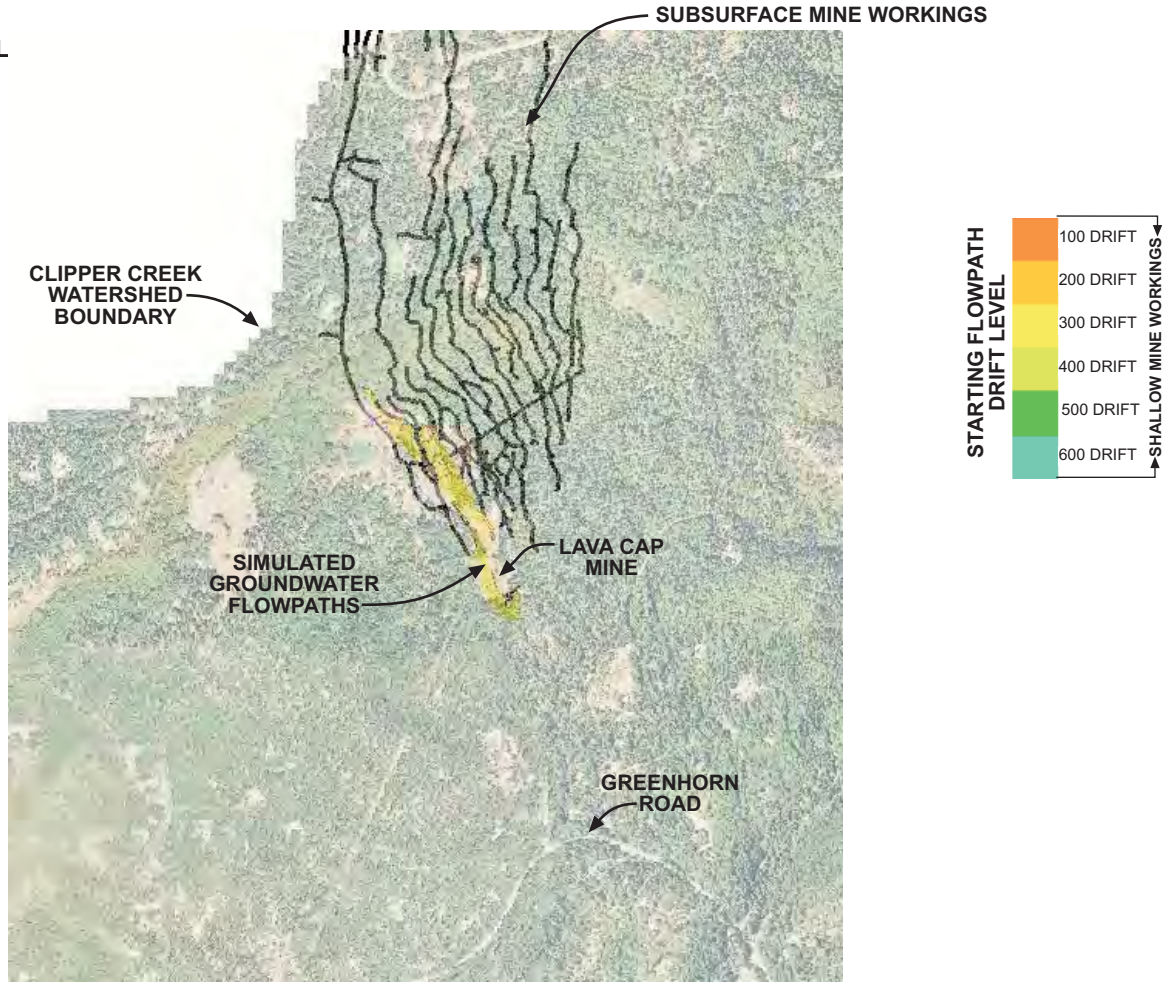
NOTE:

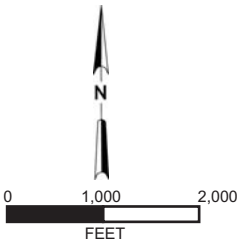
SHALLOW MINE WORKINGS INCLUDE THE 100 THROUGH 600 DRIFT LEVELS.

FIGURE 5-4 (PAGE 2 of 6)
AERIAL AND PROFILE VIEWS OF MODEL-DERIVED GROUNDWATER FLOWPATHS FROM SHALLOW MINE WORKINGS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

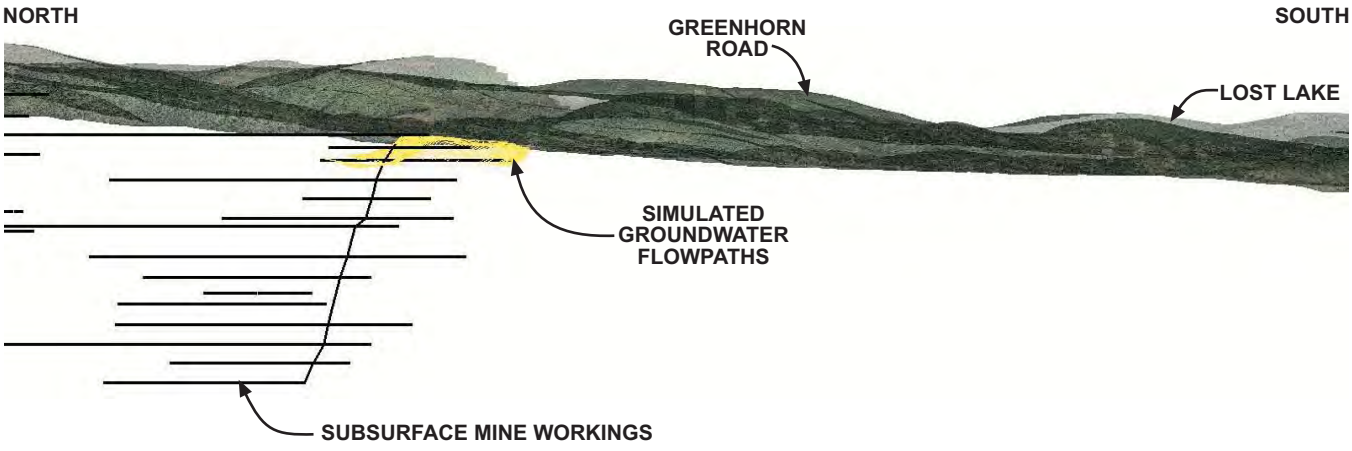
OU2_RI_FIG05-04.FH10

300 DRIFT LEVEL AERIAL





300 DRIFT LEVEL PROFILE VIEW (LOOKING EAST)



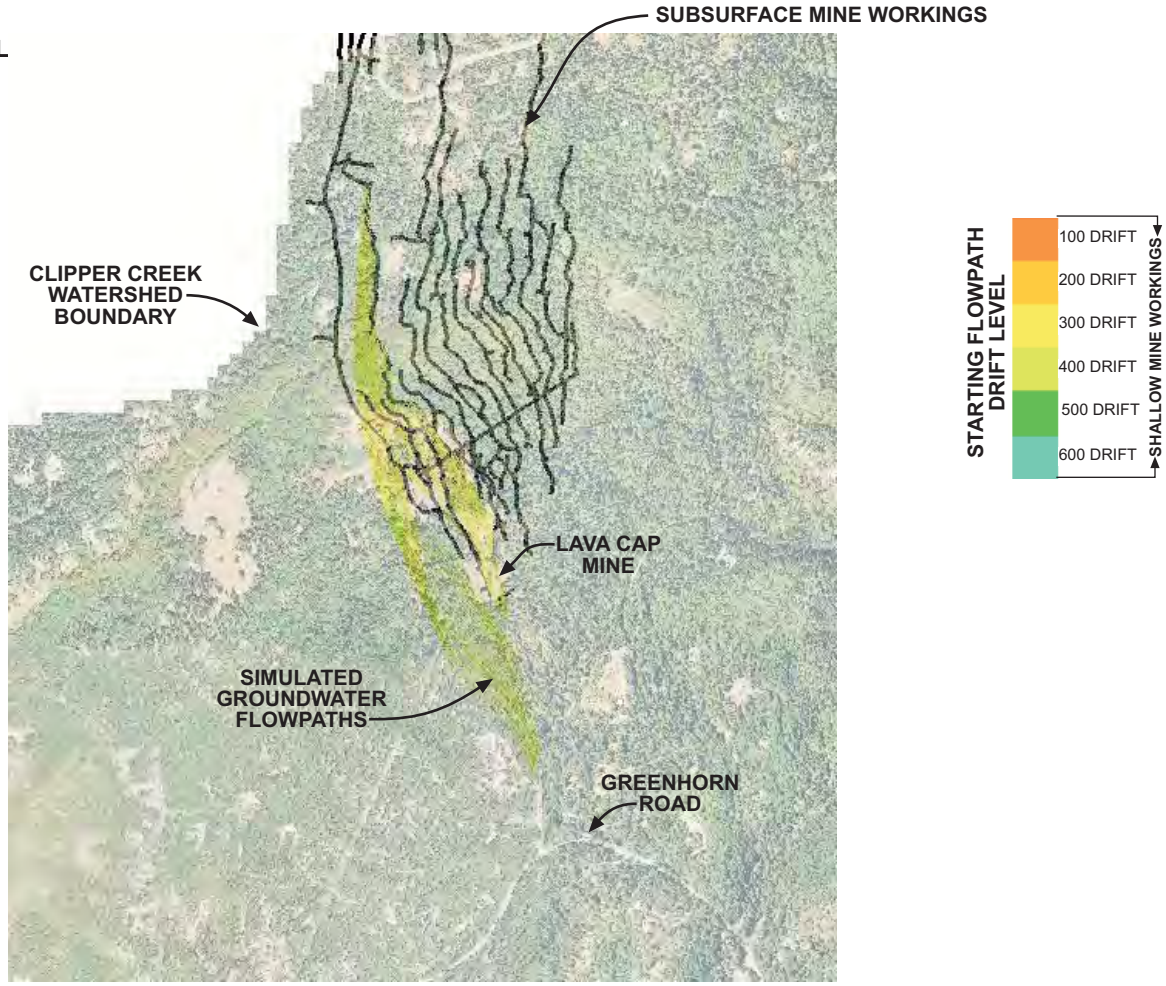
NOTE:

SHALLOW MINE WORKINGS INCLUDE THE 100 THROUGH 600 DRIFT LEVELS.

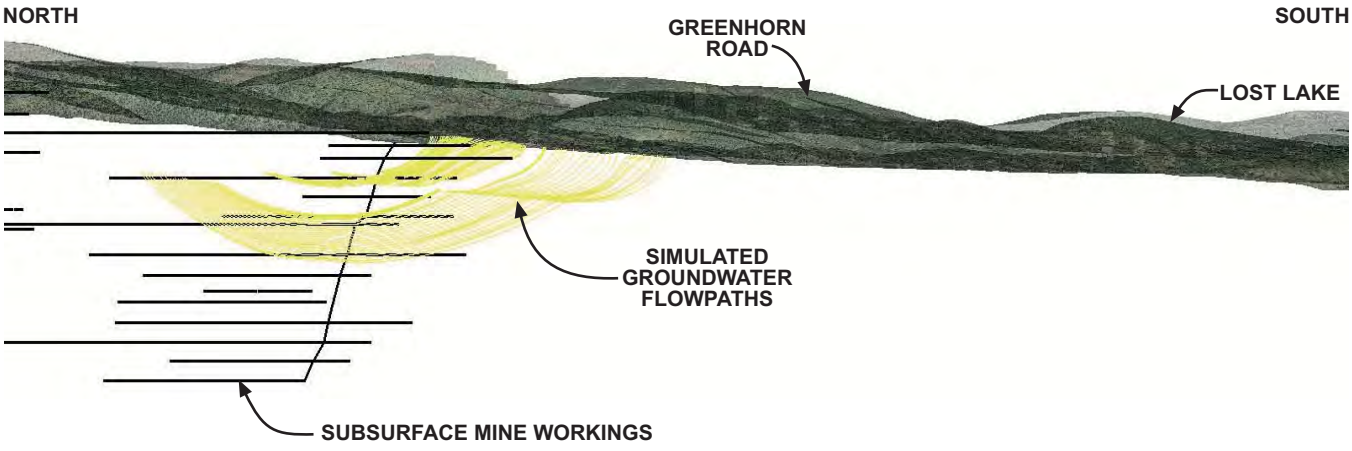
FIGURE 5-4 (PAGE 3 of 6)
AERIAL AND PROFILE VIEWS OF MODEL-DERIVED GROUNDWATER FLOWPATHS FROM SHALLOW MINE WORKINGS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

OU2_RI_FIG05-04.FH10

400 DRIFT LEVEL AERIAL



400 DRIFT LEVEL PROFILE VIEW (LOOKING EAST)



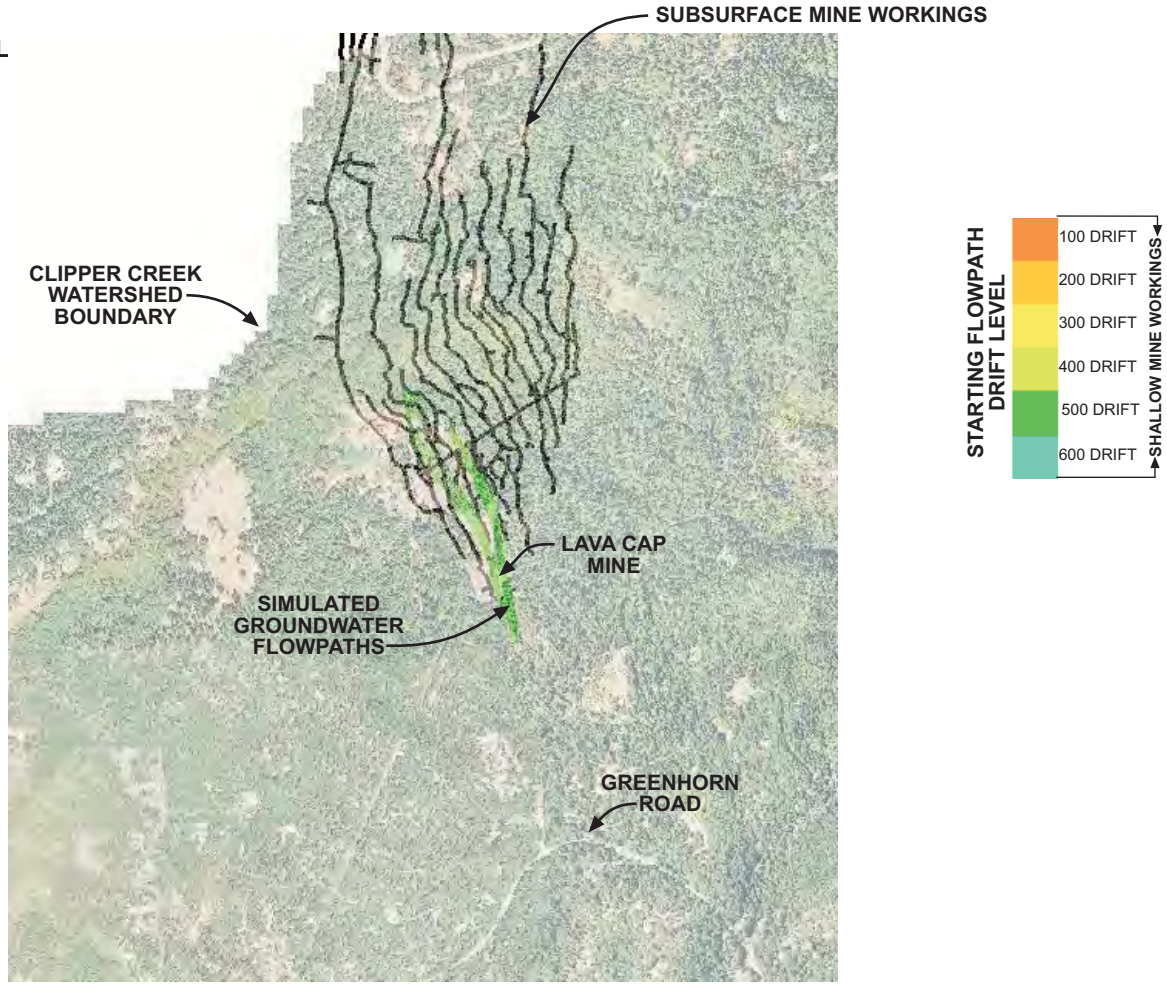
NOTE:

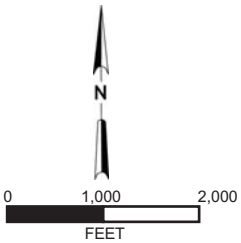
SHALLOW MINE WORKINGS INCLUDE THE 100 THROUGH 600 DRIFT LEVELS.

FIGURE 5-4 (PAGE 4 of 6)
AERIAL AND PROFILE VIEWS OF MODEL-DERIVED GROUNDWATER FLOWPATHS FROM SHALLOW MINE WORKINGS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

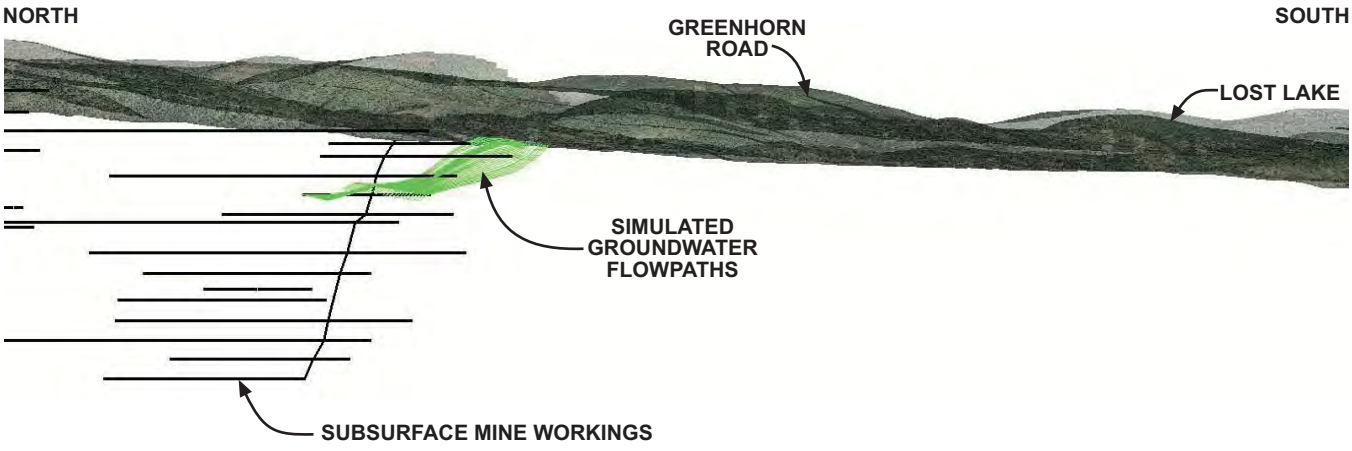
OU2_RI_FIG05-04.FH10

500 DRIFT LEVEL AERIAL





500 DRIFT LEVEL PROFILE VIEW (LOOKING EAST)



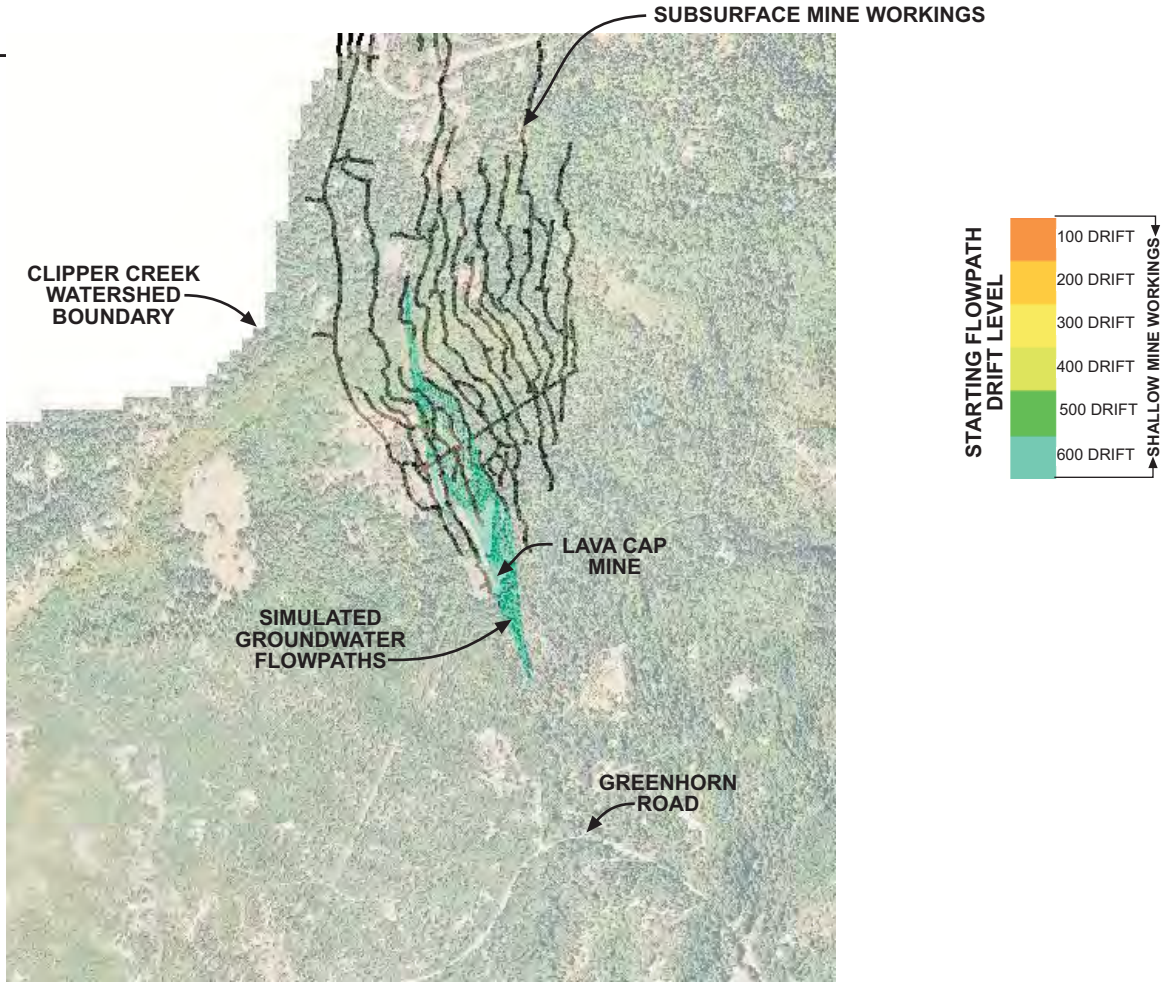
NOTE:

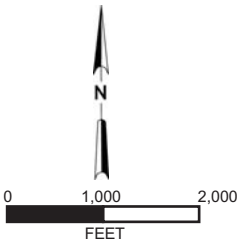
SHALLOW MINE WORKINGS INCLUDE THE 100 THROUGH 600 DRIFT LEVELS.

FIGURE 5-4 (PAGE 5 of 6)
AERIAL AND PROFILE VIEWS OF MODEL-DERIVED GROUNDWATER FLOWPATHS FROM SHALLOW MINE WORKINGS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

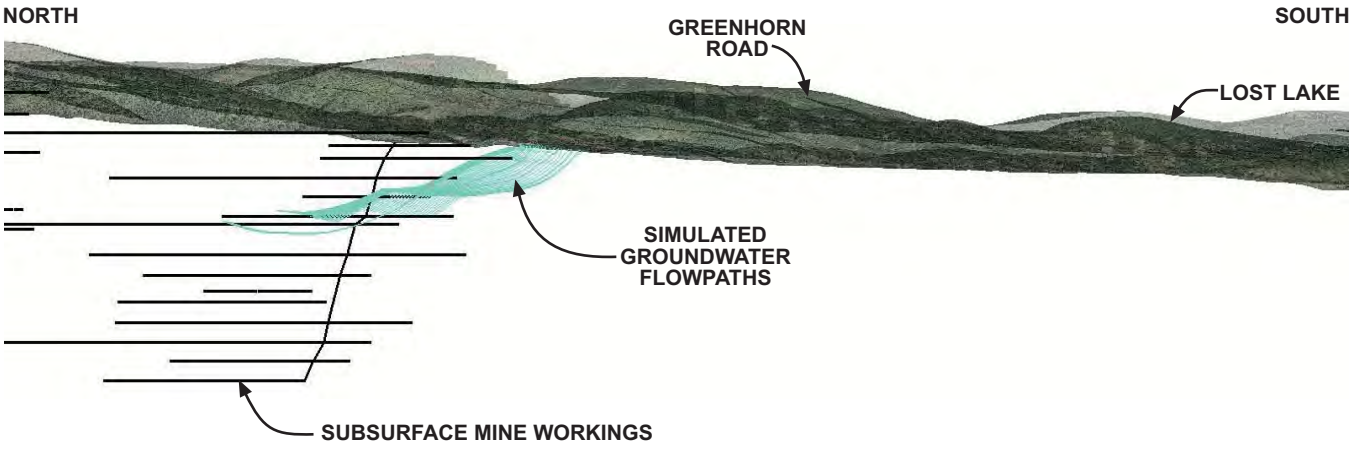
OU2_RI_FIG05-04.FH10

600 DRIFT LEVEL AERIAL





600 DRIFT LEVEL PROFILE VIEW (LOOKING EAST)



NOTE:

SHALLOW MINE WORKINGS INCLUDE THE 100 THROUGH 600 DRIFT LEVELS.

FIGURE 5-4 (PAGE 6 of 6)
AERIAL AND PROFILE VIEWS OF MODEL-DERIVED GROUNDWATER FLOWPATHS FROM SHALLOW MINE WORKINGS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

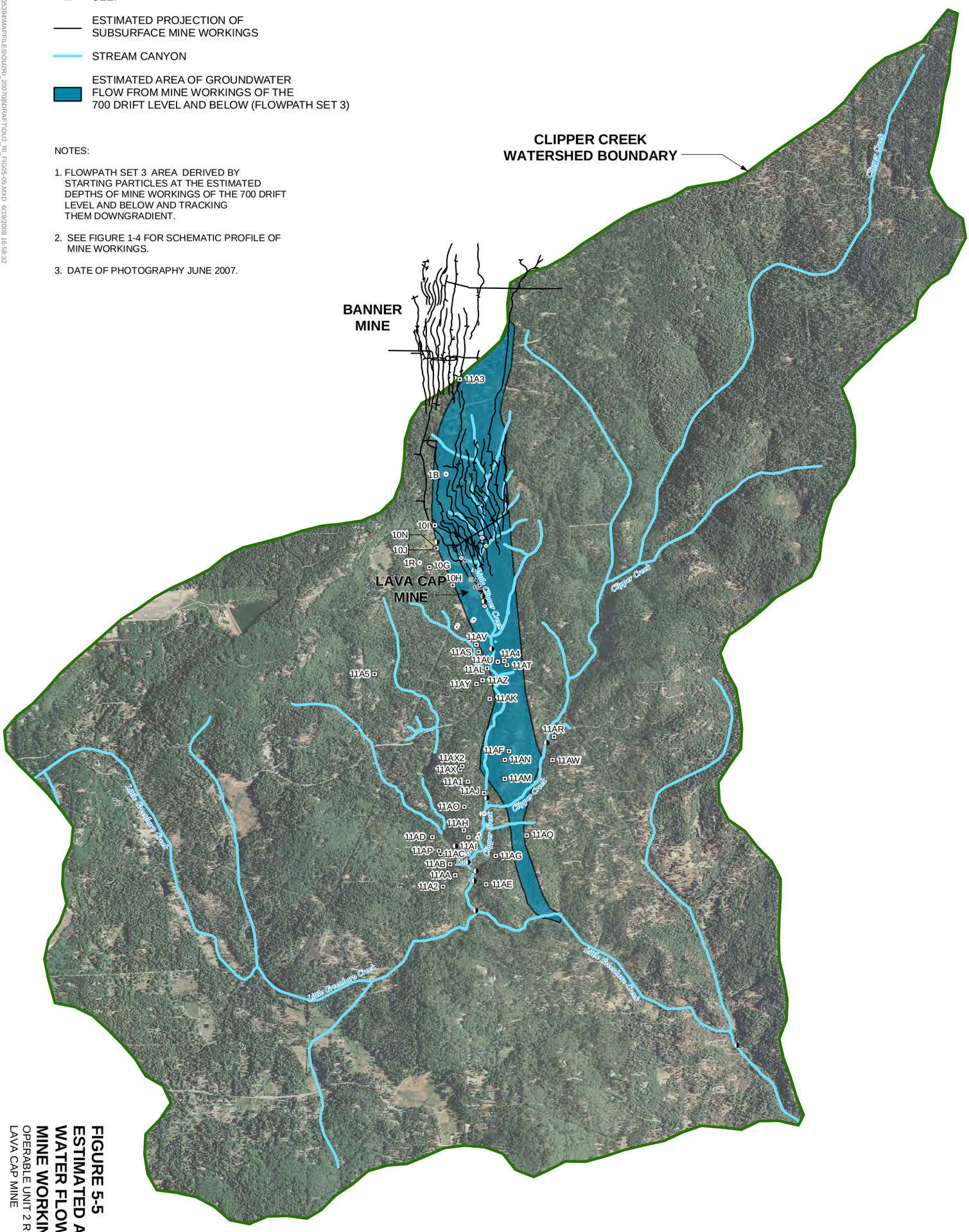
OU2_RI_FIG05-04.FH10

LEGEND

- MONITORING WELL
- PIEZOMETER
- RESIDENTIAL WELL
- SURFACE WATER SAMPLE LOCATION
- STREAM GAGE AND SURFACE WATER SAMPLE LOCATION
- STAFF GAGE
- SEEP
- ESTIMATED PROJECTION OF SUBSURFACE MINE WORKINGS
- STREAM CANYON
- ESTIMATED AREA OF GROUNDWATER FLOW FROM MINE WORKINGS OF THE 700 DRIFT LEVEL AND BELOW (FLOWPATH SET 3)

NOTES:

1. FLOWPATH SET 3 AREA DERIVED BY STARTING PARTICLES AT THE ESTIMATED DEPTHS OF MINE WORKINGS OF THE 700 DRIFT LEVEL AND BELOW AND TRACKING THEM DOWNGRADIENT.
2. SEE FIGURE 1-4 FOR SCHEMATIC PROFILE OF MINE WORKINGS.
3. DATE OF PHOTOGRAPHY JUNE 2007.



N

0 2,400 4,800 FEET

FIGURE 5-5
ESTIMATED AREA OF GROUND-WATER FLOW FROM DEEP MINE WORKINGS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

\\LOKI\PROJECTS\RDDG\SLAV\ACAPMINE_335394\MAPFILES\OU2\RI_2007\08\DRAFT\OU2_RI_FIG05-05.MXD 6/19/2008 16:58:32

FIGURE 5-6
BACKGROUND AREA, MINE AREA, AND SOURCE AREA STIFF DIAGRAMS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

\\LOKI\PROJECTS\RDDGIS\LAVACAPMINE_335394\MAPFILES\OU2RI_200708\DRAFT\OU2_RI_FIG05-06.MXD 6/4/2008 10:09:59

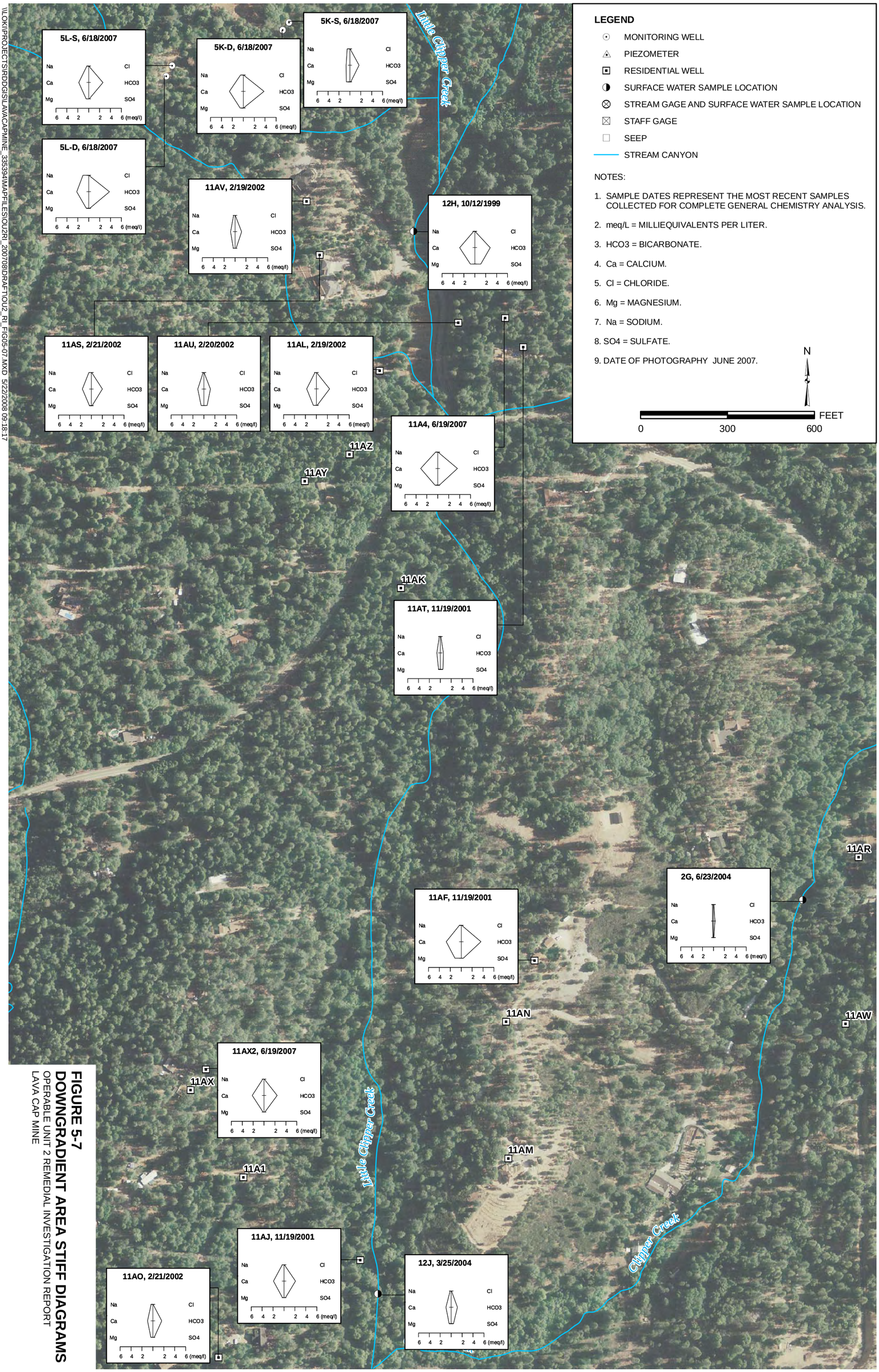


FIGURE 5-7
DOWNGRADIENT AREA STIFF DIAGRAMS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

\\LOKI\PROJECTS\RDGIS\LAVACAPMINE_3353941\MAPFILES\OU2\RI_2007\08\DRAFT\OU2_RI_FIG05-07.MXD 5/22/2008 09:18:17

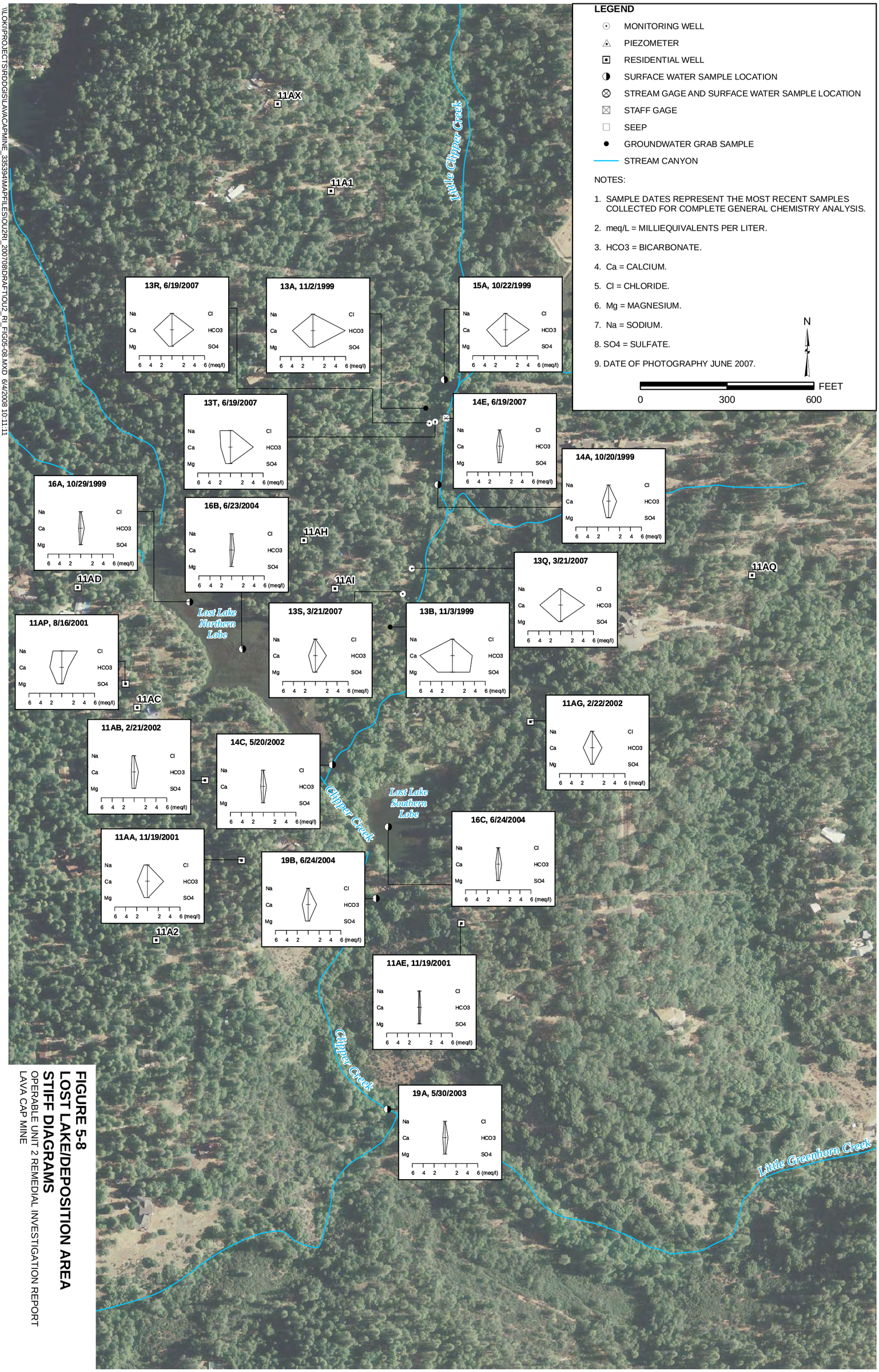
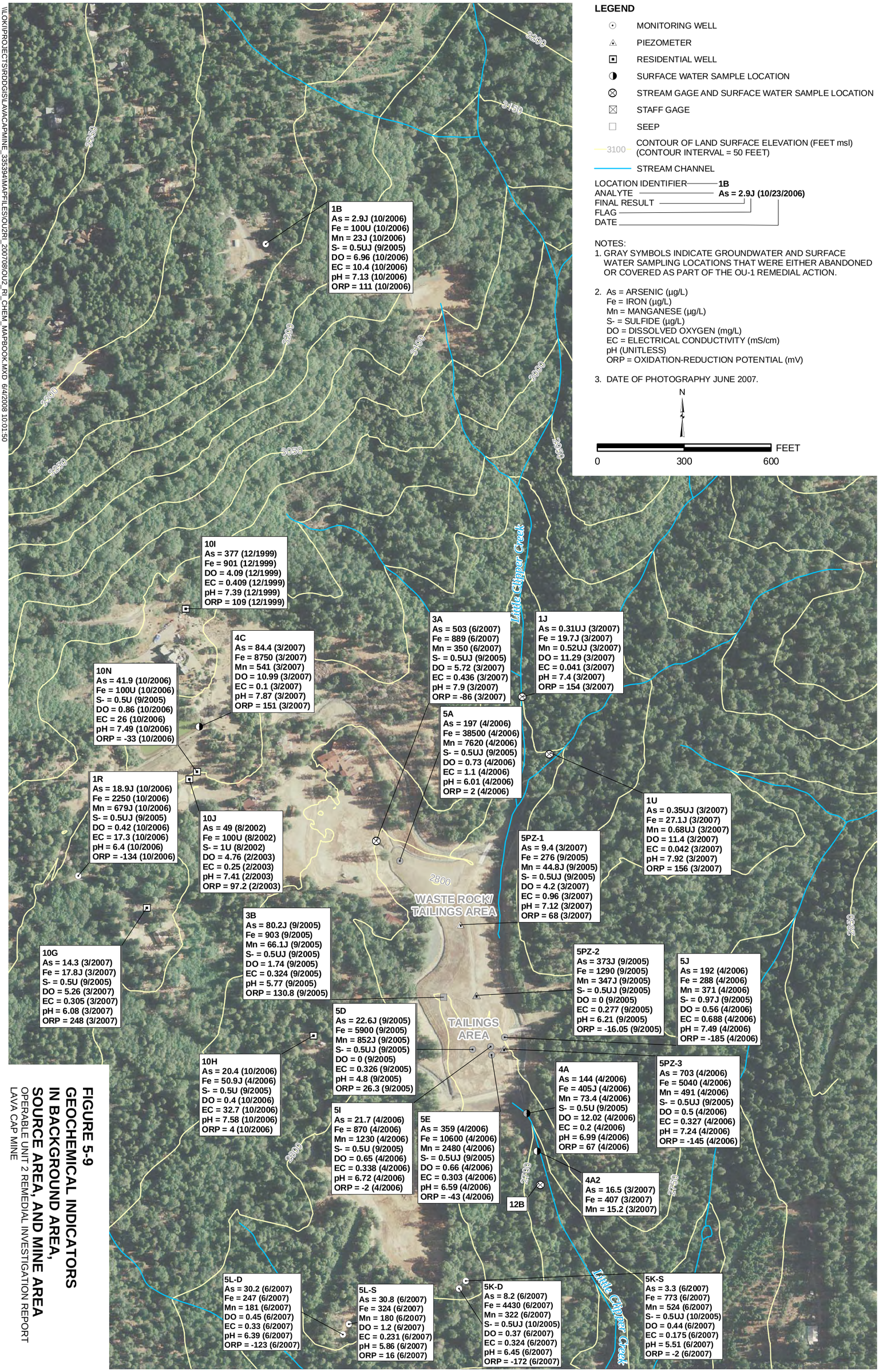


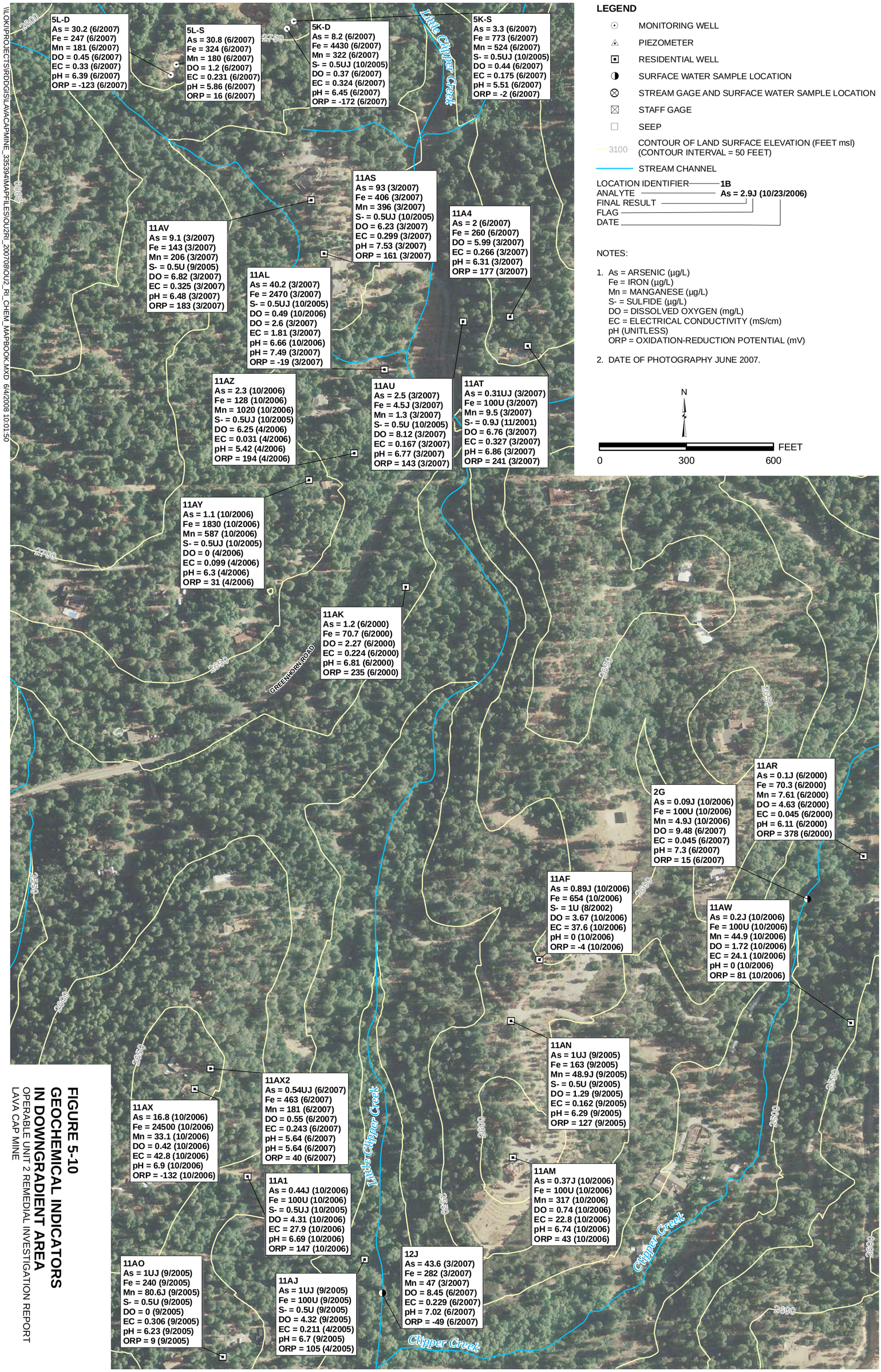
FIGURE 5-8
LOST LAKE/DEPOSITION AREA
STIFF DIAGRAMS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

\\LOKI\PROJECTS\RDGIS\LAVACAPMINE_3353941\MAPFILES\OU2\RI_200708\DRAFT\OU2_RI_FIG05-08.MXD 6/4/2008 10:11:11



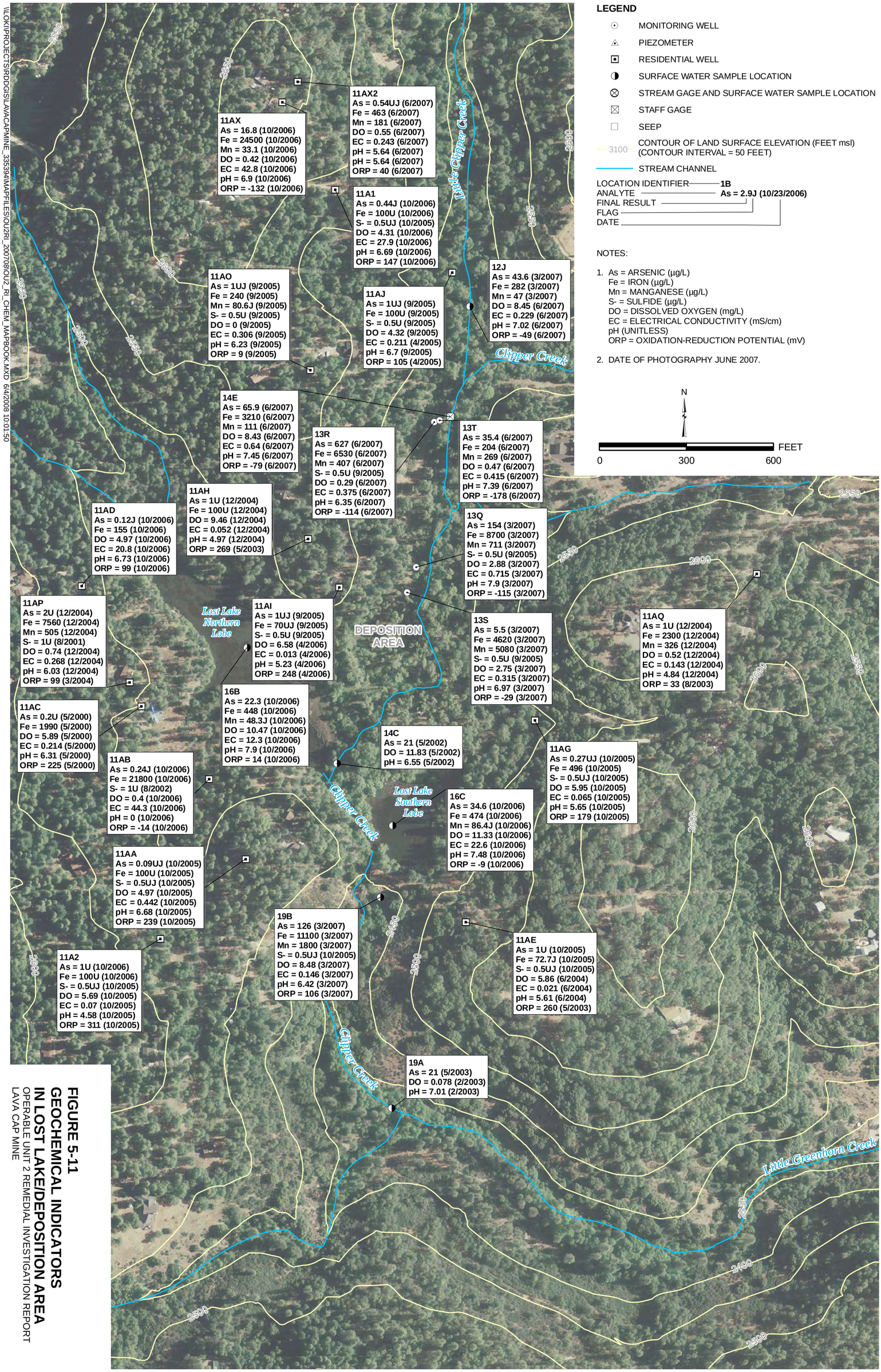
\\LOKI\PROJECTS\RDDGIS\LAVACAPMINE_3353941\MAPFILES\OU2\RI_2007080\OU2_RI_CHEM_MAPBOOK.MXD 6/4/2008 10:01:50

FIGURE 5-9
GEOCHEMICAL INDICATORS IN BACKGROUND AREA, SOURCE AREA, AND MINE AREA
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE



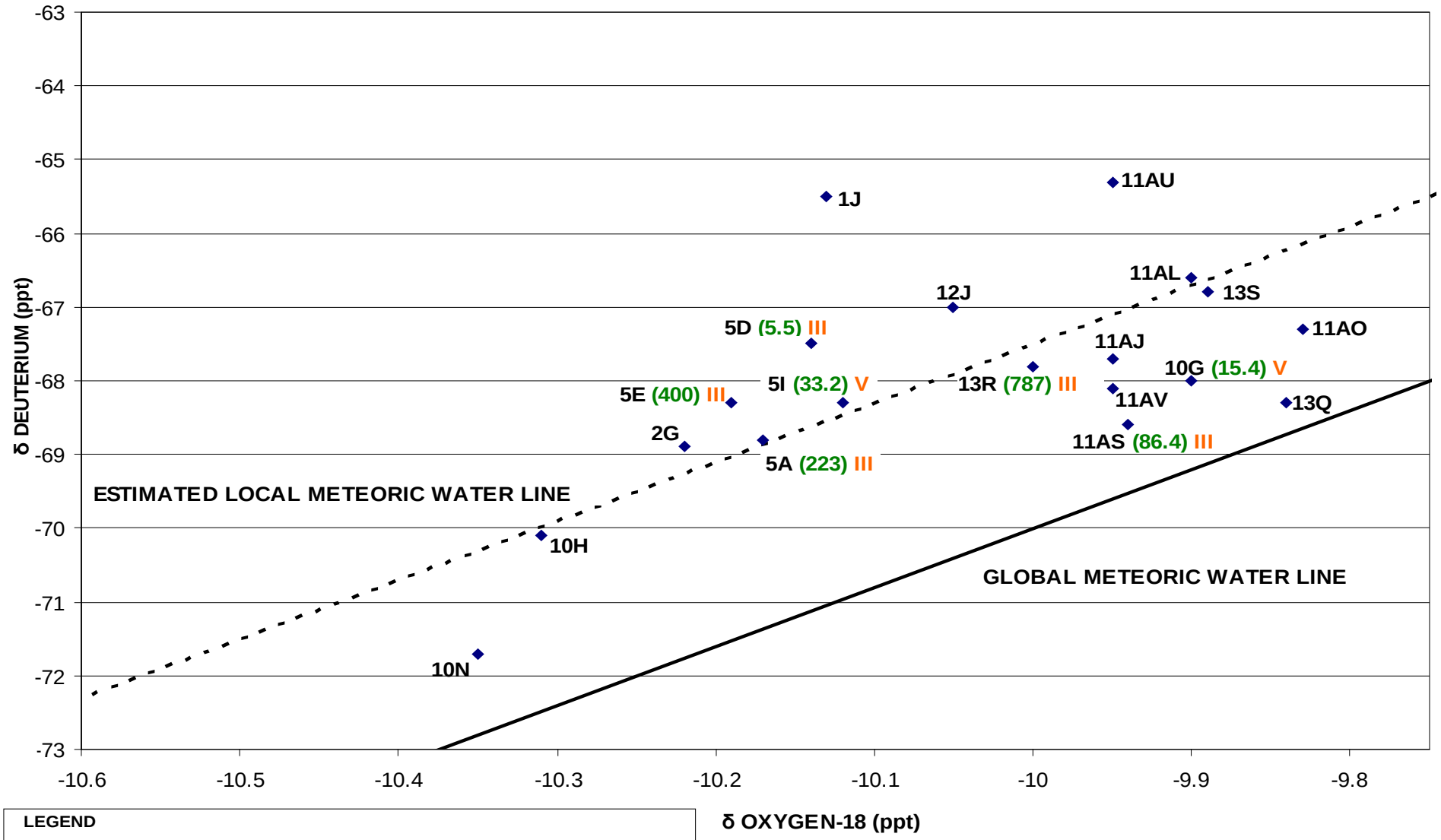
\\LOKI\PROJECTS\RDDGIS\LAVACAPMINE_335394\MAPFILES\OU2RI_2007\08\OU2_RI_CHEM_MAPBOOK.MXD 6/4/2008 10:01:50

FIGURE 5-10
GEOCHEMICAL INDICATORS IN DOWNGRADIENT AREA
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE



\\LOKI\PROJECTS\RDDGIS\LAVACAPMINE_3353941\MAPFILES\OU2\RI_2007\08\OU2_RI_CHEM_MAPBOOK.MXD 6/4/2008 10:01:50

FIGURE 5-11
GEOCHEMICAL INDICATORS
IN LOST LAKE/DEPOSITION AREA
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE



LEGEND

◆ OXYGEN-18/ DEUTERIUM SAMPLE RESULTS FOR SPECIFIED WELL LOCATION

5A (223) III
- DOMINANT ARSENIC TYPE
- TOTAL ARSENIC CONCENTRATION (µg/L)
- WELL NAME

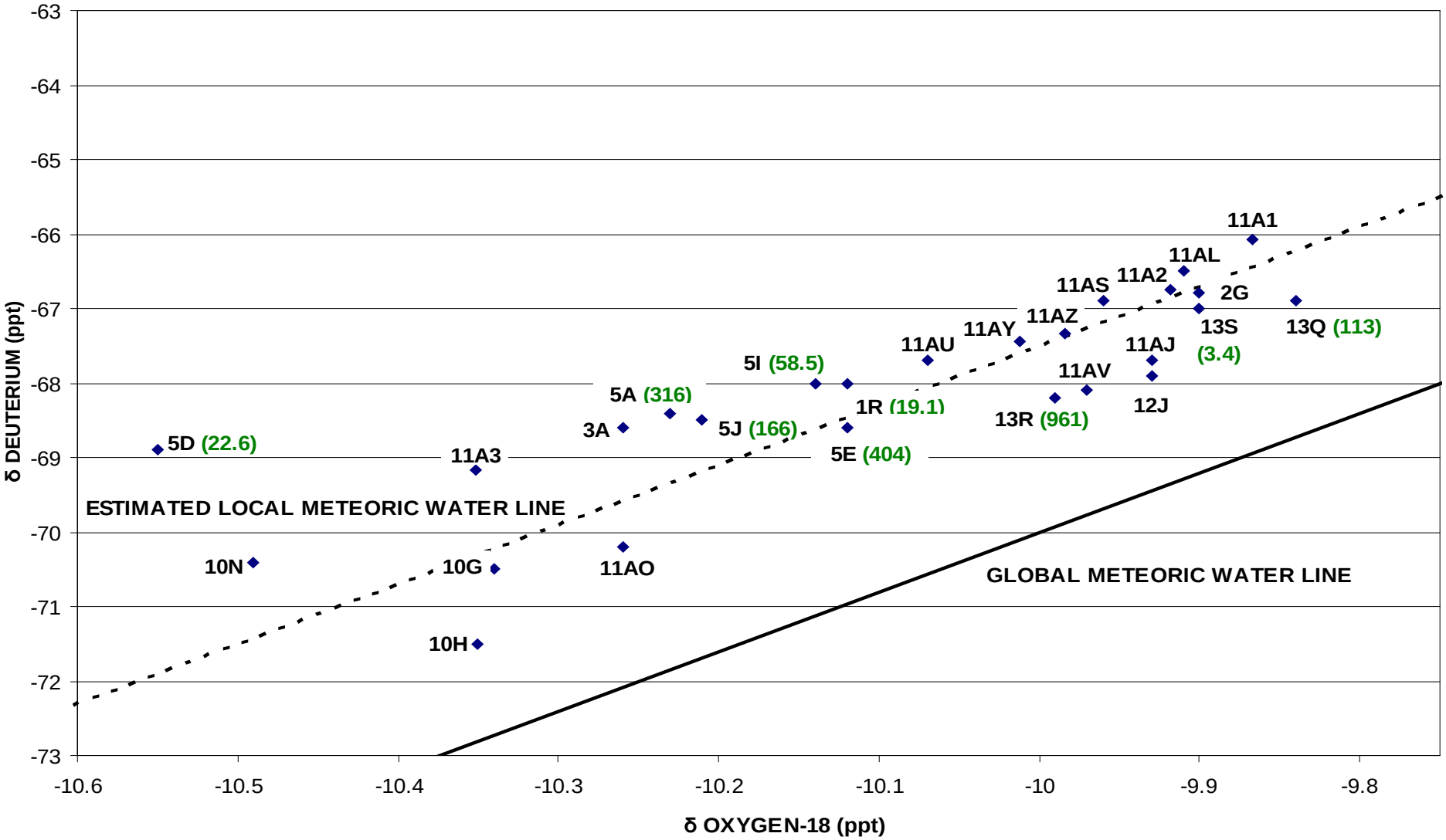
III TRIVALENT ARSENIC

V PENTAVALENT ARSENIC

ppt PARTS PER TRILLION

ES072007012RDD_13 (5/22/08)

FIGURE 5-12
APRIL 2005 DEUTERIUM AND OXYGEN-18 RESULTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE



LEGEND

◆ OXYGEN-18/ DEUTERIUM SAMPLE RESULTS FOR SPECIFIED WELL LOCATION

5A (223)

TOTAL ARSENIC CONCENTRATION (µg/L)

WELL NAME

ppt PARTS PER TRILLION

ES072007012RDD_14 (5/22/08)

FIGURE 5-13
SEPTEMBER 2005 DEUTERIUM AND OXYGEN-18 RESULTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

FIGURE 5-14
REACH OF LITTLE CLIPPER CREEK OVER WHICH ARSENIC LOADING WAS ESTIMATED
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

\\LOKI\PROJECTS\RDDGIS\LAVACAPMINE_335394\MAPFILES\OU2RI_200708\DRAFT\OU2_RI_FIG05-14.MXD 6/4/2008 10:06:35

SECTION 6.0

Human Health Risk Assessment

A human health risk assessment (HHRA) was completed in 2001 as part of the RI for the Site (EPA, 2001a). The HHRA included quantitative estimates of cancer and noncancer risks by using soil, sediment, air, surface water, and groundwater data from 1999 and 2000. The results of the 2001 HHRA for six identified exposure units (see Section 6.1) associated with the Site concluded that cancer risks for most current or future hypothetical receptors exceeded EPA's risk management range of 10^{-6} to 10^{-4}. The cancer risk values ranged from 5×10^{-5} to 5.8×10^{-3}, with nearly all receptors having estimates of risk greater than the corresponding background cancer risks. The hazard index (HI) estimates for all receptors were greater than 1 (HI estimates ranged from 2.5 to 91) and nearly all exceeded their respective background HI estimates. The risk driver for both cancer and noncancer estimates was arsenic.

As part of the continuing groundwater monitoring program that is a component of the EPA's ongoing OU-2 RI/FS work at the Site, additional groundwater samples have been collected since 2001. By using the additional groundwater data, an update of the groundwater HHRA was prepared that evaluated the use of groundwater from residential drinking water wells in OU-2. Groundwater at the Site is not considered to have a complete pathway for ecological exposure, except for discharges to creeks and as springs. The ecological risks from these surface water expressions will be evaluated as part of the OU-3 RI/FS work.

6.1 Site Exposure Units

The six exposure units that were evaluated in 2001 for the HHRA and risk and hazard estimates for the areas are summarized as follows:

- **Exposure Unit 1.** Exposure Unit 1 is a mine worker scenario with exposure through incidental soil ingestion, dermal contact with soil, and inhalation of particulate matter in fugitive dust. The estimated lifetime cancer risk (ELCR) estimate for Exposure Unit 1 is 5.3×10^{-3} with arsenic being the risk driver, mainly through the incidental soil ingestion exposure pathway. The estimated HI is 31 with arsenic being the risk driver, mainly through the soil ingestion exposure pathway.
- **Exposure Unit 2.** Exposure Unit 2 consists of residents near Lost Lake, including those who use Lost Lake for recreation. These residents might be exposed to contaminants in surface soils above the lake near homes and in groundwater from private domestic wells. Exposure to groundwater might be through ingestion of and dermal contact with groundwater. The exposure routes for contact with soils and sediments are ingestion, dermal contact, and inhalation of fugitive dust. Recreational users of Lost Lake might also be exposed to contaminants in soil around the lake shore and in the surface water and sediment in the lake. Another potential recreational exposure pathway is consumption of contaminated fish from the lake. The ELCR estimate of arsenic in

residential soils is approximately 3.8×10^{-5}, with arsenic being the primary risk driver through the soil ingestion pathway. The ELCR for exposure through recreational uses is approximately 1.1×10^{-3}, with arsenic being the risk driver through the incidental ingestion of soil pathway. The HI for the recreational receptor is 21, with arsenic being the main risk driver, primarily through the soil ingestion and surface water contact pathway. The ELCR from fish ingestion is 1.1×10^{-4}, with arsenic being the risk driver. The HI from fish ingestion is less than 1. The ELCR from exposure to groundwater is 1.2×10^{-5} for the Lost Lake/LCC domestic well dataset; arsenic is the main risk driver. The HI estimate is 1.6 for the Lost Lake/LCC domestic well dataset. The total ELCR for a resident that participates in recreational activities around Lost Lake (add together the residential soil sediment, and surface water; fish ingestion; and groundwater exposures) is 1.1×10^{-3}; the total HI is 27. For residents who do not participate in recreational activities in or around Lost Lake, the total ELCR and HI are 5.0×10^{-5} and 6.3, respectively, for exposure to surface soil and groundwater.

A semi-quantitative estimate of the risks from consumption of homegrown produce can be approximated by using EPA's Soil Screening Guidance. According to the SSL guidance for arsenic, the risk from the soil-plant-human exposure pathway can be estimated as approximately equal to that of the soil ingestion pathway. Therefore, the risks to a resident in the vicinity of Lost Lake from potential exposure to arsenic in homegrown produce are approximately 4×10^{-5}. When homegrown produce risks are combined with soil ingestion (and the soil direct contact pathways), the total risk from soils would be approximately 8×10^{-5} ELCR for a reasonable maximum exposure.

- **Exposure Unit 3.** Exposure Unit 3 consists of the residents at Lava Cap Mine. The exposure routes from soil and sediments are ingestion, dermal contact, and inhalation of fugitive dust. Residents might also be exposed through groundwater from domestic wells through ingestion and dermal contact. The ELCR for the residential receptor is 5.8×10^{-3}, with arsenic being the risk driver, mainly through the incidental ingestion of soil and ingestion of drinking water pathways. The HI estimated for the residential receptor is 91, with arsenic being the risk driver.

- **Exposure Unit 4.** Exposure Unit 4 consists of residents living along LCC below Lava Cap Mine and above the Deposition Area who use LCC for recreation. These residents might be exposed to contaminants from private domestic wells through ingestion of and dermal contact with groundwater. The exposure routes for contact with soils/sediments are ingestion, dermal contact, and inhalation of fugitive dust during recreational activities along LCC. Recreational users of LCC might also be exposed to contaminants through recreational activities along the creek (e.g., wading). The ELCR for the exposure to surface soil and sediment and surface water through recreational uses along LCC is 5.4×10^{-4}, with arsenic being the risk driver through the incidental soil ingestion pathway. The HI for recreational exposure is 11, with arsenic being the main risk driver. The ELCR from exposure to groundwater is 1.2×10^{-5} for the Lost Lake/LCC domestic well dataset and 1.1×10^{-3} for the high arsenic well dataset. Arsenic is the main risk driver in both datasets. The HI estimates are 1.6 and 5.3 for the Lost Lake/LCC and high arsenic well datasets, respectively. The total ELCR, adding together the recreational and groundwater exposures, ranges from 5.6×10^{-4} to 1.6×10^{-3} for the Lost Lake/LCC and high arsenic well domestic well datasets, respectively. The total HI ranges from 13 to

16 for these same two datasets. If the residential soil risks (equivalent to background) are included, the total risk ranges are 5.9×10^{-4} to 1.7×10^{-3} (ELCR) and 17 to 21 (HI).

- **Exposure Unit 5.** Exposure Unit 5 consists of recreational users in the Deposition Area above Lost Lake. The recreational activities in the Deposition Area include potential exposure to soil and sediment through ingestion, dermal contact, and inhalation of fugitive dust. Furthermore, recreational users of this area might also be exposed to contaminants in surface water through recreational activities (e.g., wading). The ELCR for the recreational receptor is 1.6×10^{-3}, with arsenic being the risk driver through the incidental soil ingestion and contact with surface water pathways. The estimated HI for the residential receptor is 28, with arsenic being the risk driver through the ingestion of soil/sediment pathway.
- **Exposure Unit 6.** Exposure Unit 6 consists of two recreational exposure scenarios along CC below Lost Lake. The first set of recreational users (Recreational Scenario I) consists of infant through adult receptors. The second set of recreational users (Recreational Scenario II) consists of school age children through adult users of the area. The recreational activities in this area involve potential exposure from soil and sediment through ingestion, dermal contact, and inhalation of fugitive dust. Recreational users of this area might also be exposed to contaminants in surface water through recreational activities (e.g., wading). The ELCR for Recreational Scenario I receptors is 1.6×10^{-3}, with arsenic being the risk driver through the incidental soil ingestion pathway. For Recreational Scenario II receptors, the ELCR is 2.4×10^{-4}, with arsenic being the risk driver. The estimated HI for Recreation Scenario I receptors is 45, with arsenic and manganese being the risk drivers through the ingestion of soil/sediment pathway. The estimated HI for Recreational Scenario II is 2.5, with arsenic being the main risk driver.

6.2 Human Health Risk Assessment Update Approach

A technical meeting was held with EPA on July 24, 2007, to discuss the scope, approach, and methodology of the update of the OU-2 HHRA. It was determined during the meeting that forward risk calculations for the residential drinking water scenario were not needed for the following reasons:

- All EPA statutory requirements for a baseline risk assessment have been addressed in the 2001 RI HHRA.
- Continued EPA presence at Lava Cap Mine is justified based on the results of the 2001 RI HHRA.
- EPA has already established an actionable remediation goal for the Site, the current arsenic MCL of 10 µg/L.
- EPA can justify action for all residential wells with groundwater arsenic concentrations greater than the MCL based on the results of the 2001 RI HHRA.

Because the determination that risk calculations were not needed for the update of the HHRA, a comparison of residential well data to the MCL for arsenic in drinking water was conducted. The unfiltered quarterly groundwater data for arsenic (total arsenic) were

compared to the MCL. Several wells have under-sink treatment units installed to remove arsenic from the water. For these wells, data from the wellhead were used; the sample results from the under-sink treatment units were not used.

MCLs are the maximum permissible level of a contaminant in water delivered to any user of a public water system. The current arsenic MCL was adopted on January 22, 2001, and became effective and enforceable on January 23, 2006. In 1996, Congress directed EPA to propose a new arsenic regulation by January 1, 2000, and issue the final rule by January 1, 2001. A proposed rule for arsenic of 5 µg/L was published by EPA on June 22, 2000. EPA took comments on regulatory options of 3 µg/L (the feasible level), 10 µg/L, and 20 µg/L. After careful consideration of the benefits and the costs, EPA decided to set the drinking water standard for arsenic higher than the technically feasible level of 3 µg/L; EPA believed that the cost would not justify the benefits at this level. EPA believed that the MCL of 10 µg/L maximizes health risk reduction at a cost justified by the benefits.

6.3 Human Health Risk Assessment Update

For the OU-2 RI, total arsenic concentrations in groundwater from Site residential wells from 1999 through 2007 were used to update the HHRA for OU-2. Residential wells in the following five areas at the Site were included in the updated HHRA:

- Background Areas – Wells 11A3, 11AR, 11AW, and 11A5
- Source Area and Mine Area (corresponds to Exposure Unit 3 in the 2001 RI HHRA) – Wells 10G, 10H, 10I, 10J, and 10N
- Downgradient Area corresponds to Exposure Unit 4 in the 2001 RI HHRA and includes the following:
  - Below the mine and above Greenhorn Road – Wells 11AL, 11AS, 11AT, 11AU, 11AV, 11AY, 11AZ, and 11A4
  - Between Greenhorn Road and the Deposition Area – Wells 11AF, 11AJ, 11AK, 11AM, 11AN, 11AO, 11AQ, 11AX, 11AX2, and 11A1
- Lost Lake/Deposition Area (corresponds to Exposure Unit 2 in the 2001 RI HHRA) – Wells 11AA, 11AB, 11AC, 11AD, 11AE, 11AG, 11AH, 11AI, 11AP, and 11A2

Data were not available for several of these wells when the 2001 RI HHRA was prepared, including Wells 11A3, 11AW, 11A5, 10N, 11AY, 11AZ, 11A4, 11AX, 11AX2, 11A1, and 11A2.

For each well, the total number of samples, minimum arsenic concentration, and the maximum arsenic concentration were determined from the dataset (see Table 6-1). In addition, each sample result was compared to the MCL for arsenic and the number of exceedances at each location was determined. Field duplicate samples, laboratory split samples, and sample results with a data validation qualifier of "R" (meaning the data were rejected) were not used to determine the information in Table 6-1. Arsenic concentration data used in the assessment is tabulated in Tables H-4 through H-8 in Appendix H.

TABLE 6-1
Arsenic Concentrations in Residential Wells
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada County, California

Well	Total Number of Samples	Period of Years Samples Were Collected	Minimum Arsenic Concentration (µg/L)	Maximum Arsenic Concentration (µg/L)	Arsenic MCL (µg/L)	Number of Exceedances of MCL	Frequency of MCL Exceedances	Percent Exceedances of MCL
Background Areas Residential Wells								
11A3	4	2005 – 2006	1 U	1 U	10	0	0/4	0
11AR	1	2000	0.1 J	0.1 J	10	0	0/1	0
11AW	4	2003 – 2006	0.21 J	0.41 J	10	0	0/4	0
11A5	1	2006	1	1	10	0	0/1	0
Source Area and Mine Area Residential Wells								
10G	21	1999 – 2007	7.1	41.0	10	19	19/21	90
10H	19	1999 – 2006	2.5	31.7	10	15	15/19	79
10I	2	1999	377	528	10	2	2/2	100
10J	5	2000 – 2002	41.9	56.8	10	5	5/5	100
10N	12	2002 – 2006	28.9	54.7	10	12	12/12	100
Downgradient Residential Wells along LCC, below the mine and above Greenhorn Road								
11AL	22	1999 – 2007	18.7	90	10	22	22/22	100
11AS	16	2001 – 2007	2.1	270	10	15	15/16	94
11AT	7	2001, 2004, 2006 – 2007	0.2 J	1 U	10	0	0/7	0
11AU	16	2001 – 2007	1.4	5.7	10	0	0/18	0
11AV	16	2001 – 2007	3.5	890	10	13	13/16	81
11AY	4	2005 – 2006	0.98 J	1.5	10	0	0/4	0
11AZ	4	2005 – 2006	1.4	2.4	10	0	0/4	0
11A4	4	2006 – 2007	0.84 U	2.1	10	0	0/4	0
Downgradient Residential Wells along LCC, between Greenhorn Road and the Deposition Area								
11AF	12	1999 – 2004, 2006	0.89 J	1.9 J	10	0	0/12	0
11AJ	9	1999 – 2005	0.1 J	1 UJ	10	0	0/9	0
11AK	2	1999 – 2000	1.2	1.2	10	0	0/2	0
11AM	7	1999 – 2000, 2002, 2004, 2006	0.2 U	2 U	10	0	0/7	0
11AN	10	1999 – 2005	0.2 U	9.8	10	0	0/10	0

TABLE 6-1
Arsenic Concentrations in Residential Wells
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada County, California

Well	Total Number of Samples	Period of Years Samples Were Collected	Minimum Arsenic Concentration (µg/L)	Maximum Arsenic Concentration (µg/L)	Arsenic MCL (µg/L)	Number of Exceedances of MCL	Frequency of MCL Exceedances	Percent Exceedances of MCL
11AO	9	1999 – 2000, 2002-2005	0.28	1 UJ	10	0	0/9	0
11AQ	5	1999 – 2000, 2003-2004	0.25 U	1 U	10	0	0/5	0
11AX/11AX2	7	2004, 2006 – 2007	0.54 UJ	3.5[a]	10	0	0/7	0
11A1	4	2005 – 2006	0.24 J	1 U	10	0	0/4	0
Lost Lake/Deposition Area Residential Wells								
11AA	8	1999 – 2002, 2004 – 2005	0.09 UJ	1 U	10	0	0/8	0
11AB	9	1999 – 2000, 2002 – 2004, 2006	0.2 J	5 U	10	0	0/9	0
11AC	2	1999 – 2000	0.2 U	0.2 U	10	0	0/2	0
11AD	9	1999 – 2000, 2002 – 2004, 2006	0.1 U	0.6	10	0	0/9	0
11AE	9	1999 – 2005	0.1 U	1 U	10	0	0/9	0
11AG	8	1999 – 2000, 2002 – 2005	0.1 U	1 U	10	0	0/8	0
11AH	5	1999 – 2000, 2003 – 2004	0.1 U	1 U	10	0	0/5	0
11AI	9	1999 – 2005	0.1 U	1 UJ	10	0	0/9	0
11AP	7	1999 – 2004	0.2 U	5 U	10	0	0/7	0
11A2	4	2005 – 2006	1 U	1 U	10	0	0/4	0

[a]An anomalous result of 16.8, which is not considered representative of actual groundwater conditions, was excluded from this summary because it was from a stagnant water sample (see Section 4.0). The next highest arsenic concentration at this well is 3.5 µg/L.

Notes:

U = Analyte analyzed for, but not detected.

J = Estimated value.

UJ = Analyte not detected; detection limit is estimated concentration.

Summary data exclude field duplicate and split sample results.

None of the groundwater samples from residential wells in the Background Areas and the Lost Lake/Deposition Area exceed the MCL for arsenic. Three residential wells (Wells 11AL, 11AS, and 11AV) in the Downgradient Area (along LCC, below the mine and above Greenhorn Road) had many exceedances of the arsenic MCL. For Well 11AL, all 22 samples exceeded the MCL; the maximum detected concentration was 90 µg/L. For Well 11AS, 15 of the 16 samples collected exceeded the MCL; the maximum detected concentration was 270 µg/L. Thirteen of the 16 samples collected exceeded the MCL at Well 11AV; the maximum detected concentration was 890 µg/L.

All of the residential wells (Wells 10G, 10H, 10I, 10J, and 10N) in the Source Area and Mine Area had exceedances of the MCL. Nineteen of the 21 samples collected at Well 10G exceeded the MCL; the maximum detected concentration was 41 µg/L. At Well 10H, 15 of the 19 samples collected exceeded the MCL; the maximum detected concentration was 31.7 µg/L. For Wells 10I, 10J, and 10N, all samples (2, 5, and 12, respectively) exceeded the MCL. The maximum detected concentrations at these wells were 528, 56.8, and 54.7 µg/L, respectively.

In 2003, EPA installed in-home, under-sink treatment units to remove arsenic in the water from three of the residential wells within or near the Source Area and Mine Area (Wells 10G, 10H, and 11AL). These wells were actively used for domestic purposes and have exhibited elevated arsenic concentrations (above the MCL). Two other wells (Wells 10N and 11AV) also had elevated arsenic concentrations and had previously been equipped with treatment units by the residents. The residence supplied by Well 10H was demolished in 2006 as part of the OU-1 RA, and this system is no longer in operation.

At Wells 10G and 11AL, both untreated well water (from the wellhead) and treated water (from the treatment unit discharge) samples were collected during April 2006, October 2006, and March 2007. Sample results show that the treatment unit associated with Well 11AL was operating as intended at all sampling events for the guest house, but the 1Q07 sample (from the main house) exceeded the MCL for the first time. This treatment unit was serviced and the filter replaced. The treatment unit associated with Well 10G was working as intended during all sampling events, except for September 2005. The September 2005 sample from the Well 10G treatment unit indicated the treatment system needed maintenance. The required maintenance was performed and arsenic concentrations in the treated water returned to less than 0.55 µg/L.

SECTION 7.0

Summary and Conclusions

Mine-related contaminants have adversely impacted portions of the Site including downgradient areas along LCC and CC, extending through Lost Lake to LGC. Arsenic concentrations in groundwater and surface water at selected locations on and downgradient from the mine pose a threat to human health and the environment. The OU-2 RI was conducted to characterize Site conditions, estimate the nature and extent of groundwater contamination, support informed risk-management decisions regarding potential risks to human health caused by arsenic contamination in Site groundwater, and support preparation of the OU-2 FS. Data collected between 1999 and 2007 were used for these evaluations. OU-1 RA activities, which began at the Site in May 2006, affected the OU-2 RI evaluations by modifying the topography, changing surface water flow patterns and groundwater/surface water interactions, and removing part of the groundwater monitoring well network in the Source Area and Mine Area.

The Site has a water monitoring network that includes monitoring wells, piezometers, residential wells, and surface water sampling locations in the Background Areas, Source Area, Mine Area, Downgradient Area, and Lost Lake/Deposition Area. Groundwater quality (e.g., arsenic concentrations and general chemistry parameters), hydrogeologic information (e.g., geology, groundwater elevations, and aquifer properties), and hydrologic information (e.g., streamflow) were used to estimate the nature and extent of arsenic contamination, develop a groundwater CSM for the Site, and update the human health risk evaluation.

7.1 Site Physical Characteristics

The Site physical characteristics are summarized as follows:

- Annual precipitation is approximately 52 inches and average temperatures range from approximately 30°F in winter to 98°F in summer.
- LCC is the main surface-water drainage leading south, away from the mine. The upper reaches of LCC are seasonally dry; the creek becomes perennial at the base of the Rock Buttress with flows ranging from 0.1 to 155 ft^3/sec (45 to 70,000 gpm). LCC flows downstream from the Rock Buttress and merging with CC approximately 1 mile south of the Rock Buttress. CC flows into Lost Lake, which is contained by Lost Lake Dam. CC continues below Lost Lake to LGC, which joins GC and flows into Rollins Reservoir.
- The Site contains five main rock types, including mine deposits (waste rock and tailings overlaying basal gravel), Tvb unit, Cretaceous igneous intrusive rocks, JT_Rv unit rocks, and Pms unit. Groundwater occurs in primary pore spaces in the saturated overburden throughout the Site and in secondary openings (e.g., fissures, faults, and joints) of the consolidated and crystalline rocks of the Pms unit, which has a low hydraulic conductivity (10^{-5} to 10^{-6} cm/sec). Groundwater also occurs in the more permeable Tvb

unit that overlies the Pms unit north of the mine. Springs occur at the contact between the Tvb and Pms units.

- Groundwater flow is primarily from high topographic elevations (e.g., ridges) toward deep drainages, including LCC, CC, and LGC to the south-southeast. The regional groundwater table is a subtle expression of the land surface. Groundwater in the waste rock/tailings pile (Md unit) likely seeps beneath the Rock Buttress into the Pms unit and flows toward the LCC drainage. Groundwater flow also occurs in the basal gravel and fractured metasediment present at the contact between overburden material and bedrock throughout the Site, potentially creating a preferential flowpath along the contact. Groundwater flowing from northwest of Lost Lake likely discharges into the lake on the northwest shore of the northern lobe and seeps beneath Lost Lake Dam on the southern shore of the southern lobe.
- No long-term increasing or decreasing trends have been observed in groundwater levels at the Site, suggesting that the system is in a state of dynamic equilibrium.
- Vertical hydraulic gradients are generally downward in the waste rock/tailings pile (according to pre-OU-1 RA water levels) and the Deposition Area. In the Mine Area, vertical hydraulic gradients on the ridge above LCC alternate downward and upward at Well Pair 5K-S/5K-D and are consistently upward at Well Pair 5L-S/5L-D. Initial data indicate that CC seasonally alternates as a gaining or losing stream at Staff Gauge 14E. These observations and groundwater flow modeling results suggest that the groundwater table is located very near the bottom of the CC channel near Staff Gauge 14E.
- Surface water discharge was estimated by using crest gauges, manual flow measurements, and stream gauges. Surface water discharge is summarized as follows:
  - LCC upgradient from the mine (Locations 1J and 1U) typically goes dry by the end of June and flows again by early winter. A maximum flow of 45 ft^3/sec (20,200 gpm) was observed during a large winter storm.
  - The perennial adit (Location 3A) flow (Location 3A) ranges from 0.1 to 4 ft^3/sec (45 to 1,800 gpm); however flows are typically less than 0.5 ft^3/sec (225 gpm). The peak discharges were likely not coming from the adit but were the result of surface runoff directed to the pond at the adit discharge.
  - Perennial LCC flow downgradient from the Rock Buttress and upgradient from the confluence with CC (Locations 4A/4A2, 12B, and 12J) ranges from 0.1 to 155 ft^3/sec (45 to 70,000 gpm).
  - CC flow (Locations 2G, 14E, 19A, and 19B) ranges from less than 0.01 to 22 ft^3/sec (5 to 9,900 gpm). This range does not include any winter storm events.
  - LGC flow (Location 19M) ranges from 0.2 to 30 ft^3/sec (90 to 13,500 gpm). This range does not include any large winter storm events.

7.2 Nature and Extent of Contamination

The nature and extent of arsenic concentration in Site water is summarized as follows:

- Exceedances of the arsenic MCL (10 µg/L) occurred in the following locations:
  - Source Area and Mine Area groundwater and surface water (Wells 10G, 10H, 10I, 10J, 10N, 5A, 5D, 5E, 5I, 5J, 5K-S, 5L-S and 5L-D; Piezometers 5PZ-2 and 5PZ-3; and surface water monitoring Locations 3A, 3B, and 4A/4A2)
  - Downgradient Area residential Wells 11AL, 11AS, and 11AV (between the mine and Greenhorn Road) and LCC surface water (Location 125)
  - Deposition Area Wells 13Q and 13R (completed in tailings)
  - Bedrock Well 13T (additional samples are needed to confirm this exceedance)
  - LCC and CC surface water (Locations 12J and 14E)
  - Lost Lake and at the base of Lost Lake Dam (Locations 16B, 16C, and 19B)
- Background arsenic concentrations were low in surface water and groundwater (within the areas sampled), except in areas within the footprint of the mine workings. No discernible, steadily increasing or decreasing trend in arsenic concentrations is apparent in the data during the period of record.
- Surface water and groundwater arsenic concentrations in the Source Area and Mine Area are significantly higher than background concentrations and were usually above the MCL at Wells 10G, 10H, 10I, 10J, 10N, 5A, 5D, 5E, 5I, 5J, 5K-S, 5L-S, and 5L-D; Piezometers 5PZ-2 and 5PZ-3; and surface water monitoring Locations 3A, 3B, and 4A/4A2. The highest arsenic concentrations (greater than 100 µg/L) occurred in water discharging from the mine adit and in groundwater samples from wells screened within waste rock, tailings, or mine workings. Arsenic concentrations were typically lower in wells screened in bedrock on the ridges to the northwest, west, and southwest of the waste rock/tailings pile (less than 100 µg/L). Arsenic concentrations detected in the different geologic units in and below the waste rock/tailings pile (e.g., waste rock, tailings, basal gravel, and underlying bedrock) typically were similar to each other.
- Within the Downgradient Area, elevated arsenic concentrations (above the MCL) were detected in LCC surface water downstream from the mine and in groundwater samples from downgradient Wells 11AL, 11AS, and 11AV. Except for these locations, concentrations of arsenic in surface water and groundwater of the Downgradient Area are less than the MCL, similar to background concentrations.
- Elevated arsenic concentrations (above the MCL) in the Lost Lake/Deposition Area were limited to bedrock Well 13T and locations directly impacted by the tailings deposits. Additional samples are needed to confirm MCL exceedances at Well 13T. The locations directly impacted by the tailings deposits include the surface water in CC (Location 14E), groundwater within the tailings pile (Wells 13Q and 13R), surface water in Lost Lake (Locations 16B and 16C), and surface water at the base of Lost Lake Dam (Location 19B). Groundwater from residential wells and monitoring Well 13S, which are screened in the bedrock, had low arsenic concentrations (less than 6 µg/L).

7.3 Fate and Transport

The following sections summarize the sources, transport, and fate of arsenic in the study area.

7.3.1 Arsenic Sources

The OU-1 RA minimized the likelihood of further tailings migration from the Source Area by the construction of the Rock Buttress, surface water diversions, and the waste rock/ tailings pile cap. As part of the OU-1 RA, tailings deposits in LCC (south of the Rock Buttress and north of Greenhorn Road) were removed. The remaining known or suspected sources of arsenic contamination to groundwater include the following:

- Subsurface mine workings beneath the Mine Area.
- Waste rock and tailings in the Source Area. As part of the ongoing OU-1 RA, surface water from the adit and Rock Buttress drain will be treated, significantly reducing arsenic loading from this source.
- Tailings in the Deposition Area.
- Tailings deposits in LCC, CC, and Lost Lake. Future RAs in OU-3 will mitigate adverse impacts of tailings in these areas.
- Naturally occurring arsenic not associated with mining activities (from natural ore bodies).

7.3.2 Groundwater Flowpath Evaluation

The Lava Cap Mine Groundwater Flow Model was used to estimate groundwater flowpaths from mine-related sources. Groundwater particles were started in the model from three sets of locations, as follows:

- Flowpath Set 1 – surficial mine waste areas (tailings and waste rock piles in the Source Area, Lost Lake/Deposition Area, and along LCC and CC)
- Flowpath Set 2 – shallow mine workings (600 Drift Level and above)
- Flowpath Set 3 – deep mine workings (700 Drift Level and below)

The flowpath analysis does not predict arsenic concentrations at specific points along the groundwater flowpaths. Groundwater flow along localized fracture zones, groundwater use (pumping), potential subsurface ore bodies containing arsenic, geochemical reactions, adsorption, dilution, and travel times can affect arsenic concentrations along the groundwater flowpaths.

Results from the Flowpath Set 1 analysis suggest that shallow groundwater flow from beneath areas that have mine waste and tailings is confined to the Source Area; Mine Area; LCC, downstream from the mine; CC, downstream from the confluence with LCC; and the Lost Lake/Deposition Area. Shallow groundwater flow converges toward drainage channels. Shallow groundwater in the Source Area and Mine Area converges toward LCC; shallow groundwater in the Deposition Area converges toward LGC. The convergence of shallow groundwater flow limits the flowpath area from these source areas. Flowpaths from

surficial mine waste areas are shallow and discharge to springs or directly to stream channels after short travel distances. Only a few residential wells in the Mine Area (10-series wells), Downgradient Area (Wells 11AL and 11AU), and Lost Lake/Deposition Area (Wells 11AI and 11AE) appear to be within the potential area of Flowpath Set 1.

Results from the Flowpath Set 2 analysis suggest that groundwater from shallow mine workings (600 Drift Level and above) flows through portions of the subsurface beneath the Source Area, Mine Area, LCC, and a larger area west of these locations. Groundwater from the shallow mine workings is predicted to eventually discharge to LCC, CC, and LGC, exiting the CC watershed primarily as stream outflow in LGC. The potential area of Flowpath Set 2 includes two additional Downgradient Area residential wells that have elevated arsenic concentrations (Wells 11AS and 11AV) but also includes many wells that have very low arsenic concentrations. Groundwater samples collected from Monitoring Well Pairs 5K-S/5K-D and 5L-S/5L-D, located upgradient from residential Wells 11AS and 11AV, had detected arsenic concentrations above the MCL.

Results from the Flowpath Set 3 analysis suggest that groundwater from deep mine workings (700 Drift Level and below) flows through portions of the subsurface beneath the Source Area, Mine Area, LCC, and CC. Groundwater from the deep mine workings is predicted to eventually discharge to LGC and exit the CC watershed primarily as stream outflow. The potential area of Flowpath Set 3 also includes the same residential wells with elevated arsenic concentrations as Flowpath Set 2 plus several additional residential wells where low arsenic concentrations were detected. Most of the flowpaths from the deep mine workings would be much deeper than the residential wells in the area.

The combination of these three groundwater flowpath areas provides a conservative estimated geographic footprint of where groundwater could be flowing from known or potential mine-related arsenic sources. Uncertainty in these geographic areas increases with depth (i.e., the extent of the Flowpath Set 2 area has greater uncertainty than the Flowpath Set 1 area, and the Flowpath Set 3 area has greater uncertainty than the Flowpath Set 2 area) because the influence of topography on groundwater flow patterns lessens with increasing depth. Furthermore, limited data are available regarding the characteristics of the deep bedrock aquifer system. Additionally, geochemical processes that impact arsenic concentrations along flowpaths are not known; therefore, uncertainty regarding arsenic concentrations along flowpaths from source areas increases with increasing travel distance from the source areas.

7.3.3 Arsenic Geochemistry

Conclusions from the geochemistry analysis (e.g., general chemistry, trace metals, natural tracers, arsenic speciation, and stable isotopes) do not provide a clear indication of the influence of mine-related contamination on groundwater in the area. Other conclusions include the following:

- Groundwater in the area generally is a calcium-bicarbonate type with low TDS.
- Water samples from the Source Area have a more pronounced sulfate presence than most of the surrounding Site wells. This sulfate signature persists in downstream samples from LCC but does not appear to persist in groundwater away from the mine.

This suggests that the effect of mine-related contamination on local groundwater could be limited.

- Stable hydrogen and oxygen isotope signatures form a very tight range for all samples analyzed. This geochemical tool was not useful for identifying the effects of mine-related contamination on groundwater in residential wells.
- Arsenic speciation results show that elevated arsenic exists predominantly in the As(III) state, with a few exceptions. Initial speciation sampling results suggested a possible link between mine-related contamination and residential wells, but sampling in 2006 showed that speciation is variable and does not clearly indicate such a link.
- Groundwater chemical conditions downgradient from the Site generally indicate oxidizing conditions that favor the less mobile forms of arsenic. The abundance of iron oxide minerals in the aquifer matrix suggest a high capacity for the adsorption of arsenic, potentially limiting arsenic mobility in the aquifer.

7.3.4 Groundwater Arsenic Loading to Little Clipper Creek

After the arsenic concentration in water discharging from the mine adit and Rock Buttress drain is treated and reduced to 10 µg/L (as specified in the OU-1 ROD [EPA, 2004b]), other groundwater contributions of arsenic to LCC and arsenic-related chemical reactions in the creek (adsorption or precipitation) could increase or decrease downstream arsenic concentrations. Available data are insufficient to accurately forecast the effect of these processes on arsenic concentrations in LCC. If groundwater contributing to LCC has average arsenic concentrations higher than 10 µg/L, and if chemical reactions do not decrease the overall arsenic concentration in LCC, arsenic concentrations could increase downstream from the Rock Buttress because of the additional arsenic loading from groundwater discharge. However, if groundwater contributing to LCC has an average arsenic concentration less than 10 µg/L, arsenic concentrations in LCC surface water would be expected to remain below the MCL, assuming that all of the arsenic-contaminated tailings in and near the stream channel have been removed. After the OU-1 and OU-3 RAs, continued monitoring of LCC surface water arsenic concentrations and flow will be required to assess the impacts of these processes.

7.4 Human Health Risk Assessment

An update of the groundwater HHRA was prepared that compared residential well data to the arsenic MCL (10 µg/L). None of the groundwater samples from residential wells in the Background Areas and the Lost Lake/Deposition Area exceeded the MCL for arsenic. Groundwater samples from three residential wells (Wells 11AL, 11AS, and 11AV) in the Downgradient Area (along LCC, below the mine and above Greenhorn Road) exceeded the arsenic MCL. Groundwater samples from all of the residential wells in the Source Area and Mine Area (Wells 10G, 10H, 10I, 10J, and 10N) exceeded the MCL.

7.5 Recommendations

This report describes an evaluation of the groundwater system at and near the Site by using available data and a groundwater flow model that attempts to balance a reasonable level-of-effort scientific analysis with uncertainty in results. The Lava Cap Mine Groundwater Flow Model was constructed as a reconnaissance-level, steady-state numerical tool capable of simulating large-scale features and processes of the hydrologic system. The spatial distribution of aquifer properties and precipitation recharge simulated in the model are based on the results from past geologic and hydrologic studies, aquifer tests, local climate data, and professional judgment. Any numerical representation of an aquifer system is a simplification of the actual Site conditions. Some features of the hydrologic system and patterns of water use are not explicitly represented in the model. These features could be incorporated into future versions of the model to reduce the uncertainty associated with the model output. However, because of the complex nature of the bedrock aquifer system in the area, incorporation of additional complexity into the Lava Cap Mine Groundwater Flow Model might not significantly reduce uncertainty in the evaluations of remedial alternatives that will take place during the OU-2 FS. Despite this limitation, output from the current version of the Lava Cap Mine Groundwater Flow Model provides useful insights into long-term patterns of groundwater flow and arsenic pathways on a watershed and subwatershed scale.

Recommendations for additional data collection attempt to balance Site access, cost, and value for reducing uncertainty in future groundwater evaluations. The following are higher priority recommendations:

- Continue routine monitoring of all active residential wells that exceed the arsenic MCL (Wells 10G, 10H, 10N, 11AL, 11AS, and 11AV).
- Continue semiannual monitoring and maintenance of existing EPA-maintained residential well head treatment systems.
- Install stream weirs at (1) Location 12J on LCC, immediately upstream from the confluence with CC, (2) Location 19A, upstream from LGC, and (3) LGC, where it exits the watershed. Stream discharge measurements from these weirs would provide insights into the groundwater/surface-water interactions and water budget calculations for the watershed. These data would also provide additional constraints on aquifer property estimates for the Pms unit and improve the CSM and predictive capabilities of the Lava Cap Mine Groundwater Flow Model. Surface water samples should be collected at least quarterly from the new weir locations and from stream gauge Location 12B; the samples should be analyzed for total and dissolved arsenic for use in the mass load calculations.
- Collect at least two additional groundwater samples for dissolved arsenic from Well 13T to determine if the arsenic concentration in this well will stabilize below the MCL.
- Collect a surface water sample for total arsenic analysis from LGC, within the area projected to potentially have mine-impacted groundwater discharge (near elevation 2,350 feet msl). The travel times from the mine area to this LGC discharge location are likely extremely long (i.e., many hundreds of years).

- Continue bimonthly water level measurements through December 2008 in Site monitoring wells, piezometers, and staff gauges.
- Continue stream discharge monitoring through December 2008 to complete an annual cycle and to validate and correct existing streamflow data.

The following are lower priority recommendations:

- Resample the wells sampled in October 2006 for arsenic speciation to evaluate whether arsenic speciation trends are a result of field or laboratory quality control problems, seasonal fluctuations, or a combination of both.
- Install new monitoring wells in the Source Area to help evaluate how groundwater elevations and arsenic concentrations have changed as a result of the OU-1 RA.
- Perform depth-discrete groundwater sampling in Well 5L-D to determine the depth of the greatest arsenic concentrations. This information could aid in the placement of new monitoring wells as part of the OU-2 FS.
- Collect surface water samples from tributaries upstream from Lost Lake, LGC upstream from the confluence of CC, and LGC to verify the assumption of low arsenic concentrations in these waters.
- Perform a reach-specific stream discharge analysis in LCC between the Rock Buttress and Lost Lake (collect accurate stream discharge measurements with a current meter in LCC at several distances from the Rock Buttress). This should include sampling and analysis for total and dissolved arsenic in surface water at each discharge measurement location to help evaluate arsenic concentrations and groundwater/surface water interactions along LCC.
- Incorporate any new information into the Lava Cap Mine Groundwater Flow Model.

SECTION 8.0

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Appendix A
Analytical Data Summary

Appendix A is included on the CD-ROM provided with this report.

Appendix B
Field Parameter Data Summary

Appendix B is included on the CD-ROM provided with this report.

Appendix C
2005 and 2007 Monitoring Well Installations and Aquifer Testing

APPENDIX C

2005 and 2007 Monitoring Well Installations and Aquifer Testing

This appendix describes field procedures used for the OU-2 RI field investigations performed in 2005 and 2007 with emphasis on new monitoring well installations, a staff gauge installation, and aquifer testing. Procedures followed the associated field sampling plans (CH2M HILL, 2005a and 2006).

C.1 Monitoring Well Installations

To fill data gaps identified in 2005 (CH2M HILL, 2005b), CH2M HILL installed five new groundwater monitoring wells at the Lava Cap Mine site (Site). The work included installation, development, and aquifer testing as follows:

- A new shallow/deep monitoring well pair (Wells 5K-S/5K-D) between the mine and arsenic-impacted residential Wells 11AL, 11AS, and 11AV. Work was performed between May 25, 2005, and June 22, 2005.
- A new shallow/deep monitoring well pair (Wells 5L-S/5L-D) between the mine and arsenic-impacted residential Wells 11AL, 11AS, and 11AV. Work was performed between February 5, 2007, and March 15, 2007.
- A new deep monitoring well (Well 13T) and Clipper Creek (CC) Staff Gauge 14E adjacent to existing shallow Well 13R. Well 13T was installed between February 5, 2007, and March 15, 2007. Staff Gauge 14E was installed in December 2006.

The purpose of the Mine Area wells located between the mine site and Tensey Lane (Wells 5K-S/5K-D and 5L-S/5L-D) was to provide insight into potential sources of arsenic that might be causing elevated arsenic concentrations in Wells 11AL, 11AS, and 11AV. The deep well installed in the Lost Lake/Deposition Area (Well 13T) was co-located with existing shallow monitoring Well 13R and a new Staff Gauge 14E to monitor groundwater/surface water interactions in this area. Shallow/deep well pairs were used to estimate vertical hydraulic gradients and groundwater contaminant trends. These wells were installed during two drilling efforts in spring 2005 and winter 2007 using procedures described in the associated field sampling plans (CH2M HILL, 2005a and 2006).

C.1.1 Drilling

The first drilling effort (spring 2005) was performed by Diamond Well Drilling of Auburn, California; the second drilling effort (winter 2007) was performed by Water Development Corporation of Woodland, California. CH2M HILL provided construction oversight for both phases. Soil borings 5K-S and 5K-D were drilled with a Rotodrill Schramm T450 WS rig using the direct air rotary drilling method. The direct air rotary method involves the circulation of air down the drill string and out of the bit. Circulated air served as the

primary drilling fluid (to stabilize the borehole, prevent collapse, and remove cuttings from the borehole) for both soil borings. When the driller had difficultly removing cuttings from the borehole using only air, water or Hydrofoam®, or both were added to the drilling fluid. Hydrofoam® is an alcohol-based detergent used to increase the viscosity of the drilling fluid to facilitate removal of cuttings. Because of the difficulty in keeping the borehole open during the drilling of 5K-S, 11-inch-diameter steel conductor casing was advanced to 100 feet below ground surface (bgs) in both boreholes. Soil borings 5L-S, 5L-D, and 13T were drilled with a Star30K rig using the air rotary casing hammer (ARCH) method. The ARCH method is similar to the direct air rotary method; it uses the circulation of air down the drill string to remove cuttings; however, ARCH also incorporates driving outer steel casing via a pneumatic hammer in advance of the drill string to maintain an open borehole to the desired depth.

Soil samples were visually inspected by the CH2M HILL field geologist/engineer. These samples were collected at approximately 5-foot depth intervals and when a noticeable change in lithology was indicated by the driller. Soil borings were logged in accordance with instructions in the OU-2 FSP. Soil boring logs are presented in Appendix D. Total depths of the soil borings are presented in Table 2-2 of the main text.

C.1.2 Well Installation

After the desired drilling depth was achieved, preparations were made for the construction of the monitoring wells. Four of the wells (Well Pairs 5K-S/5K-D and 5L-S/5L-D) were constructed as shallow/deep well pairs. Well 13T was designed and located to be the deep well in a shallow/deep well pair with Well 13R (existing shallow well). The objective of the well design was to allow evaluation of the difference in both hydraulic properties and arsenic contamination with depth. Two of the deep wells, Wells 5K-D and 5L-D, were designed as open-hole bedrock monitoring wells. An approximately 10- to 11.75-inch borehole was advanced to approximately 170 and 143 feet bgs at Wells 5K-D and 5L-D, respectively. After the desired depth was achieved, 6-inch-inner-diameter mild steel blank casing was installed. Approximately 20-foot lengths of blank casing were connected using a butt-weld. Mild steel centralizers (consisting of four mild steel rods welded to the casing at 90 degrees) were installed approximately every 50 feet on the monitoring Well 5K-D casing. After the blank casing was installed, it was grouted in place using a combination of cement and bentonite chips. Cement was installed using a tremie pipe. Significant void space was observed during the grouting of Well 5K-D, as evidenced by the loss of cement slurry to the formation. It was necessary to use hydrated medium bentonite chips to overcome the loss of slurry to the formation. A cement seal was installed from 25 feet bgs to ground surface at this location. Approximately 3 feet of bentonite chips were placed from approximately 143 to 140 feet bgs at Well 5L-D. A cement-bentonite slurry was then used to grout the well from approximately 140 feet bgs to ground surface. After grouting of the blank casing at Wells 5K-D and 5L-D, 6-inch-diameter boreholes were drilled below the blank casing to depths of approximately 221 and 220 feet bgs, respectively.

Procedures used during the installation of the 4-inch-diameter monitoring wells (Wells 5K-S, 5L-S, and 13-T) were generally as follows: a 6-inch-long polyvinyl chloride (PVC), threaded endcap was fitted to a 5-foot-long section of blank 4-inch-inner diameter, schedule 40 PVC well casing (serving as the well sump) for Well 5K-S. Wells 5L-S and 13T

were constructed with only a 6-inch-long PVC endcap threaded onto the bottom of the well screen (no sump). Screen length design varied among the three monitoring wells. Twenty feet of schedule 40 PVC well screen (40-slot) were installed at Well 5K-S. Thirty feet of 0.02-inch aperture (20-slot) schedule 40 PVC well screen were installed from 30 to 60 feet bgs at Well 5L-S. A 10-foot length of factory-slotted 0.04-inch aperture (40-slot) schedule 40 PVC well screen was installed from 65 to 75 feet bgs at Well 13T. Because the total borehole depth at this location was 70 feet bgs, 10 feet of medium bentonite chips were installed prior to well construction. Well screen and blank schedule 40 PVC were threaded together at the surface and inserted into the borehole (which was being supported with the steel conductor casing) with the aid of the drilling rig until the desired total well depth was achieved with the well screen located at the desired depth interval. Well screen intervals were placed using information from the soil samples (drill cuttings) collected during drilling at each soil boring location. As the casing material was threaded together and lowered into the borehole, stainless steel centralizers were installed onto the PVC casing at 10-foot intervals to ensure the plumbness of the PVC casing within each borehole.

With the PVC well suspended in the hole at the desired depth, a filter pack of 8x16 (Well 5K-S) and 8-mesh (Wells 5L-S and 13-T) sand (SRI Supreme) was installed from the bottom of the soil boring to approximately 2 to 13 feet above the PVC well screen within the annular space between the PVC casing/well screen and the borehole wall. After the desired height of filter pack was achieved, wells were swabbed to settle the sand. Additional filter pack sand was added as needed to raise the level back to the desired height. After the filter pack sand was installed, approximately 2 to 4 feet of RMC Pacific Materials #2/16 transition sand was installed above the filter pack in the annular space at Wells 13T and 5K-S, respectively. No transition sand was installed at Well 5L-S. After the filter pack and transition sand was in place, the steel conductor casing was gradually removed, leaving the filter pack material as the formation stabilizer outside of the suspended PVC casing.

After installation of the filter pack and transition sand, a seal consisting of hydrated medium bentonite chips was installed at each well location. Seal thickness ranged from 2.5 feet at Well 5L-S to 4 feet at Well 13T. Because of the difficulty in grouting Well 5K-D, hydrated, medium bentonite chips were placed from approximately 18- to 88-feet bgs at Well 5K-S. A cement-bentonite slurry was installed above the bentonite chips at each well location to provide a surface seal in the upper section of the well.

The aboveground wellhead completions consisted of 8- to 12-inch-diameter steel stovepipe and a locking lid. Concrete pads (approximately 4-foot square and 4 inches above grade) were constructed to secure the well housing. A summary of well construction details is presented in Table 2-3 of the *OU-2 Remedial Investigation Report* (RI Report). Well completion diagrams are provided in Appendix E. Location and construction information for all site monitoring wells, piezometers, residential wells, and surface water sampling locations are provided in Appendix F.

C.1.3 Well Development

After completion of well construction, each monitoring well was developed. The purpose of well development was to consolidate and stabilize the filter pack by removing soil debris from the well screen opening or open borehole interval, to create an effective filter zone between the aquifer and well screen/open interval. Wells were developed by a combination

of surging, swabbing, bailing, and pumping until the purge water was clear and field parameters stabilized.

The first step in development of the monitoring wells was to measure the static groundwater level and total depth of each well. The initial (heavy) well development of Wells 5K-S and 5K-D was performed using the drill rig. The wells were purged by air-lift pumping until field parameters (pH, temperature, and electrical conductivity) stabilized and turbidity was within a 10 nephelometric turbidity unit (NTU) range, if possible. Flow rates were measured periodically by recording the time necessary to fill a vessel of known volume (manual measurement). Initial development of Wells 5L-S, 5L-D, and 13T was accomplished by swabbing and bailing. Heavy development continued until approximately 30 to 60 gallons were bailed from the wells.

After the initial well development, constant rate pumping tests were performed at all new monitoring wells, except Well 5L-S. This well pumped dry after 5 to 10 minutes during well development. A submersible pump was used to purge each of the four other wells at a constant rate for up to 4 hours or until the rate of drawdown stabilized. Problems with equipment were encountered during the test at Well 5K-S; therefore, the pumping duration for this test was 1 hour. The initial flow rates for the aquifer tests were based on the observations made during heavy development. Throughout the test, groundwater levels (in both the pumping and nearby monitoring wells), pumping rates, and field parameters were recorded. Recovery of groundwater levels were recorded in both wells until measurements were within approximately 10 percent of the initial depth to water. A more detailed description of the short-term aquifer testing is presented in Section C.2.

C.1.4 Investigation-derived Waste Management

Wastes generated during drilling, well construction, and well development activities included soil cuttings and purge water. During the drilling and construction of Wells 5K-S and 5K-D, an approximately 550-cubic-foot pit was excavated before drilling for the storage of solid investigation-derived waste (IDW). A 4-inch-diameter PVC discharge line (approximately 300 feet long) was installed from the pit downhill to two temporary storage tanks along the access road, approximately 100 feet north of the Tensey Lane gate. The 4,500-gallon tanks were plumbed together to drain purge water and cuttings from the pit.

During the drilling and construction of Wells 5L-S and 5L-D, an onsite solid IDW storage area for soil cuttings was designated by the property owner. Soil cuttings and purge water were collected beneath the drill rig cyclone in a 3-cubic-yard hopper. The liquid IDW was pumped off of the top of the hopper through approximately 500 feet of flexible fire hose to the 5,000-gallon storage tanks on the access road. The soil cuttings left in the hopper after evacuating the liquid waste were transported via forklift to the solid IDW storage area and later spread on the ground.

After completion of the drilling program, the cuttings were spread onto the ground to restore pre-drilling site conditions. Drill cuttings and purge water from drilling activities at Well 13T were applied directly during drilling operations. The discharge lines and hose were disassembled and transported offsite. A composite sample was collected from each of the liquid IDW storage tanks. Because of the analytical results from these samples, it was

necessary to transport the contents of one tank to a treatment facility. The tank with arsenic concentrations below the maximum contaminant level were drained onsite.

C.1.5 Staff Gauge Installation

In December 2006 Staff Gauge 14E was installed in CC in the Lost Lake/Deposition Area (see the RI Report, Figure 1-8). The staff gauge is a 4-inch-wide by approximately 6.5-foot-long iron gauge coated with porcelain to minimize rusting and discoloration. The staff gauge is graduated in 0.02-foot increments. Installation involved driving a fencepost 3.5 to 4 feet vertically into the streambed and cementing it in place. The staff gauge was then attached to the fencepost with screws and cable ties. The 3.2-foot graduation on the staff gauge was surveyed in April 2007 to provide vertical control. The device is not a continuous recording station; measurements of stream stage are collected periodically by manually recording the height of surface water. These measurements are then correlated to the surveyed vertical datum to calculate the elevation of the surface water. Figure 3-11 of the RI Report presents a plot of stream stage elevations over time at this location. Staff Gauge 14E is adjacent to the shallow/deep well pair 13R/13T. Surface water elevation data from this staff gauge can be used to evaluate the potential interaction between the surface water and groundwater systems in this area.

C.2 Aquifer Testing

To refine estimates of hydraulic properties for the Site, several short-term aquifer tests (pumping tests) were conducted at residential and monitoring wells. The types of aquifer testing performed at the site include the following:

- **Short-term aquifer testing during well sampling**. Hydraulic data, including flow rates and water level measurements, were collected from residential and monitoring wells during the quarterly groundwater monitoring event in September 2004. These data were used to estimate aquifer transmissivity near the wells. Figures C-1A through C-1C present drawdown versus time plots for these tests (all figures are located at the end of this appendix).
- **Short-term aquifer testing at the end of well development.** Constant-rate pumping tests were performed during the final stages of well development at Wells 5K-S, 5K-D, 5L-D, and 13T as previously described. Data from these tests were used to estimate the horizontal and vertical aquifer properties near the shallow/deep well pairs. Figure C-2 presents drawdown versus time plots for these tests.
- **Short-term aquifer testing to evaluate unexpected low well yields.** During the OU-1 remedial activities at the Site in 2006, LCC surface water was diverted to below Greenhorn Road. Additionally, LCC was lined with fine-grained materials in June 2006. During this time, residents along Tensey Lane began reporting diminished well yields (Wells 11A4, 11AT, and 11AU). To evaluate whether or not the decrease in well yields was caused by decreases in stream flow, short-term aquifer tests were performed at the impacted wells in August 2006 during construction activities, and again in March 2007, after water to LCC had been restored. Water levels drew down to the pump intakes quickly and the presence of wires, pipes, and pumps in the wells made measuring the

depth to water difficult. In some cases, pumping rates could not be determined or stable drawdown levels were not achieved; therefore, specific capacity values were not calculated for these wells.

The methodology for the short-term aquifer testing during well sampling and at the end of well development was generally as follows:

- Measurement of the static depth to water in the pumping well and nearby monitoring wells.
- Installation of a temporary pump (either submersible or peristaltic) in monitoring wells. The dedicated pumps installed in residential wells were used during aquifer testing at those locations.
- Collection of frequent measurements of depth to water and flow rate when the pumps were started. Manual flow rates were estimated during all of the tests by recording the time necessary to fill a vessel of known volume. Totalizing flow meters were used as a second method of estimating flow rates during aquifer testing at Wells 5K-S, 5K-D, 5L-D, and 13T.
- After the rate of drawdown in the pumping well had stabilized or groundwater samples had been collected, the pump was stopped and water level recovery was monitored.

Hydraulic data from the pumping tests were used to estimate aquifer properties near the wells using analytical and graphical methods. These data are summarized in Table C-1. Drawdown data from the pumping well was used to calculate the specific capacity by dividing the average pumping rate by the maximum drawdown during pumping. The specific capacity provides a measure of a well's ability to yield water and can be used to estimate aquifer transmissivity as shown in Equation 1 (Driscoll, 1986):

$$T = Sc * 2000 * 0.1337 \quad (1)$$

Where:

T = aquifer transmissivity (square foot per day [ft^2/day])
Sc = specific capacity (gallons per minute per foot [gpm/ft])

Transmissivity was also calculated using a graphical method (called the Cooper-Jacob Straight-line Method (Cooper and Jacob, 1946). This analysis was used for recovery data and involves constructing a semi-log plot of time (normalized time for recovery) versus recovery data and calculating aquifer transmissivity as shown in Equation 2:

$$T = 264 * Q / \Delta s \quad (2)$$

Where:

T = aquifer transmissivity (gallons per day per foot)
Q = pumping rate (gpm)
Δs = slope of the recovery curve over one-log cycle

TABLE C-1
Summary of Lava Cap Mine Site Aquifer Tests
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Well	Date	Duration of Pumping (minutes)	Average Pumping Rate (gpm)	Maximum Drawdown (feet)	Specific Capacity (gpm/ft)	Estimated Transmissivity (ft^2/d)	Material Screened In
10H	9/30/2004	40	9.66	19.45	0.50	132.8[a] – 681.9[b]	Metasediments
11AG	9/30/2004	14	6.2	0.38	16.3	1,215.7[b] – 4,363[a]	Metasediments
11AI	9/30/2004	10	N/A	13.8	Not determined	Not determined	Metasediments
13Q	9/29/2004	35	0.16	0.36	0.44	118.8[a]	Tailings
13R	9/29/2004	33	0.17	0.6	0.28	75.8[a]	Tailings
13S	9/29/2004	33	0.15	1.33	0.11	30.2[a]	Metasediments
13T	3/14/2007	107	6.00	33.32	0.18	48.1[a] – 211.8[b]	Metasediments
1B	9/28/2004	36	0.76	34.07	0.02	1.53[b] – 6.0[a]	Metasediments
1R	9/28/2004	60	0.69	7.38	0.09	3.14[b] – 25.0[a]	Metasediments
5A	9/27/2004	60	0.17	0.55	0.31	82.6[a] – 300[b]	Tailings/metasediment
5D	9/27/2004	41	0.14	0	Not determined	Not determined	Basal gravel
5E	9/27/2004	44	0.16	0.17	0.94	251.7[a]	Basal gravel
5I	9/27/2004	60	0.14	1.15	0.12	32.6[a] – 32.9[b]	Metasediments
5J	9/27/2004	64	0.03	3.6	0.01	0.16[b] – 2.20[a]	Weathered metasediments
5K-D	6/21/2005	240	1.95	31.92	0.06	8.60[b] – 16.3[a]	Metasediments
5K-S	6/22/2005	76	2.07	52.46	0.04	2.71[b] – 10.6[a]	Overburden
5K-S	6/22/2005	55	1.03	26.51	0.04	5.19[b] – 10.4[a]	Overburden
5L-D	2/27/2004	214	4.00	47.6	0.08	12.83[b] – 22.5[a]	Metasediments
5PZ-2	9/29/2004	33	0.16	0.87	0.18	49.2[a]	Tailings
5PZ-3	9/28/2004	60	0.15	5.28	0.03	7.60[a]	Tailings

[a]Specific Capacity Method

[b]Cooper-Jacob Straight-line Method

Note:
Estimates of aquifer properties by the methods above will overestimate transmissivity and well yield because of the short duration of the tests.

Use of this equation assumes the following:

- The aquifer is confined
- All geologic formations are horizontal and infinite
- The potentiometric surface of the aquifer is horizontal prior to pumping
- The potentiometric surface of the aquifer is not changing when pumping starts
- All changes in the potentiometric surface of the aquifer are due to pumping
- The aquifer is homogeneous and isotropic
- All flow is radial
- Groundwater flow is horizontal
- Darcy's Law is valid
- Groundwater has constant density and viscosity
- The pumping well is screened over the entire length of the aquifer
- The pumping well is 100 percent efficient and has an infinitesimal diameter
- The well is pumped at a constant rate

The final step in the aquifer test analysis, for the post-well development tests at Wells 5K-S, 5K-D, 5L-D, and 13T, was to estimate the hydraulic properties using the MLU (Multi-layer Unsteady-state) computer program (Hemker and de Boer, 2002). This software simultaneously fits the time-series of drawdown measured in the observation well during the drawdown and recovery phases of an aquifer test. MLU allows the user to fix or optimize the transmissivity, vertical conductance between layers (horizontal to vertical hydraulic conductivity ratio), and storage coefficient of each aquifer or aquitard in the simulation. For the well pair (Wells 5K-S/5K-D), where there were two aquifer tests, the analysis was iterative. When a good match between simulated and observed data was achieved for one of the tests, those data were used as input for the second test. Parameters were adjusted until an acceptable match between simulated and observed data was achieved for both tests. Simulated versus observed drawdown curves are presented on Figure C-3. Final MLU parameters are listed in Table C-2.

TABLE C-2
Summary of MLU Analysis
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Pumping Well Name	Observation Well Name	Radial Distance From Pumping Well (feet)	Number of Simulated Layers	Range in Simulated Transmissivity (ft^2/d)	Range in Simulated Kh:Kv
5K-D	5K-S	33	4	2 – 5	0.86 – 2.26
5K-S	5K-D	33	4	2 – 5	0.86 – 2.26
5L-D	5L-S	40.8	2	20 – 50	54.3
13T	13R	20	2	35 – 50	1.5 – 444

Note:
Kh:Kv = ratio of horizontal hydraulic conductivity (Kh) to vertical hydraulic conductivity (Kv)

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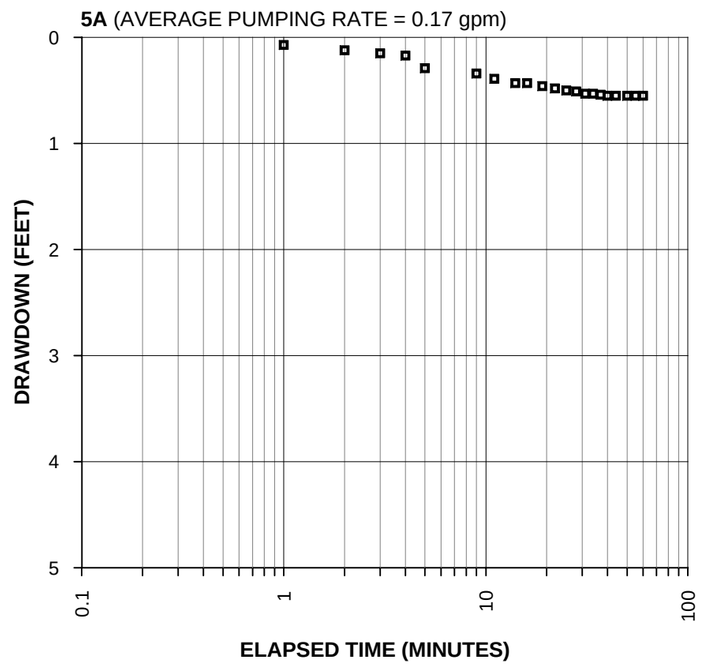
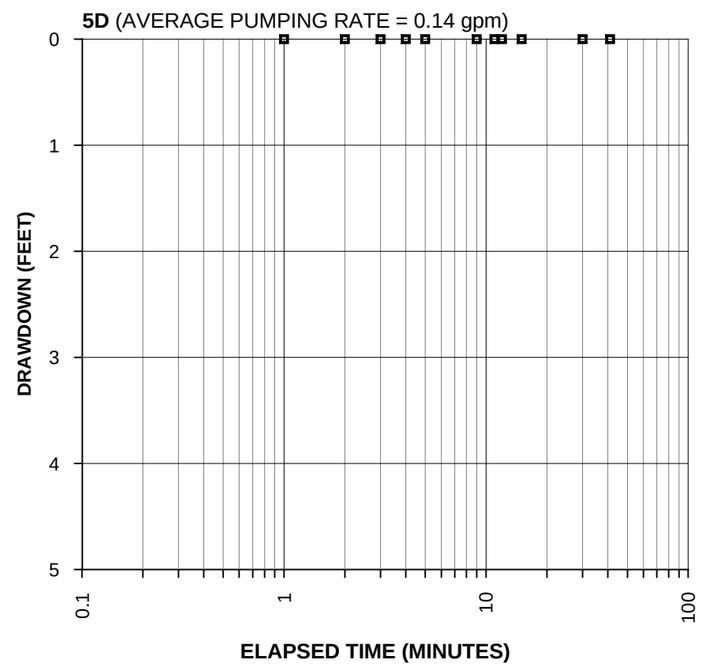
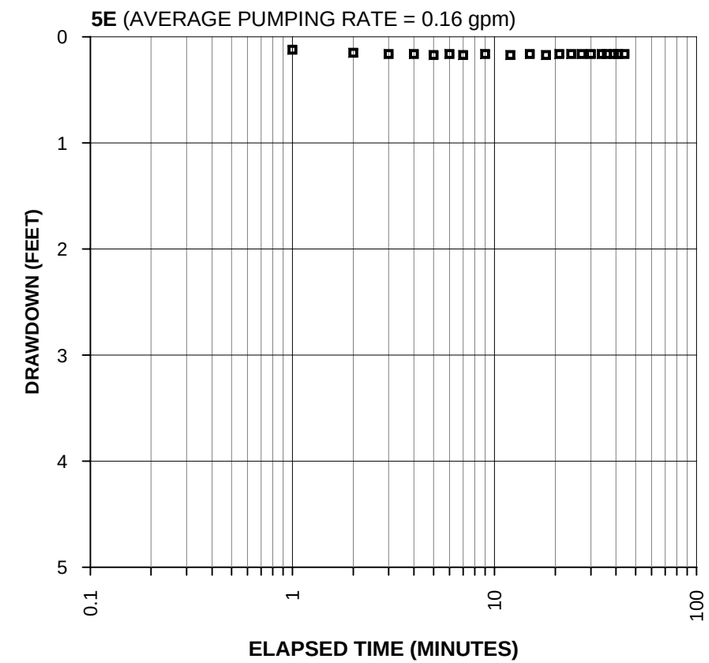
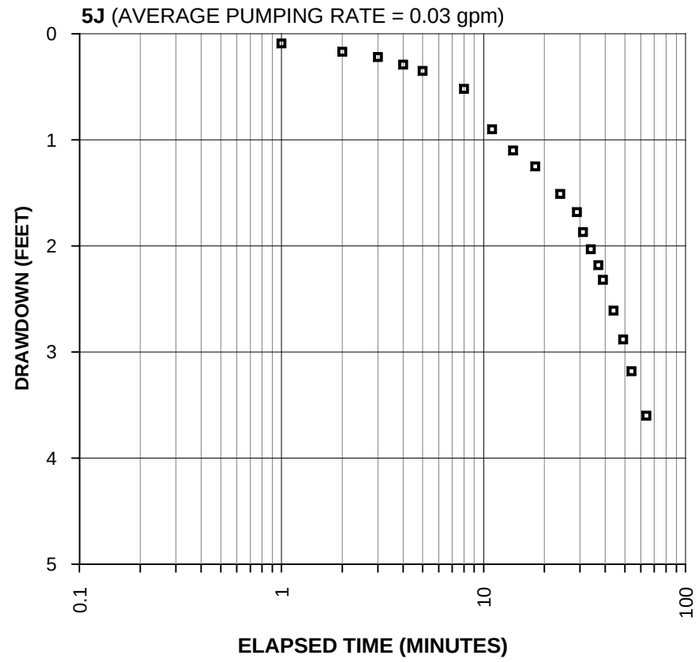








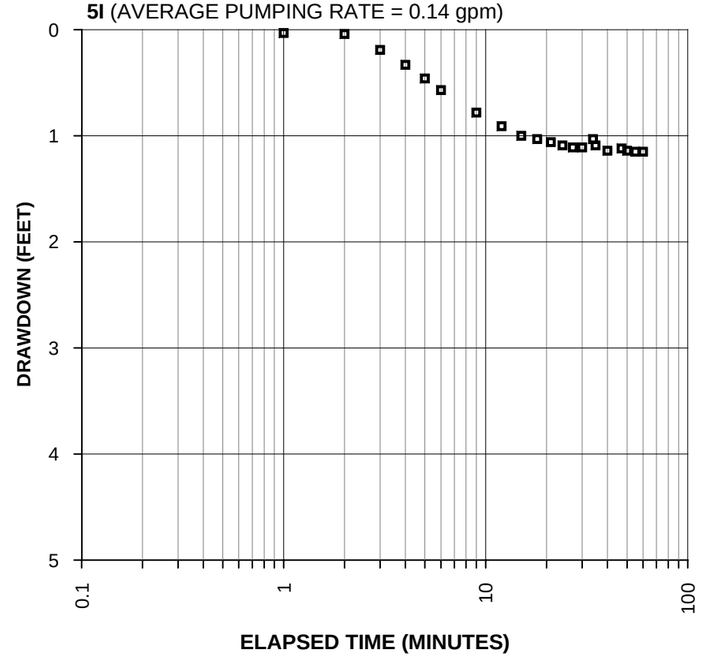
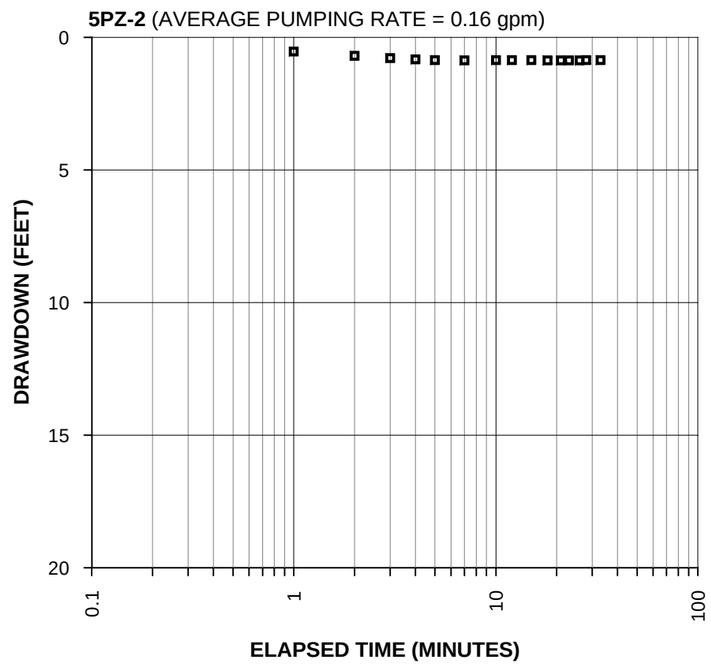
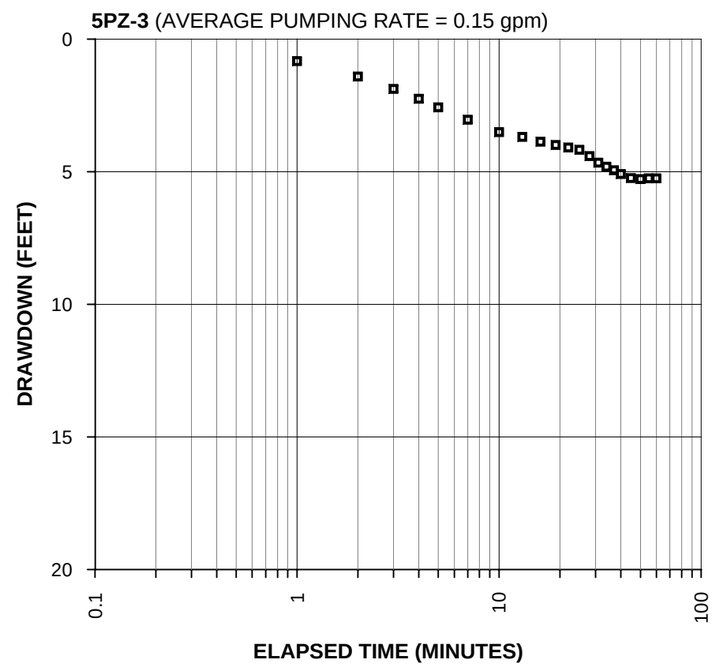
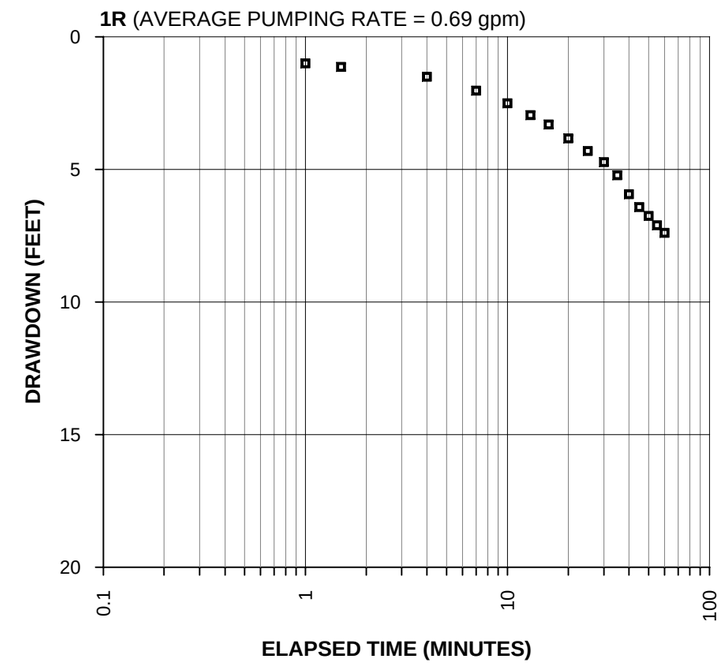
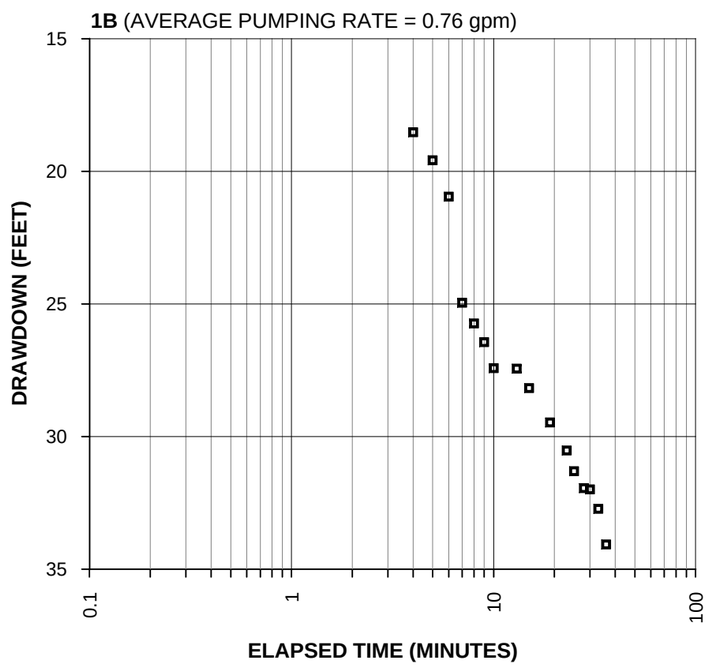


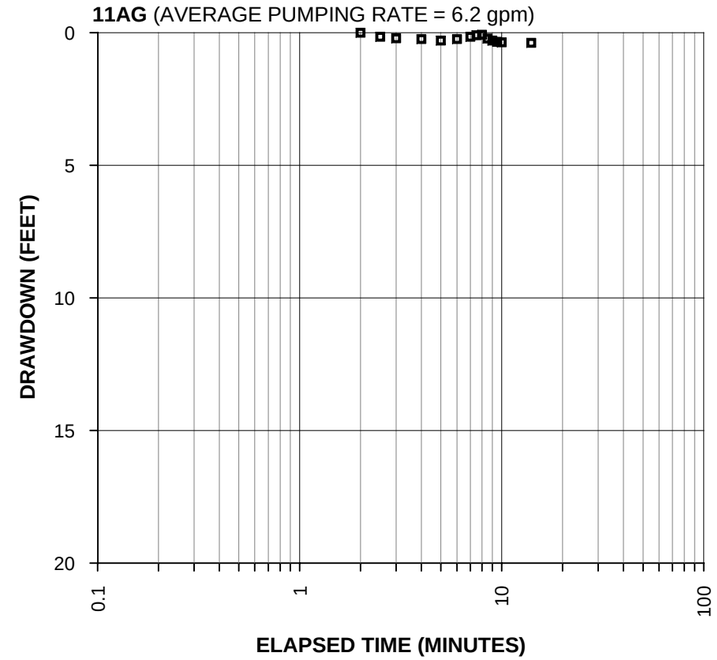
FIGURE C-1 (PAGE 1 of 3)
TIME VERSUS DRAWDOWN FOR WELL SAMPLING AQUIFER TESTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE











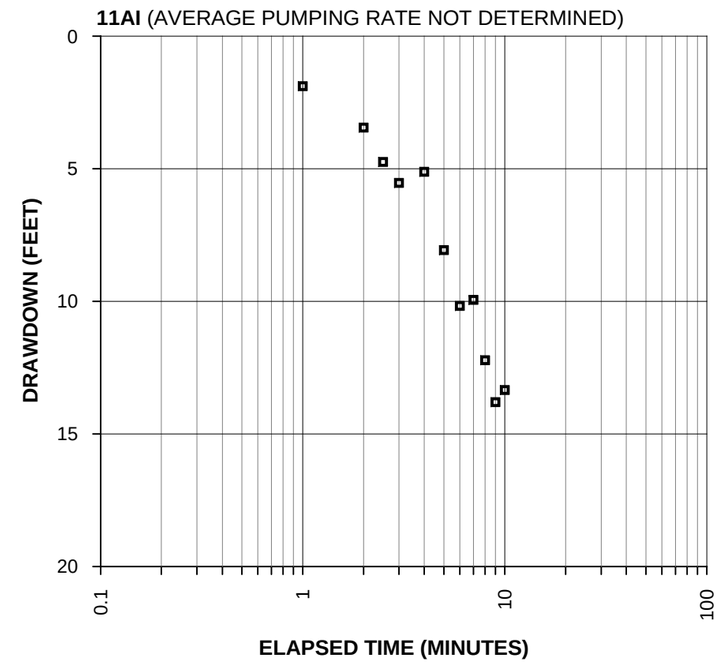
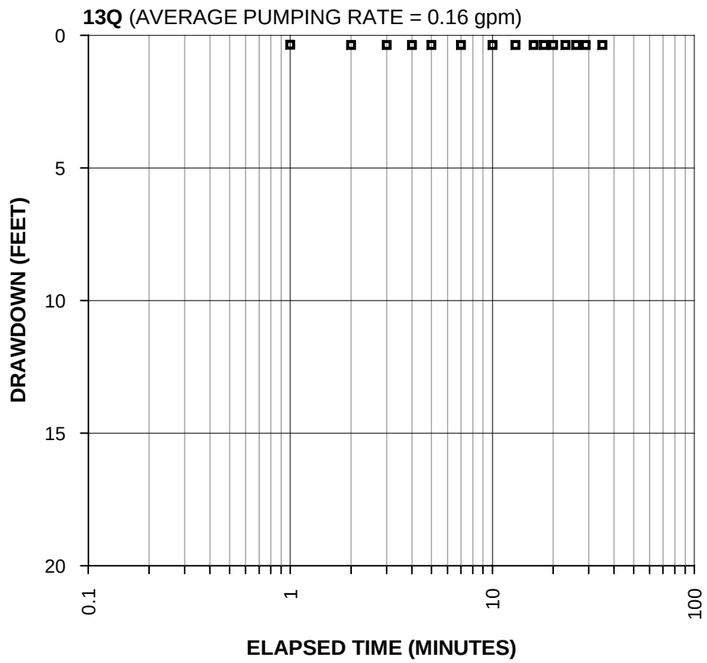
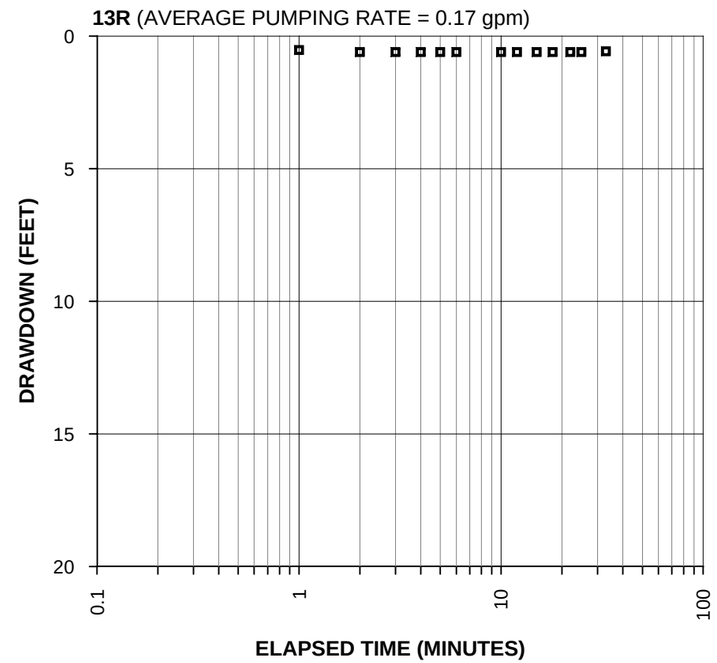
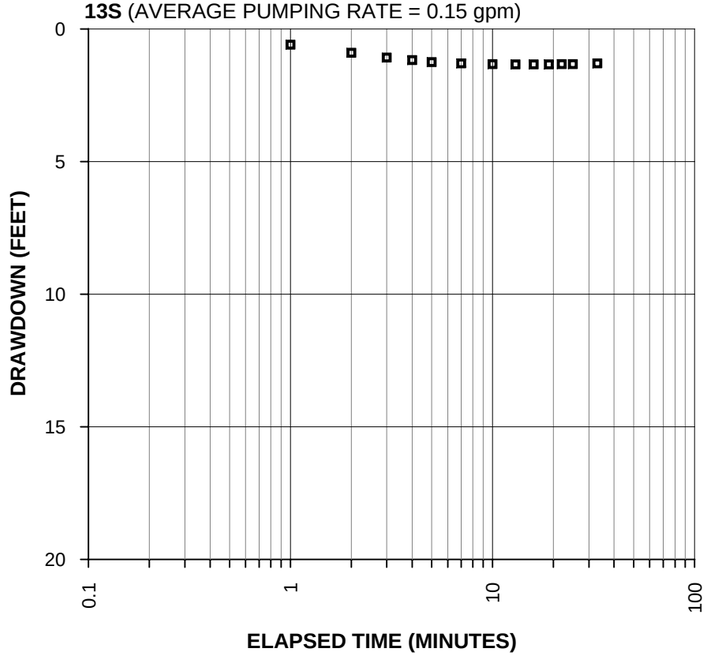


FIGURE C-1 (PAGE 2 of 3)
TIME VERSUS DRAWDOWN FOR WELL SAMPLING AQUIFER TESTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE







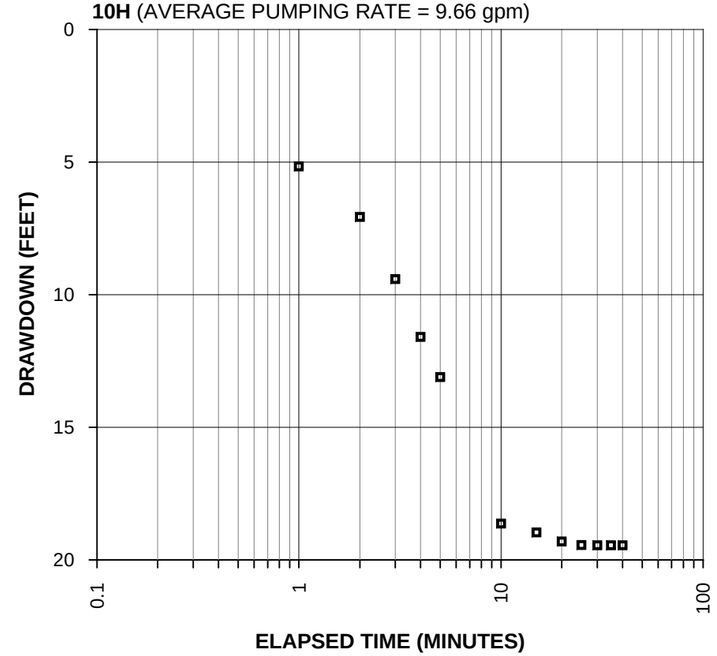


FIGURE C-1 (PAGE 3 of 3)
TIME VERSUS DRAWDOWN FOR
WELL SAMPLING AQUIFER TESTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

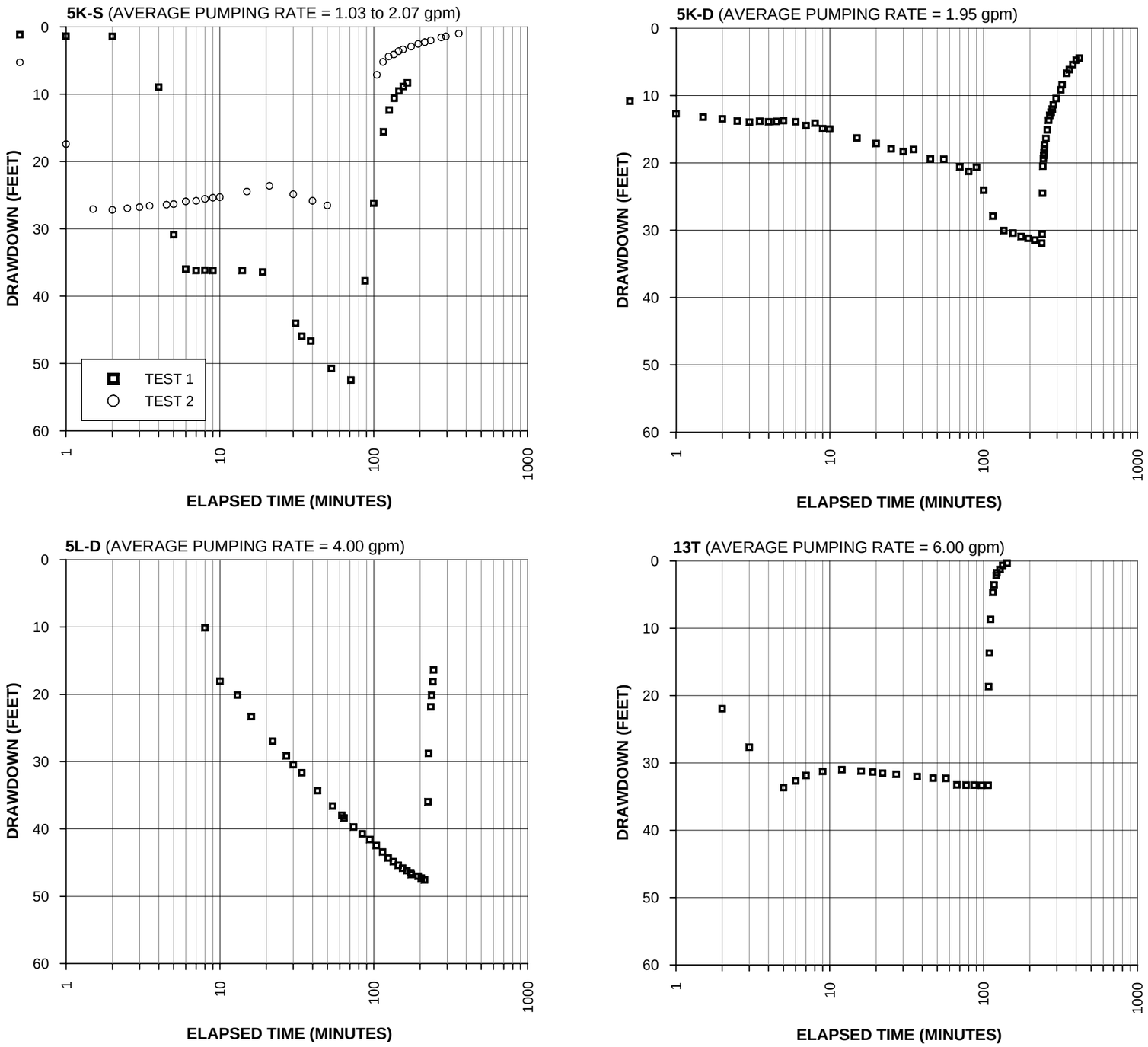
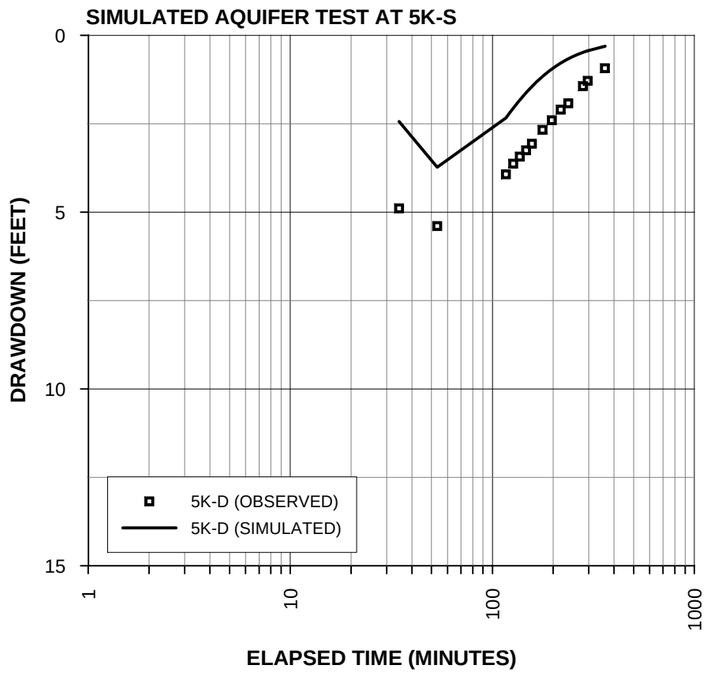
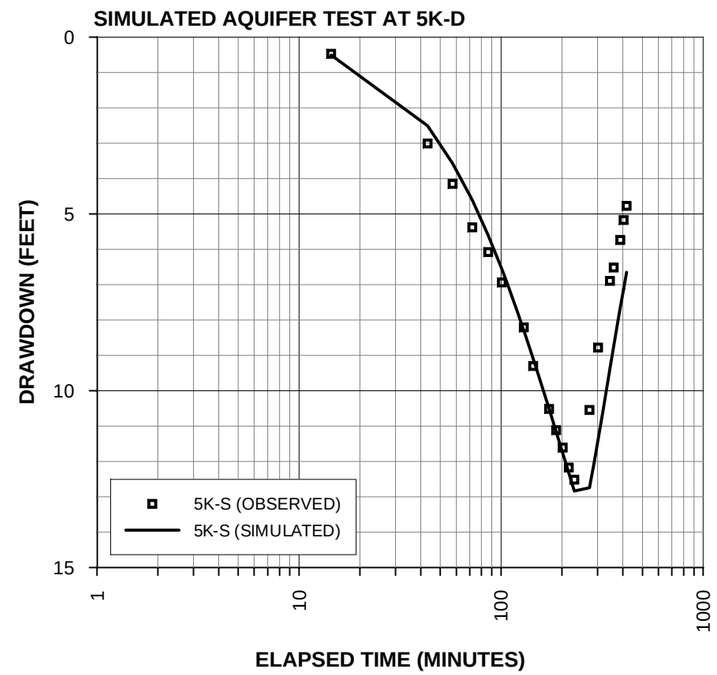
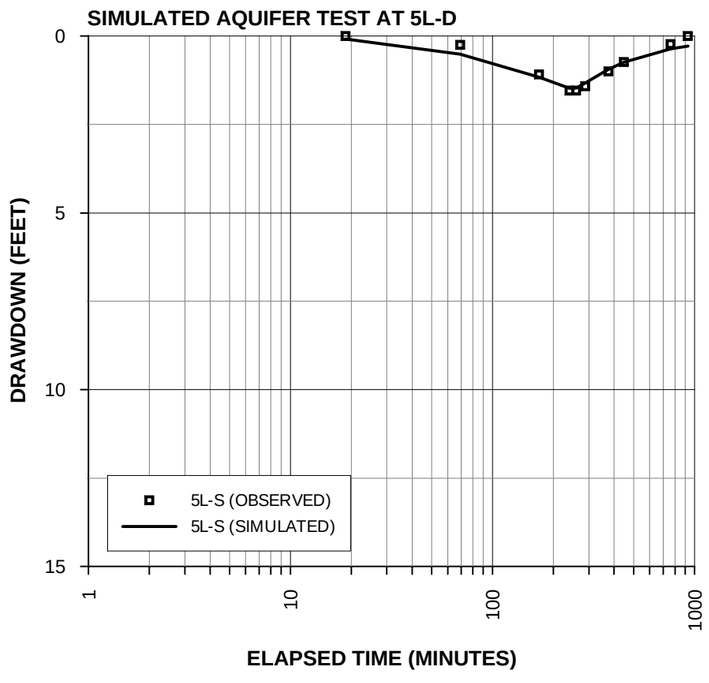


FIGURE C-2
DRAWDOWN OVER TIME FOR
POST WELL DEVELOPMENT AQUIFER TESTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE







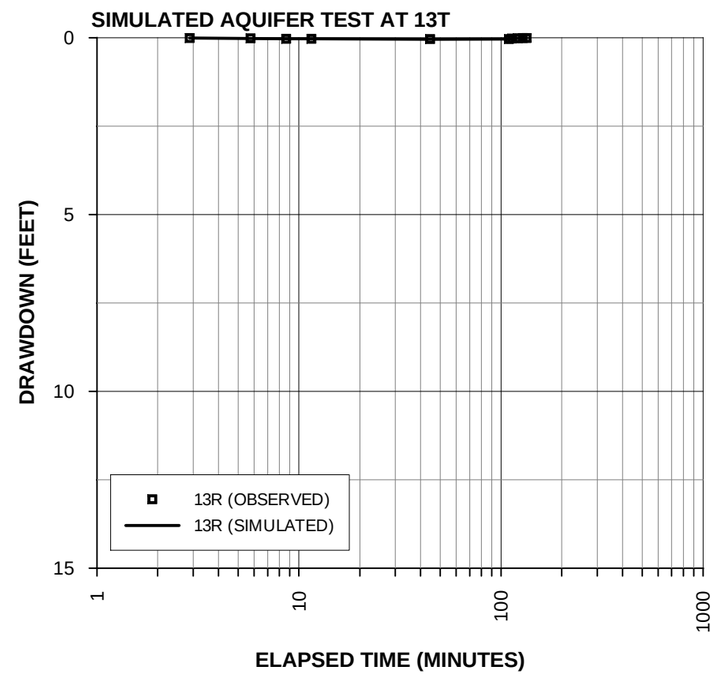


FIGURE C-3
SIMULATED VERSUS OBSERVED DRAWDOWN FOR MLU RESULTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

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Appendix D
Soil Boring Logs

Appendix D is included on the CD-ROM provided with this report.

Appendix E
Well Construction Diagrams

Appendix E is included on the CD-ROM provided with this report.

Appendix F
Sampling Location Information

Appendix F is included on the CD-ROM provided with this report.

Appendix G
Groundwater Flow Model Documentation

APPENDIX G

Groundwater Flow Model Documentation

This appendix describes the numerical groundwater flow model that was developed to aid in hydrologic evaluations at the Lava Cap Mine Superfund Site (Site) located in Nevada City, California. Information presented in this appendix follows the guidelines described in the *Standard Guide for Documenting a Ground-Water Flow Model Application* (American Society for Testing and Materials, 2006).

G.1 Introduction

Arsenic is present in groundwater at monitoring wells and some residential wells at the Site and in surrounding areas. The locations where arsenic concentrations in groundwater are elevated tend to coincide with locations where elevated concentrations of arsenic occur in soils, sediments, and surface water. However, this pattern is not consistent at all monitoring and residential wells. Because of the complexity of the hydrogeologic system, the source and subsurface migration pathways of arsenic cannot be determined from the available analytical and groundwater level data. The lack of information on three-dimensional groundwater flow directions and rates, subsurface ore bodies containing arsenic located outside of the Site, and the presence and geometry of faults limits the understanding of how arsenic migrates through the groundwater system. In 2004, CH2M HILL created the Lava Cap Mine Groundwater Flow Model as a reconnaissance-level numerical tool capable of simulating large-scale features and processes of the hydrologic system.

G.1.1 Modeling Objectives

The objectives of developing the Lava Cap Mine Groundwater Flow Model include the following:

- Refine the conceptual site model (CSM) with respect to areas of groundwater recharge and discharge, groundwater elevations, groundwater flow pathways, and source areas of arsenic.
- Gain insights into groundwater flow rates and patterns, the transport of arsenic from historical mining areas, and potential ongoing releases from arsenic-impacted areas at the Site and surrounding areas.
- Gain insights into groundwater/surface-water interactions.
- Help identify data gaps related to groundwater flow and arsenic transport.
- Help select new monitoring locations where water samples could be collected to fill data gaps.
- Forecast potential impacts of implementing different remedial action (RA) alternatives that will be evaluated during the feasibility study, which will follow this remedial

investigation (RI). Modeling output and projected costs will be compared to forecast the cost-benefit of implementing different RA alternatives.

G.1.2 Model Function

The Lava Cap Mine Groundwater Flow Model was developed to evaluate the groundwater system under steady-state conditions. Steady-state models simulate groundwater inflow rates that are equal in magnitude to groundwater outflow rates. A steady-state model is suitable for addressing the modeling objectives described in Section G.1.1. The model contains interpretations of available hydrogeologic data and has been periodically updated as new information became available (e.g., land surface elevation at locations where construction activities have altered the topography and subsurface hydraulic properties determined by aquifer testing.).

G.2 Conceptual Site Model

A description of the CSM, including information regarding the local climate, hydrology, topography, and geologic setting is presented in Sections 3.0 and 5.0 of the *Operable Unit 2 Remedial Investigation Report* (RI Report).

When a groundwater system is in a long-term state of equilibrium, the long-term rate of groundwater discharge is equal to the long-term rate of groundwater recharge. Groundwater level data from the Site monitoring wells and piezometers show no indication of a steadily increasing or decreasing trend in groundwater levels over time. This observation supports the hypothesis that the Lava Cap area groundwater system was in a state of long-term equilibrium prior to the Operable Unit 1 (OU-1) RA activities. Assuming that the groundwater system is in a long-term state of equilibrium helps bound certain components to the groundwater budget. The primary components of the groundwater budget include the following:

- Inflows from the deep percolation of precipitation (precipitation recharge), applied water, leakage from streams, septic systems, and subsurface inflow from adjacent watersheds
- Outflows by evapotranspiration (ET) of shallow groundwater; groundwater discharge to streams, springs, seeps, lakes, and ponds; groundwater pumping; and subsurface outflow to adjacent watersheds

G.3 Computer Code Description

MicroFEM (Hemker and Nijsten, 2003), an integrated groundwater modeling program developed in the Netherlands, was chosen to simulate the groundwater flow system at the Site. MicroFEM is a three-dimensional, finite-element groundwater modeling code that operates in a Windows™ environment and can be used to solve groundwater flow problems for unconfined, semiconfined, and confined aquifer systems. The current version of the program (Version 3.60) can simulate field conditions with up to 25 numerical layers and 250,000 surface nodes. MicroFEM is capable of modeling saturated, single-density

groundwater flow in layered systems. MicroFEM was chosen as the modeling platform for the Lava Cap Mine Groundwater Flow Model for the following reasons:

- The finite-element scheme allows the construction of a model grid covering a large geographic area with a coarse node spacing outside of the area of interest and a finer node spacing within areas of interest (e.g., Source Area, Mine Area, and Lost Lake/ Deposition Area). The finer node spacing in the areas of interest provides greater resolution of simulated groundwater levels and flow.
- The graphical user interface allows for rapid assignment of aquifer parameters and allows inspection of these values by graphical means.
- MicroFEM is commercially available, and the current version has more than 20 years of development (MicroFEM, 2007).

Further details regarding this software's design, capabilities, and functionality are described in two reviews by Diodato (1997 and 2000).

G.3.1 Assumptions

The numerical approximations of the governing groundwater flow equations used in MicroFEM for the Site are based on the following assumptions:

- The saturated thickness of the aquifer system does not change significantly over time (i.e., model layers are simulated as confined aquifers).
- The hydrologic system is in a state of dynamic equilibrium, meaning that groundwater inflow rates are equal to groundwater outflow rates with no change in groundwater storage (i.e., steady state). Although groundwater levels at the Site respond to seasonal hydrology and short-term stresses (e.g., groundwater pumping), they tend to return to a typical range under time-weighted average conditions. Field data do not indicate any long-term trends in the groundwater flow system. Therefore, the pursuit of a transient calibration effort was not deemed necessary to fulfill the modeling objectives described in Section G.1.1.

G.3.2 Solution Techniques

MicroFEM uses a combination of the finite element and finite difference methods for the calculation of groundwater elevation (head) and flow. The finite element method is used for computing the horizontal flow components, whereas the finite difference method is used for computing the vertical flow components. The iterative solution technique of MicroFEM uses the successive over-relaxation method in head and flow calculations (Hemker and Nijsten, 2003).

G.4 Model Construction

G.4.1 Model Domain and Grid

Horizontally, the Lava Cap Mine Groundwater Flow Model grid consists of 32,532 nodes and 64,729 elements in each model layer (see Figure G-1; all figures are located at the end of this appendix). Nodes are spaced at approximately 30-foot centers in the Mine Area, Source

Area, Lost Lake/Deposition Area, and along Little Clipper Creek (LCC) to approximately 500 feet near the model boundary. The finer node spacing in the areas of interest allows a more refined estimate of steady-state heads, flow, and groundwater/surface-water interaction. The lateral extent of the model grid represents the extent of the Clipper Creek (CC) watershed, which covers approximately 13 square miles as defined by the topographic divides.

Vertically, the Lava Cap Mine Groundwater Flow Model was discretized into four layers. The top of Model Layer 1 represents the steady-state groundwater table. From top to bottom, Model Layers 1 through 3 have saturated thicknesses of 50, 100, and 350 feet, respectively. Model Layer 4 was extended to a uniform elevation at depth corresponding to the deepest available driller's log. Model Layer 4 has a variable thickness ranging from 1,225 to 2,880 feet.

G.4.2 Hydraulic Parameters

Hydraulic conductivity was assumed to be uniform within each model layer. Table G-1 summarizes the saturated thicknesses, horizontal hydraulic conductivities, transmissivities (the mathematical product of hydraulic conductivity and saturated thickness), and the horizontal-to-vertical hydraulic conductivity (Kh:Kv ratio) (also known as the vertical anisotropy) by model layer. The simulated distribution of the total transmissivity (the sum of transmissivities from all four layers) is presented on Figure G-2.

TABLE G-1
Summary of Aquifer Properties Assigned in the Lava Cap Mine Groundwater Flow Model
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Model Layer	Model Layer Thickness (feet)	Horizontal Hydraulic Conductivity (ft/day)	Aquifer Transmissivity (ft^2/day)	Vertical Anisotropy[a]
1	50	6E-02	3	NA
2	100	2E-02	2	2.4[b]
3	350	1E-02	4	0.9[c]
4	1,225 to 2,880	3E-03	4 to 9	1.0[d]

[a]Kh:Kv ratio
[b]Between Model Layers 1 and 2
[c]Between Model Layers 2 and 3
[d]Between Model Layers 3 and 4

Note:
NA = not applicable

The Kh:Kv ratio is a measure of an aquifer's ability to transmit water horizontally versus vertically. A Kh:Kv ratio greater than 1 indicates that Kh is greater than Kv and vice versa. MicroFEM simulates vertical anisotropy at the model layer interfaces via a vertical

resistance term. The vertical resistance term defines the resistance to vertical flow between model layers according to Equation 1:

$$VR = \frac{\left(\frac{Kh}{Kv}\right)_{i-j} \times \left(\frac{b_i^2}{T_i} + \frac{b_j^2}{T_j}\right)}{2} \quad (1)$$

Where:

VR	=	vertical resistance (days)
Kh/Kv_{I-J}	=	Kh:Kv ratio or vertical anisotropy between adjacent model layers "i "and "j" (dimensionless)
$b_{I,J}$	=	saturated thickness of adjacent model layers "i "and "j" (feet)
$T_{I,J}$	=	transmissivity of adjacent model layers "i "and "j" (square feet per day [ft^2/day])

Hydraulic conductivity (actually, transmissivity, which is the mathematical product of the model layer thickness and the Kh) values were assigned according to results from well development aquifer testing described in Appendix C and professional judgment for bedrock aquifer systems. The values presented in Table G-1 are indicative of a low-permeability bedrock aquifer system described in Section 3.2.4 of the RI Report. Because the Lava Cap Mine Groundwater Flow Model is a steady-state model, groundwater storage was set to zero in all model layers.

G.4.3 Boundary Conditions

Boundary conditions are mathematical statements describing either the head or the flux at specific locations within the model domain (Anderson and Woessner, 1992). Boundary conditions can represent either physical boundaries, such as impermeable rock, or hydraulic boundaries, such as groundwater divides or streams. The three types of boundary conditions included in the Lava Cap Mine Groundwater Flow Model are as follows:

- Specified-flux boundary – a constant groundwater flux is prescribed at the boundary. The portion of precipitation that infiltrates the land surface and collects on the groundwater table is simulated as a specified-flux boundary.
- Head-dependent flux boundary – the groundwater flux across the boundary is computed using the following input data:
  - A prescribed land surface (i.e., drain) elevation and a drain vertical resistance term
  - A prescribed elevation interval representing a vegetation root zone from which ET of shallow groundwater is simulated and a maximum ET rate occurs when simulated heads are at or above land surface
- No-flow boundary – groundwater flux across the boundary is prohibited.

G.4.3.1 Specified-flux Boundary

Precipitation and surface water runoff are not directly input or simulated in the Lava Cap Mine Groundwater Flow Model. Instead, precipitation recharge is input as a specified-flux boundary variable. Precipitation recharge represents the portion of precipitation that infiltrates the land surface and collects on the groundwater table. A spatially variable precipitation recharge rate of up to 7.5 inches per year (in/yr) was assigned to the specified-flux boundary on the surface of the Lava Cap Mine Groundwater Flow Model. The precipitation recharge rate was also scaled by elevation, whereby higher elevation areas in the model received higher rates than lower elevation areas (see Figure G-3). This is because orographic factors affect precipitation patterns in the region encompassing Lava Cap Mine, where large elevation differences can occur over relatively short distances. The precipitation recharge rate was used as a calibration variable that was modified until there was a reasonable match between measured and simulated groundwater levels.

G.4.3.2 Head-dependent Flux Boundary

Two types of head-dependent flux boundaries are used in the Lava Cap Mine Groundwater Flow Model; one type simulates the consumption (i.e., discharge) of shallow groundwater via ET, and the other type simulates groundwater discharge to the land surface as described below.

Evapotranspiration of Shallow Groundwater

A head-dependent boundary condition was assigned at each node in Model Layer 1 to simulate discharge via ET of shallow groundwater within the CC watershed. The Lava Cap Mine Groundwater Flow Model computes ET of shallow groundwater as shown in Equation 2:

$$\begin{aligned} \text{Volumetric } ET &= ET_{max} \times a, \qquad h1 \geq eh1 \\ &= 0, \qquad h1 \leq el1 \\ &= a \times ET_{max} \times \frac{(h1 - el1)}{(eh1 - el1)}, \; el1 < h1 < eh1 \end{aligned} \tag{2}$$

Where:

a	=	nodal area (square feet)
$h1$	=	simulated head in Model Layer 1 (feet msl)
$eh1$	=	specified head of the ET system, which is the land surface elevation (feet msl)
$el1$	=	elevation of the ET extinction depth (feet msl)
ET_{max}	=	maximum ET rate when h1 ≥ eh1, computed as the product of the reference ET and fraction of area with vegetation (assumed to be 50 percent) (ft/day)

The land surface elevation was defined by a combination of data from regional digital elevation model data, data from a more refined digital terrain model in the Mine and Deposition Areas, and survey data collected after the OU-1 RA. The extinction depth (eh1-el1), which is the assumed elevation interval representing the vegetation root zone, and ET_{max} variables were assigned as constant values throughout the model domain at 6 feet below ground surface (bgs) and 0.0043 ft/day (approximately 19 in/yr), respectively. An average reference ET value of 37.5 in/yr was computed using reference ET data for Grass

Valley and Nevada City, California, from the University of California, (Goldhamer and Snyder, 1989).

Groundwater Discharge to Land Surface

An additional head-dependent boundary condition, the drain package, was also assigned at every node in Model Layer 1 to simulate groundwater discharge to the land surface. The drain package simulates the discharge of groundwater as shown in Equation 3:

$$\begin{aligned} \text{Volumetric Drain Outflow} &= a \times \frac{(h1 - dh1)}{dc1}, \; h1 > dh1 \\ &= 0, \qquad h1 < dh1 \end{aligned} \tag{3}$$

Where:

a = nodal area (square feet)

h1 = simulated head in Model Layer 1 (feet msl)

dh1 = drain elevation (i.e., land surface elevation) (feet msl)

dc1 = soil thickness divided by the vertical hydraulic conductivity (i.e., vertical resistance across the drainage surface) (days)

The dc1 was specified at a low value of 10 days to minimize resistance to groundwater discharge in the Lava Cap Mine Groundwater Flow Model.

G.4.3.3 No-flow Boundary

A no-flow boundary was used along the entire lateral model boundary for all model layers to simulate the lateral extent of the groundwater basin underlying the CC watershed (i.e., at the topographic divides of the CC watershed). Assignment of this boundary assumes that no groundwater leaves or enters the basin via subsurface underflow and that all water leaving the basin exits only through the head-dependent flux boundaries. A no-flow boundary was also specified at the bottom boundary of Model Layer 4.

G.5 Calibration

Model calibration is a process of adjusting a numerical model to replicate measured hydrologic data within a reasonable degree of accuracy. This process generally involves adjusting model parameters and specified boundary conditions (i.e., stresses) until the desired levels of precision and accuracy are achieved. Professional judgment must be used to ensure that the final set of model input parameters are reasonable for the geologic and hydrologic setting.

G.5.1 Calibration Targets

Calibration targets for the Lava Cap Mine Groundwater Flow Model are defined as the selected field-measured values that quantify hydrologic conditions of interest with consideration of data quality and worth. Both qualitative and quantitative calibration targets were selected to evaluate the progress of calibration during development of the Lava Cap Mine Groundwater Flow Model.

G.5.1.1 Qualitative Targets

Qualitative calibration targets, for the purposes of calibrating the Lava Cap Mine Groundwater Flow Model, refer to general observations of temporal or spatial patterns of the field problem that were compared to model output. These targets include, but are not limited to the following:

- **Simulated groundwater recharge and discharge areas**. Simulated heads were compared to land surface elevations to evaluate whether the relative locations of groundwater recharge and discharge were reasonable (e.g., groundwater discharge areas should be at relatively lower elevations, such as stream channels).
- **Simulated groundwater flow directions**. Simulated heads were evaluated to assess whether groundwater flowed from higher topographic elevations to lower topographic elevations.

G.5.1.2 Quantitative Calibration Targets

Quantitative calibration targets refer to the actual measured field data. Simulated output are compared to quantitative calibration targets by computing the difference (i.e., residual) between them. The only available quantitative calibration targets for the Lava Cap Mine Groundwater Flow Model include measured groundwater levels at the Site and at select residential wells in the area. Table G-2 lists the average measured head values used as quantitative calibration targets at monitoring and residential wells located throughout the CC watershed, the number of measurements, and the source of data for each target head value. The target head values were computed as the average of the available head measurements for a given location. Figure G-4 shows the locations of the calibration target wells.

TABLE G-2
Average Groundwater Elevations Used for Steady-state Calibration
Operable Unit 2 Remedial Investigation Report; Lava Cap Mine Superfund Site, Nevada City, California

Well	Average Measured Head (feet msl)	Number of Measurements	Data Source
13Q	2,461.7	31	LCM quarterly groundwater monitoring
13S	2,461.3	29	LCM quarterly groundwater monitoring
13T	2,463.5	2	LCM quarterly groundwater monitoring
1B	3,165.6	29	LCM quarterly groundwater monitoring
1R	2,881.0	25	LCM quarterly groundwater monitoring
5A	2,781.7	22	LCM quarterly groundwater monitoring
5D	2,741.1	25	LCM quarterly groundwater monitoring
5E	2,739.2	22	LCM quarterly groundwater monitoring
5K-S	2,694.5	15	LCM quarterly groundwater monitoring
5K-D	2693.5	15	LCM quarterly groundwater monitoring
5L-S	2,717.2	3	LCM quarterly groundwater monitoring
5L-D	2,723.9	3	LCM quarterly groundwater monitoring
5I	2,733.9	24	LCM quarterly groundwater monitoring
5J	2,733.6	20	LCM quarterly groundwater monitoring
5PZ-1	2,754.5	24	LCM quarterly groundwater monitoring
5PZ-2	2,746.2	20	LCM quarterly groundwater monitoring
5PZ-3	2,743.6	20	LCM quarterly groundwater monitoring

TABLE G-2
Average Groundwater Elevations Used for Steady-state Calibration
Operable Unit 2 Remedial Investigation Report; Lava Cap Mine Superfund Site, Nevada City, California

Well	Average Measured Head (feet msl)	Number of Measurements	Data Source
11AT	2,597.9	3	LCM quarterly groundwater monitoring
11AU	2,602.9	5	LCM quarterly groundwater monitoring
11AM	2,541.8	1	Driller's log
11AS	2,634.6	1	Driller's log
11AV	2,647.8	1	Driller's log
RW-130	3,506.8	1	Hydrosearch Associates, Ltd., 1984
RW-135	3,178.9	1	Hydrosearch Associates, Ltd., 1984
RW-136	2,620.2	1	Hydrosearch Associates, Ltd., 1984
RW-139	3,005.1	1	Hydrosearch Associates, Ltd., 1984
RW-140	3,027.1	1	Hydrosearch Associates, Ltd., 1984
RW-145	3,567.8	1	Hydrosearch Associates, Ltd., 1984
RW-153	3,552.6	1	Hydrosearch Associates, Ltd., 1984
RW-163	3,533.3	1	Hydrosearch Associates, Ltd., 1984
RW-166	2,647.0	1	Hydrosearch Associates, Ltd., 1984
RW-177	2,575.9	1	Hydrosearch Associates, Ltd., 1984
RW-180	3,294.8	1	Hydrosearch Associates, Ltd., 1984
RW-182	3,601.7	1	Hydrosearch Associates, Ltd., 1984
RW-184	3,194.0	1	Hydrosearch Associates, Ltd., 1984
RW-188	2,577.6	1	Hydrosearch Associates, Ltd., 1984
RW-190	3,353.0	1	Hydrosearch Associates, Ltd., 1984
RW-198	3,227.1	1	Hydrosearch Associates, Ltd., 1984
RW-13	3,163.9	1	Driller's log
RW-24	3,148.7	1	Driller's log
RW-27	3,230.7	1	Driller's log
RW-29	3,246.1	1	Driller's log
RW-33	3,186.5	1	Driller's log
RW-35	2,668.5	1	Driller's log
RW-40	2,912.3	1	Driller's log
RW-42	2,753.9	1	Driller's log
RW-45	2,626.8	1	Driller's log
RW-54	2,609.8	1	Driller's log
RW-62	2,816.4	1	Driller's log
RW-64	2,894.2	1	Driller's log
RW-68	2,505.7	1	Driller's log
RW-69	2,439.1	1	Driller's log
RW-70	2,516.1	1	Driller's log
RW-73	2,572.9	1	Driller's log
RW-93	2,556.1	1	Driller's log
RW-97	2,481.2	1	Driller's log

Notes:
See Figure G-4 for target well locations.
LCM = Lava Cap Mine

Calibration statistics provide a quantitative measure of a model's ability to replicate the selected target data. Poor calibration statistics can result from a lack of understanding of the hydrologic system, incorrect conceptualization, poor quality of model inputs, poor quality of observed data, or some combination thereof. The progress of the Lava Cap Mine Groundwater Flow Model calibration was evaluated by reviewing the results against the qualitative targets described in Section G.5.1.1 and the "root mean squared error" (RMSE) divided by the range in measured target heads (RMSE/Range) as shown in Equation 4:

$$RMSE/Range = \frac{\left(\frac{1}{n} \times \sum_{i=1}^{n} (H - h)^2\right)^{0.5}}{(H_{max} - H_{min})} \tag{4}$$

Where:

n = number of target values
H = measured head (feet msl)
H_{max} = maximum of measured head values (feet msl)
H_{min} = minimum of measured head values (feet msl)
H = simulated head (feet msl)

The goal of the calibration effort was to minimize the RMSE/Range; the maximum target RMSE/Range value was 10 percent.

G.5.2 Sources of Error

Calibration target values and model output each have associated uncertainty, resulting in overall uncertainty in results. The sources of uncertainty include transient effects, human errors, scaling effects, interpolation errors, and numerical errors (Anderson and Woessner, 1992).

G.5.2.1 Transient Effects

Groundwater level measurements in wells could reflect the presence of transient effects in the groundwater system that might not be represented in the numerical model. The only available subsurface access to directly monitor groundwater conditions is through groundwater wells. Groundwater wells allow measurement of groundwater levels and collection of water quality samples. If transient effects of the groundwater system manifested in groundwater levels in wells at shorter time scales than those in the numerical model, some portion of the difference (residual) between the field-measured groundwater level and the simulated output could be due to these transient effects.

G.5.2.2 Human Errors

Human errors include measurement, data management, and conceptualization errors.

Measurement Errors. Calibration target values include measurement errors. Measurement errors relate to the accuracy and consistency of the measuring device or structure, the accuracy and consistency of the elevation survey datum, and the diligence of the field or laboratory technician collecting or analyzing the data. Thus, some portion of the residual between the field-measured data and the simulated output could also be due to measurement error in the calibration target value.

Data Management Errors. Errors can also be introduced as a result of data management activities. Examples of data management errors include, but are not limited to, associating input data with an incorrect location (resulting in spatial errors), evaluating time-series data incorrectly (resulting in temporal errors), or otherwise inputting values incorrectly. A portion of the residual between the field-measured data and the simulated output could also be due to data management errors.

Conceptualization Errors. Errors can also be introduced as a result of inadequately conceptualizing the field problem. For example, if there were significant errors in the assigned boundary conditions, a portion of the residual between the field-measured data and the simulated output would be due to conceptualization errors.

G.5.2.3 Scaling Effects

A numerical model uses a discrete space to represent the hydrologic system. The Lava Cap Mine Groundwater Flow Model grid was created to strike a balance between maximizing the number of nodes in key areas of the domain and minimizing the number of nodes in areas of the domain that are less important. This reduces the numerical burden and associated model runtimes. However, all numerical grids are subject to errors resulting from scaling effects.

Errors associated with scaling effects result when and where significant spatial heterogeneities in the field problem are not represented at the scale of the numerical nodes. For example, the height to which water rises in a groundwater well is the result of the average head conditions of the depth interval over which the groundwater well is screened. Groundwater wells in the study area have variable-length well screens. Therefore, a portion of the residual between field-measured groundwater levels and the simulated output could be due to scaling effects resulting from the difference between model layer thicknesses and the well screen lengths of calibration target wells.

G.5.2.4 Interpolation Errors

Calibration target locations would ideally be represented in the Lava Cap Mine Groundwater Flow Model to coincide perfectly with locations of the model nodes, but in practice, this is not possible. Therefore, interpolation errors are introduced in the calibration evaluation. Interpolation errors also result from spatially distributing point values of parameters or stresses (such as precipitation recharge or ET) over the model domain. To manage interpolation errors, one of the goals for selecting calibration target locations was to seek spatially distributed calibration target wells over the model domain.

G.5.2.5 Numerical Errors

Errors associated with the way a model solves the governing flow equations, coupled with the assumptions inherent in the governing equations being solved, are inherent in all numerical models. Numerical errors are also associated with the selection of convergence-closure criteria by the user. User selection of convergence-closure criteria is an iterative process during calibration to strike a balance between making calibration progress by completing as many simulations as possible within the project schedule while achieving adequate accuracy in the numerical solution. Selecting convergence-closure criteria that are too low during initial stages of model calibration will result in completing fewer simulations due to longer runtimes and possible convergence problems. The final convergence criteria

for the Lava Cap Mine Groundwater Flow Model were set to $1x10^{-5}$ feet for heads and 1.0 cubic foot per day for flow, which resulted in a low overall mass balance error of 0.02 percent.

G.5.3 Calibration Results

The following sections compare the calibration results with the qualitative and quantitative targets described in Sections G.5.1.1 and G.5.1.2.

G.5.3.1 Qualitative Results

Figure G-5 shows the areas of the model domain where the simulated drains are active in the Lava Cap Mine Groundwater Flow Model. Active top systems indicate that the simulated head is above the land surface. As shown on Figure G-5, these areas generally coincide with low domain elevations where groundwater discharge is more likely to occur. Conversely, groundwater recharge is simulated in areas of the domain located outside of the groundwater discharge areas shown on Figure G-5.

A contour map of simulated heads and groundwater flow directions from Model Layer 1 near the Site is also presented on Figure G-5. This map indicates that simulated heads generally follow the topography, with groundwater flowing from higher to lower topographic elevations.

G.5.3.2 Quantitative Results

Table G-3 presents the measured heads, simulated heads, and residuals in heads for all of the calibration targets. These data are depicted graphically on the scatter plot presented on Figure G-6. The scatter plot shows that points fall both above and below the hypothetical line representing a match between measured and simulated heads. A well calibrated model should have low residuals with some simulated heads occurring above and below their measured target heads. Thus, the calibration results of the Lava Cap Mine Groundwater Flow Model do not indicate global bias (i.e., it does not indicate all positive or all negative residuals).

TABLE G-3
Measured versus Simulated Heads
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location	Average Measured Head (feet msl)	Simulated Head (feet msl)	Residual[a] (feet)
11AM	2,541.8	2,494.0	-47.8
11AS	2,634.6	2,648.2	13.6
11AT	2,597.9	2,616.7	18.8
11AU	2,602.9	2,618.2	15.3
11AV	2,647.8	2,666.9	19.1
13Q	2,461.7	2,460.0	-1.7
13S	2,461.3	2,459.3	-2.0
13T	2,463.5	2,464.3	0.8
1B	3,165.6	3,124.1	-41.5
1R	2,881.0	2,894.8	13.8
5A	2,781.7	2,787.6	5.9

TABLE G-3
Measured versus Simulated Heads
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location	Average Measured Head (feet msl)	Simulated Head (feet msl)	Residual[a] (feet)
5D	2,741.1	2,748.4	7.3
5E	2,739.2	2,744.8	5.6
5K-S	2,694.5	2,701.7	7.2
5K-D	2693.5	2,704.9	11.4
5L-S	2,717.2	2,720.6	3.4
5L-D	2,723.9	2,721.8	-2.1
5I	2,733.9	2,751.4	17.5
5J	2,733.6	2,752.6	19.0
5PZ-1	2,754.5	2,775.6	21.1
5PZ-2	2,746.2	2,759.4	13.2
5PZ-3	2,743.6	2,746.7	3.1
RW-130	3,506.8	3,513.8	7.0
RW-135	3,178.9	3,010.5	-168.4
RW-136	2,620.2	2,645.4	25.2
RW-139	3,005.1	2,886.0	-119.1
RW-140	3,027.1	2,874.5	-152.6
RW-145	3,567.8	3,569.7	1.9
RW-153	3,552.6	3,551.7	-0.9
RW-163	3,533.3	3,514.1	-19.2
RW-166	2,647.0	2,608.3	-38.7
RW-177	2,575.9	2,594.4	18.5
RW-180	3,294.8	3,290.4	-4.4
RW-182	3,601.7	3,586.1	-15.6
RW-184	3,194.0	3,024.0	-170.0
RW-188	2,577.6	2,625.1	47.5
RW-190	3,353.0	3,363.6	10.6
RW-198	3,227.1	3,251.1	24.0
RW-13	3,163.9	3,081.8	-82.1
RW-24	3,148.7	3,136.6	-12.1
RW-27	3,230.7	3,227.2	-3.5
RW-29	3,246.1	3,193.1	-53.0
RW-33	3,186.5	3,089.2	-97.3
RW-35	2,668.5	2,682.3	13.8
RW-40	2,912.3	2,936.3	24.0
RW-42	2,753.9	2,780.9	27.0
RW-45	2,626.8	2,574.9	-51.9
RW-54	2,609.8	2,613.5	3.7
RW-62	2,816.4	2,771.2	-45.2

TABLE G-3
Measured versus Simulated Heads
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location	Average Measured Head (feet msl)	Simulated Head (feet msl)	Residual[a] (feet)
RW-64	2,894.2	2,822.4	-71.8
RW-68	2,505.7	2,468.0	-37.7
RW-69	2,439.1	2,453.3	14.2
RW-70	2,516.1	2,464.4	-51.7
RW-73	2,572.9	2,525.6	-47.3
RW-93	2,556.1	2,524.6	-31.5
RW-97	2,481.2	2,520.8	39.6

[a]Computed as the simulated head minus the average measured head.

The RMSE/Range for the quantitative calibration targets using Equation 4 is 4.4 percent, indicating that the quantitative calibration goal of 10 percent or less was satisfied. Groundwater level data collected and simulated at Site monitoring and select residential wells are included in the quantitative statistics. Data quality at Site monitoring wells was considered higher than at the residential wells for the following reasons:

- Reference points at the wellheads where depth-to-water measurements were made based on surveyed data. The quality of the reference point elevations used during the Hydrosearch Associates, Ltd., study (1984) or past drilling activities at residential wells is not known.
- Groundwater levels have been consistently measured at these locations using the same measuring devices and methods.
- Multiple measurements of groundwater levels were available for monitoring wells.

G.5.4 Sensitivity Analysis

A sensitivity analysis is the process of systemically varying selected parameters in the calibrated model, one at a time, to quantify the impact of that change on model calibration. The purpose of a sensitivity analysis is to identify the key most sensitive key model parameters. For the Lava Cap Mine Groundwater Flow Model, the precipitation recharge in Model Layer 1 and the transmissivities and vertical resistance in Model Layers 1 through 4 were selected as the parameters of interest. As part of the sensitivity analysis, these parameters were changed by ±25, ±50, and ±75 percent and the RMSE/Range statistic was recomputed to evaluate the cause-and-effect relationship between the parameter of interest and the quantitative calibration results.

As shown on Figure G-7, the Lava Cap Mine Groundwater Flow Model was most sensitive to decreases in precipitation recharge. Increases in the precipitation recharge had little impact on the calibration, as shown by the RMSE/Range. The vertical resistance was generally the least sensitive of the parameters evaluated. The model was somewhat sensitive to increases and decreases in total transmissivity.

G.6 Model Application

The primary purpose of the Lava Cap Mine Groundwater Flow Model was to gain insight into groundwater flowpaths that originate from historical mining areas (mine-related source areas) at the Site. This groundwater flowpath evaluation was accomplished by starting groundwater particles (i.e., flowlines) at selected areas and tracking them forward (i.e., downgradient) under steady-state flow conditions (with no restrictions on travel time; flowlines travel from the point of origin until they terminate at the water table). This type of flowpath analysis provides insight into potential long-term groundwater flowpaths from mine-related source areas; however, it does not provide predictions of arsenic concentrations along the groundwater flowpaths. Groundwater flow along localized fracture zones, groundwater use, potential unmapped subsurface ore bodies containing arsenic, geochemical reactions, adsorption, dilution, and travel times can affect arsenic concentrations along the groundwater flowpaths. The goal of this groundwater flowpath analysis was to identify areas where groundwater that has flowed from areas known to be affected by past mining activities or ongoing contaminant releases. Within those areas, it is possible that elevated arsenic concentrations detected in groundwater at residential wells could be associated with past mining operations or ongoing contaminant releases.

Mine-related sources of arsenic contamination in groundwater were assumed to come from the following sources:

- Subsurface mine workings (shown schematically on Figure 1-4)
- Surficial tailings and waste rock (i.e., mine waste) in the Source Area
- Stream channels south of the Rock Buttress and north of the confluence of CC and LGC that potentially contain tailings or adit discharge
- Lost Lake/Deposition Area

The following groundwater flowpath scenarios were evaluated using the Lava Cap Groundwater Flow Model:

- **Scenario 1.** Groundwater particles were tracked downgradient from the simulated water table beneath areas with mine wastes, including the following:
  - Waste/rock tailings pile in the Source Area
  - LCC channel
  - CC channel, downstream from the confluence of LCC and upstream from Lost Lake
  - Lost Lake/Deposition Area
  - CC downstream from Lost Lake to the confluence with LGC

These areas were considered to have the greatest potential for adverse groundwater and surface water impacts from mine waste.

- **Scenario 2.** Groundwater particles were tracked from shallow mine workings, including the subsurface drifts of the 600 Level and above (see Figure 1-4 in the RI Report). Available well construction data were reviewed to estimate the maximum residential well depth (i.e., lowest elevation) in the area of the mine workings. The 600 Level drift is estimated to occur approximately 200 feet below the deepest known residential well in

the mine workings area. Thus, groundwater flowpaths from these drifts (600 Level and above) were considered to occur among the depth intervals of the known residential wells in the mine workings area. The shallow mine workings are considered to have the next greatest potential for adverse groundwater impacts compared with the areas underlying mine waste. However, the low hydraulic conductivity associated with the Palezoic to Upper Jurassic metamorphic rocks (Pms unit) could cause long travel times (hundreds of years) for groundwater to reach downgradient wells from this source. Groundwater flow through fractures, which was not explicitly modeled, could cause faster travel times along some flowpaths.

- **Scenario 3.** Groundwater particles were tracked from deep mine workings, including the subsurface drifts from the 700 Level to the 1400 Level. No known wells are screened at these depths in the area of the mine workings. The deep mine workings are considered to have the lowest potential for adverse groundwater impacts. Furthermore, groundwater travel times from these locations might be very long because of the likely low permeability of the Pms unit at these depths and distances to downgradient residential well locations.

The modeled groundwater flowpath areas under Scenarios 1 and 2 are presented on Figure G-8. The modeled groundwater flowpath area under Scenario 3 is presented on Figure G-9. These areas were delineated by projecting the three-dimensional groundwater flowlines from the Lava Cap Mine Groundwater Flow Model to the land surface and drawing a geographic boundary around them. The groundwater flowlines are not shown on Figures G-8 and G-9 to improve visual clarity. The groundwater flowpath areas presented on these figures encompass potential groundwater flowpaths from known and potential source areas; however, residential wells not impacted by arsenic exist in some of these areas. Localized groundwater flow features (e.g., fractures) could locally redirect contaminated groundwater flow, or geochemical processes could decrease arsenic concentrations in some of these areas before the groundwater reaches residential wells. The groundwater flow rates in the Pms unit are generally slow, and depending on the starting depth of the groundwater particle, impacts to downstream residential wells might not be likely. This approach for delineating the groundwater flowpath areas from known or potential arsenic source areas (see Figures G-8 and G-9) are conservative and could overestimate the potentially impacted area.

G.6.1 Scenario 1 Results

Results from the Scenario 1 flowpath analysis (see Figure G-8) suggest that shallow groundwater flow from beneath areas with mine waste is confined to the Source Area; Mine Area; LCC downstream from the mine with CC, downstream from the confluence with LCC; and the Lost Lake/Deposition Area. This is because shallow groundwater flow from recharge areas near the northern boundary of the LCC subwatershed tend to converge on LCC (in some areas actually discharging to LCC) in a southerly direction, toward Lost Lake (see Figure G-5 for groundwater elevation contours). This convergence of shallow groundwater flow limits the flowpath area from the surficial mine waste areas. Convergence of shallow groundwater flow toward drainage channels is a common hydrologic feature in mountainous settings. However, simulated groundwater from the LCC/CC confluence area flows south-southeast and eventually discharges into LGC, south of Lost Lake, bypassing

the Lost Lake on its eastern side. These modeling results are consistent with the downward hydraulic gradients near Wells 13Q, 13R, 13S, and 13T.

G.6.2 Scenario 2 Results

Results from the Scenario 2 flowpath analysis (see Figure G-8) suggest that groundwater from shallow mine workings (600 Level and above) flows through portions of the subsurface beneath the Source Area and Mine Area, LCC, and a larger area west of these locations. Groundwater from the shallow mine workings is predicted to discharge to LCC, CC, and LGC exiting to the CC watershed primarily as stream outflow in LGC. The western edge of the flowpath area coincides with the western extent of deep flowpaths projected onto the land surface. The large western portion of the Scenario 2 flowpath area, which is significantly larger than the Scenario 1 flowpath area, results from simulated groundwater particles that flow from the 100 Level (see Haulage Level drift on Figure 1-4 in the RI Report) near the northern CC watershed boundary. This watershed boundary is a no-flow boundary, across which groundwater does not flow. Instead, groundwater flows subparallel to and away from this boundary (i.e., groundwater divide). As groundwater flows south, the effects of the no-flow boundary lessens and groundwater flow begins to converge on LCC and LGC. As shown on Figure G-8, simulated groundwater flowpaths from the shallow mine workings also flow east of Lost Lake and eventually discharge into LGC.

G.6.3 Scenario 3 Results

Results from the Scenario 3 flowpath analysis (see Figure G-9) suggest that groundwater from deeper mine workings (700 Level and below) flows through portions of the subsurface beneath the Source Area, Mine Area, LCC, and CC. The Scenario 3 flowpath area extends farther east than the Scenario 2 flowpath area because the mine workings of the 700 Level and below are located farther east with increasing depth (i.e., the central shaft that bisects the subsurface drifts is inclined to the northeast [compare Figure 1-4 in the RI Report and Figure G-9]). Groundwater from the deeper mine workings is predicted to eventually discharge to LGC and exit the CC watershed primarily as stream outflow (also flowing east of Lost Lake).

G.7 Model Limitations

Because of the remoteness of the Site, the geologic setting (i.e., bedrock aquifer system), limited information on groundwater pumping locations and rates, and challenges associated with installation and maintenance of monitoring locations in steep, vegetated terrain, the following processes and features of the hydrologic system are poorly understood on a local scale:

- Three-dimensional groundwater flow directions and rates near individual residential wells near the Site
- Onsite and offsite locations of subsurface ore bodies that contain arsenic
- Prevalence, connectivity, and geometry of local fractures and faults

These processes and features affect where and how arsenic migrates through the groundwater system, and interpretations of such processes and features include a level of uncertainty. In some cases, installation and monitoring of new monitoring wells in this geologic setting would not necessarily reduce uncertainty in interpretations. The development and application of the Lava Cap Mine Groundwater Flow Model attempts to balance a reasonable level-of-effort scientific analysis with uncertainty in results.

The Lava Cap Mine Groundwater Flow Model was constructed as a reconnaissance-level, steady-state numerical tool to simulate large-scale features and processes of the hydrologic system. The spatial distribution of aquifer properties and precipitation recharge that is simulated in the model are based on the results from past geologic and hydrologic studies, aquifer tests, local climate data, and professional judgment. Any numerical representation of an aquifer system is a simplification of the actual site conditions. Some features of the hydrologic system and patterns of water use are not represented discretely in the model; such processes could be incorporated into later versions of the model in an attempt to reduce the uncertainty associated with the model output. Despite these model limitations, output from the current version of the Lava Cap Mine Groundwater Flow Model and available data provide useful insights into long-term groundwater inflows and outflows, patterns of groundwater flow, and arsenic pathways at a watershed and subwatershed scale.

Groundwater flowpath areas derived from modeling output represent a conservative estimated geographic area where groundwater could be flowing from known or potential arsenic sources. Uncertainty in these geographic areas increases with depth (i.e., the extent of the Scenario 2 flowpath area has greater uncertainty than the Scenario 1 flowpath area, and the Scenario 3 flowpath area has greater uncertainty than the Scenario 2 flowpath area) because the strong influence of topography on groundwater flow patterns at shallow depths lessens with increasing depth. Data that could provide insights into the deep bedrock aquifer system are not available. Because of the complexity of the bedrock aquifer system in the area, it is possible that incorporation of additional complexity into the Lava Cap Mine Groundwater Flow Model will not necessarily reduce uncertainty in the evaluations of remedial alternatives that will take place during the OU-2 feasibility study.

G.8 Works Cited

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Figures

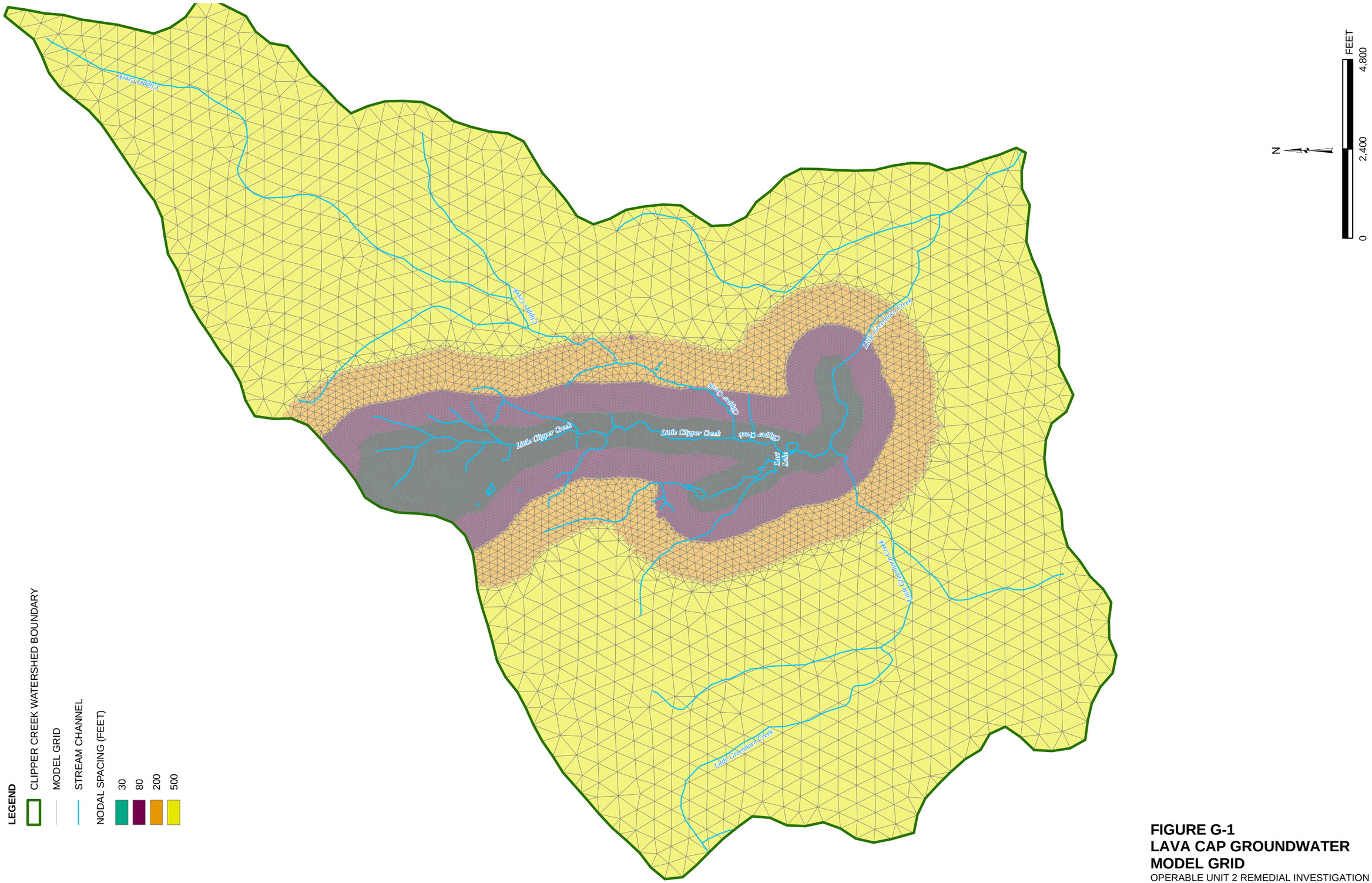

FIGURE G-1
LAVA CAP GROUNDWATER MODEL GRID
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

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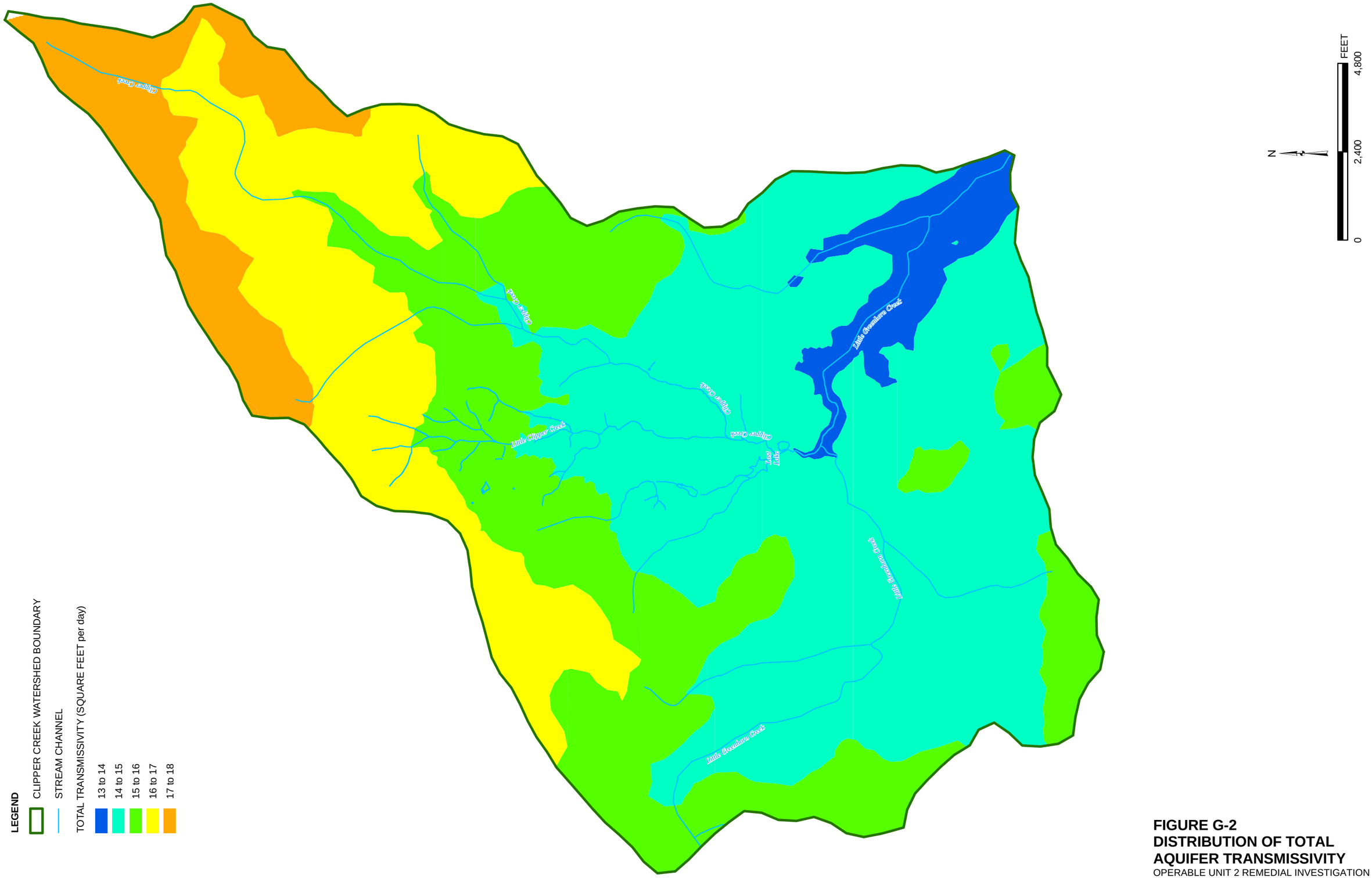

FIGURE G-2
DISTRIBUTION OF TOTAL AQUIFER TRANSMISSIVITY
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

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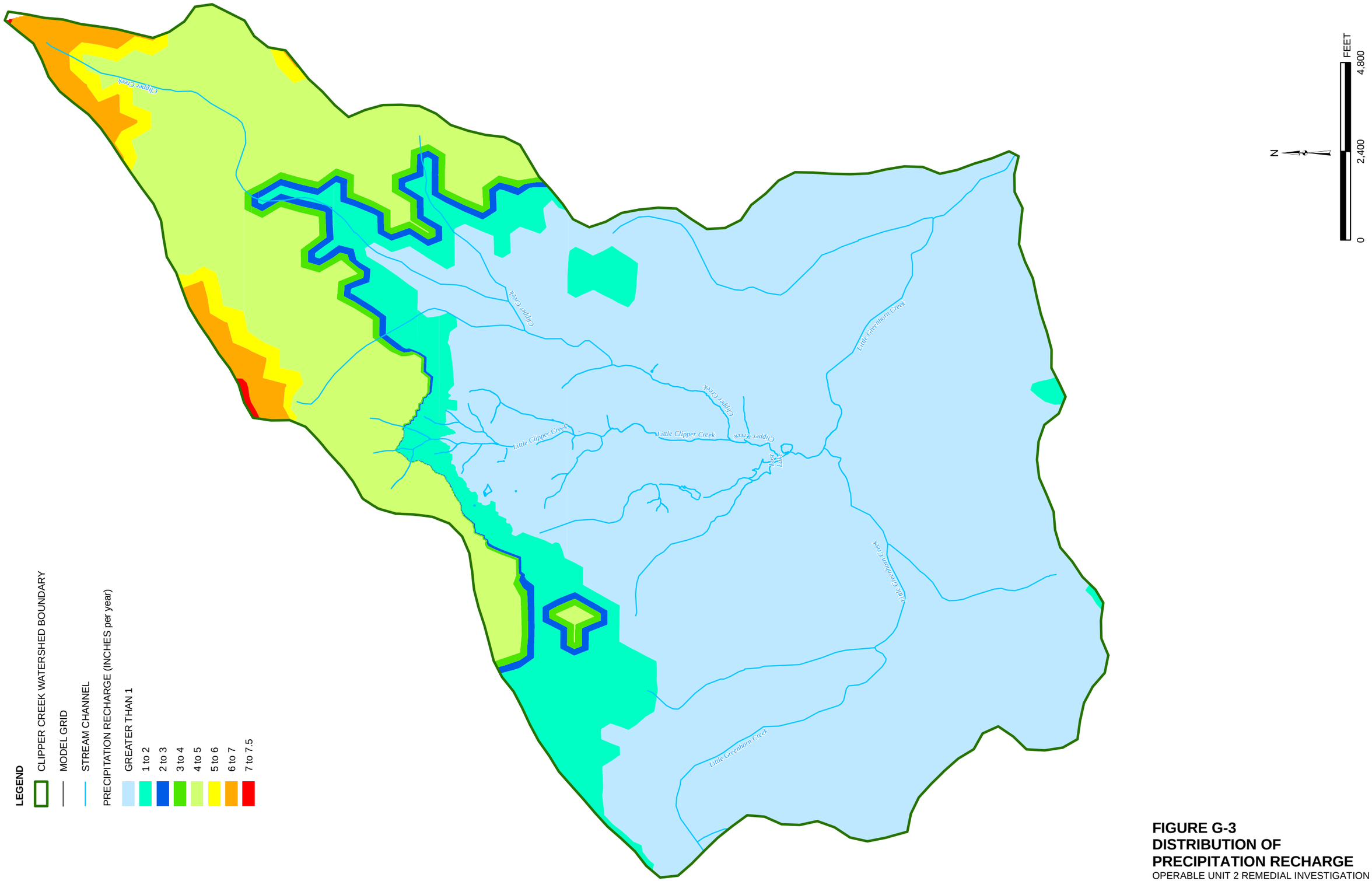

FIGURE G-3
DISTRIBUTION OF PRECIPITATION RECHARGE
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

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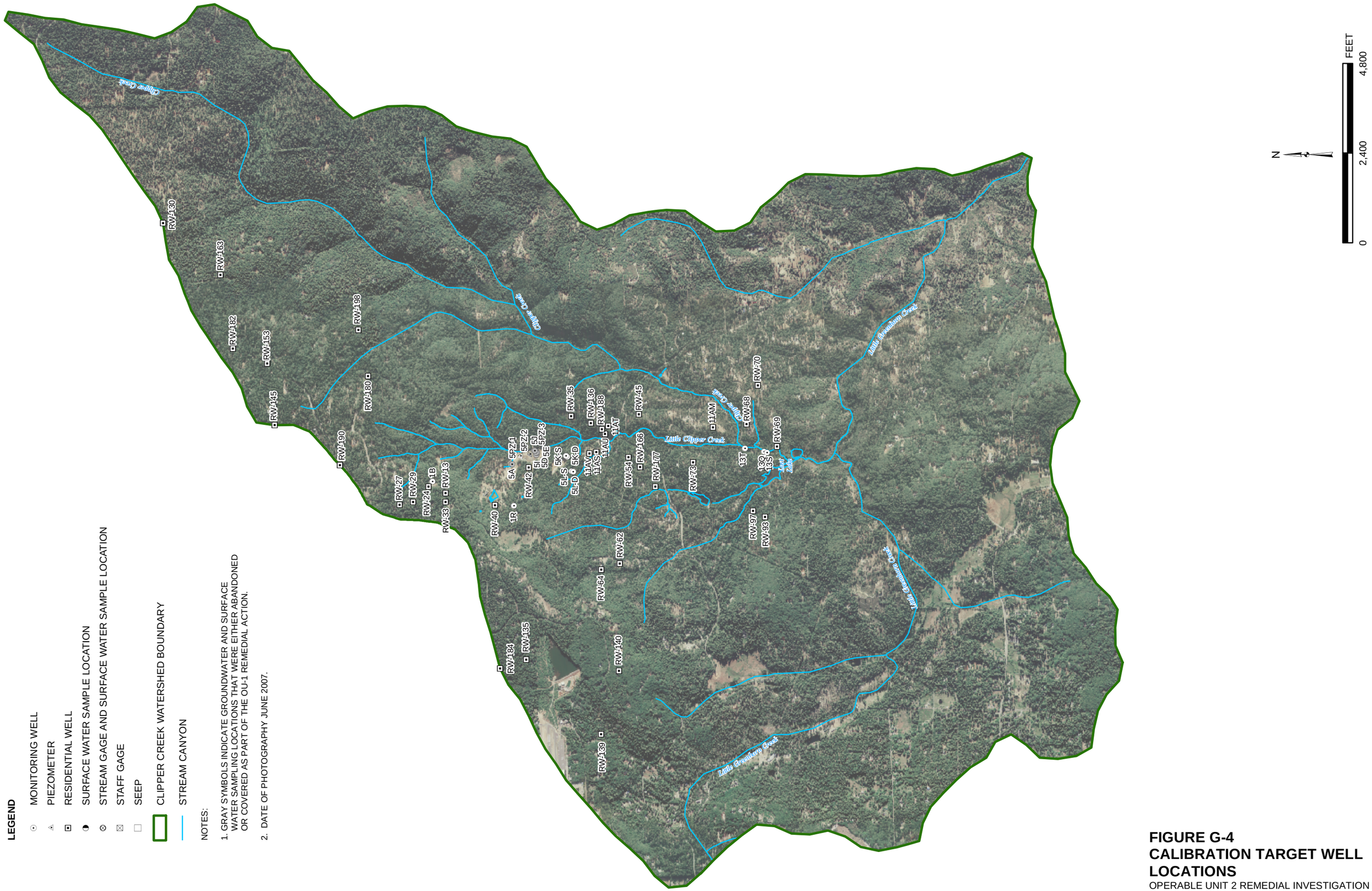


LEGEND

- MONITORING WELL
- PIEZOMETER
- RESIDENTIAL WELL
- SURFACE WATER SAMPLE LOCATION
- STREAM GAGE AND SURFACE WATER SAMPLE LOCATION
- STAFF GAGE
- SEEP
- CLIPPER CREEK WATERSHED BOUNDARY
- STREAM CANYON

NOTES:

1. GRAY SYMBOLS INDICATE GROUNDWATER AND SURFACE WATER SAMPLING LOCATIONS THAT WERE EITHER ABANDONED OR COVERED AS PART OF THE OU-1 REMEDIAL ACTION.
2. DATE OF PHOTOGRAPHY JUNE 2007.

\\LOKI\PROJECTS\RDDGIS\LAVACAPMINE_335394\MAPFILES\OU2RI_200708\DRAFT\OU2_RI_FIG_G-04.MXD 6/4/2008 10:12:28

FIGURE G-4
CALIBRATION TARGET WELL LOCATIONS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

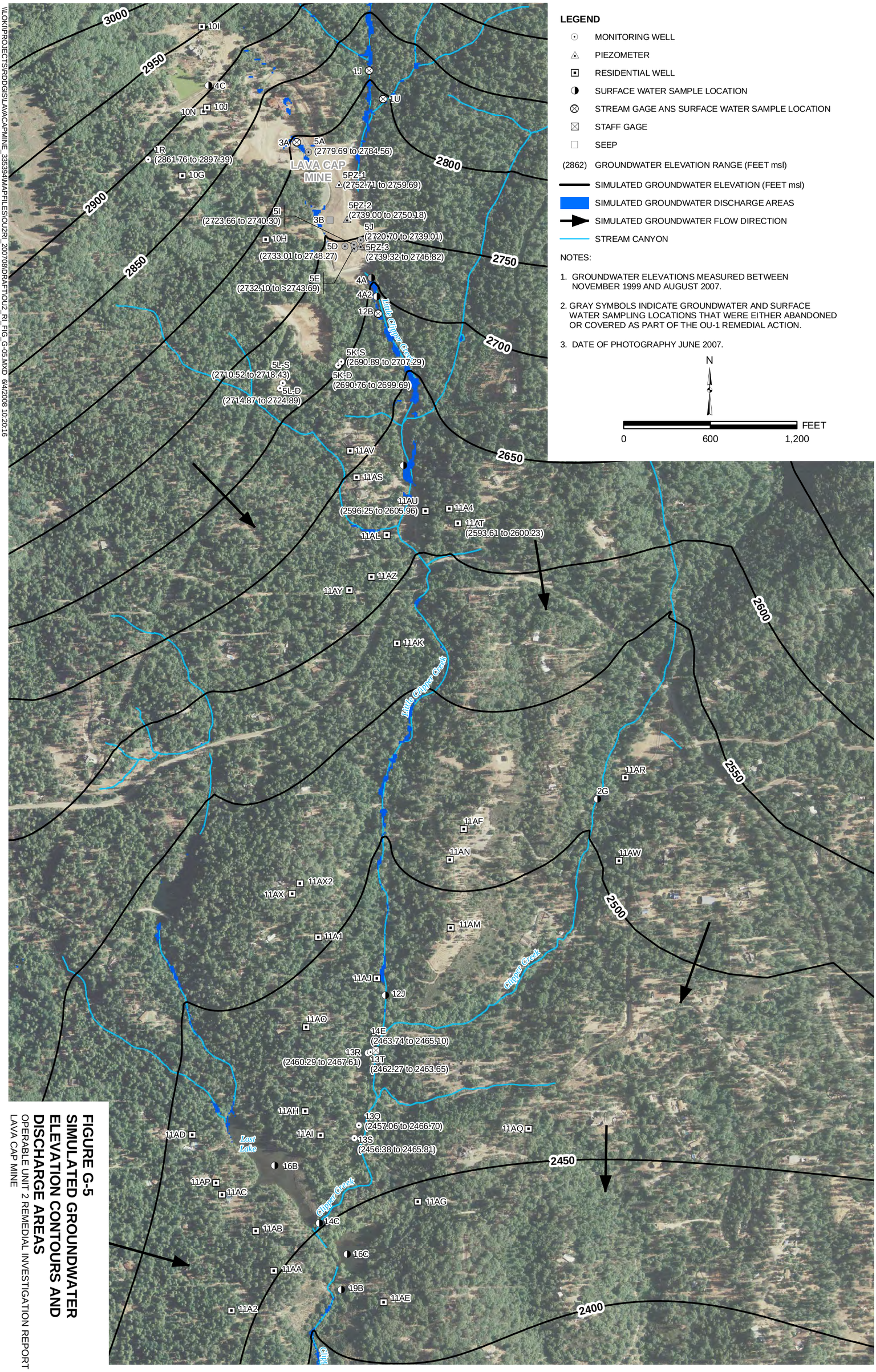


FIGURE G-5
SIMULATED GROUNDWATER ELEVATION CONTOURS AND DISCHARGE AREAS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

\\LOKI\PROJECTS\RDDGIS\LAVACAPMINE_3353941\MAPFILES\OU2\RI_2007\08\DRAFT\OU2_RI_FIG_G-05.MXD 6/4/2008 10:20:16

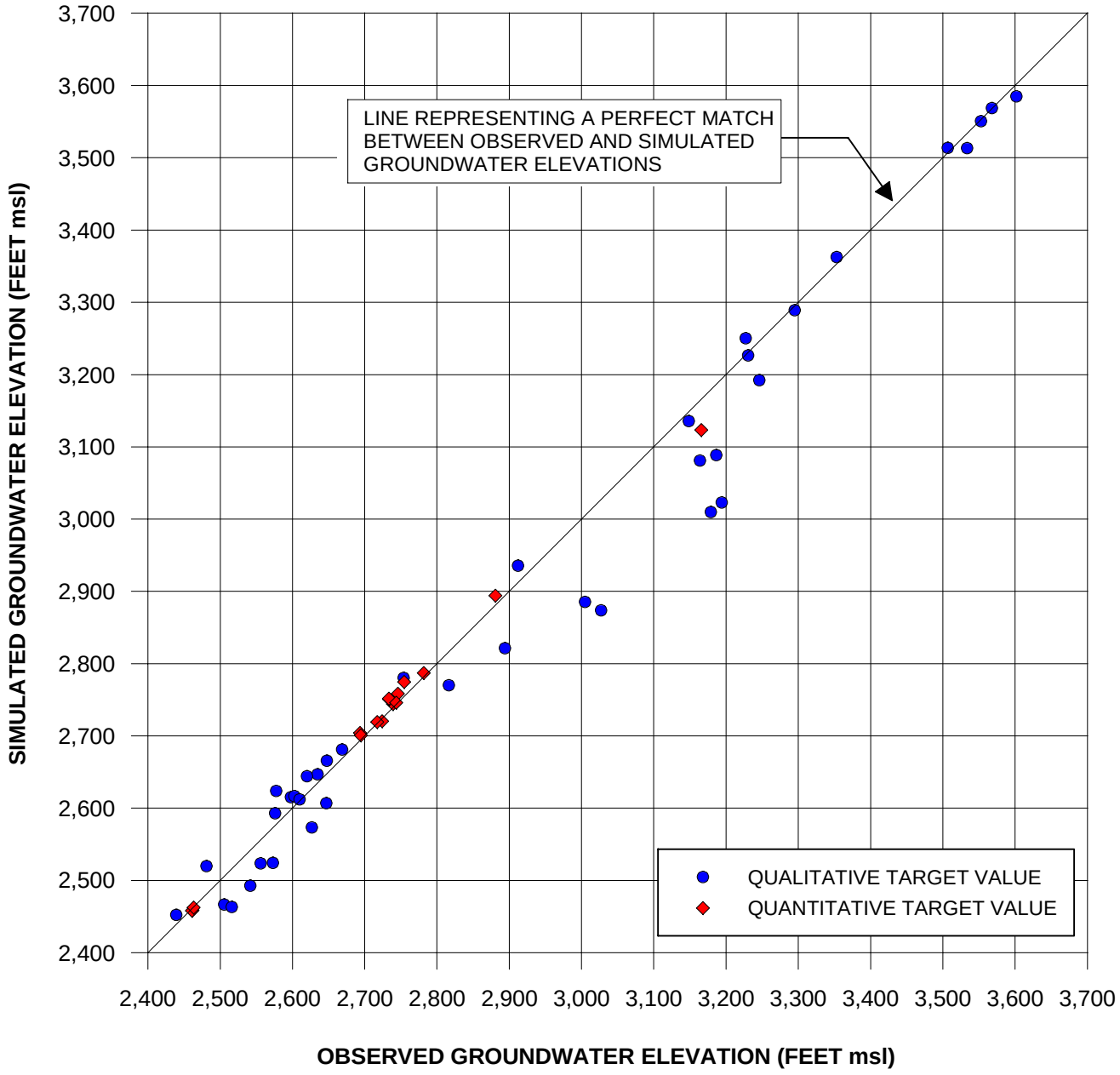
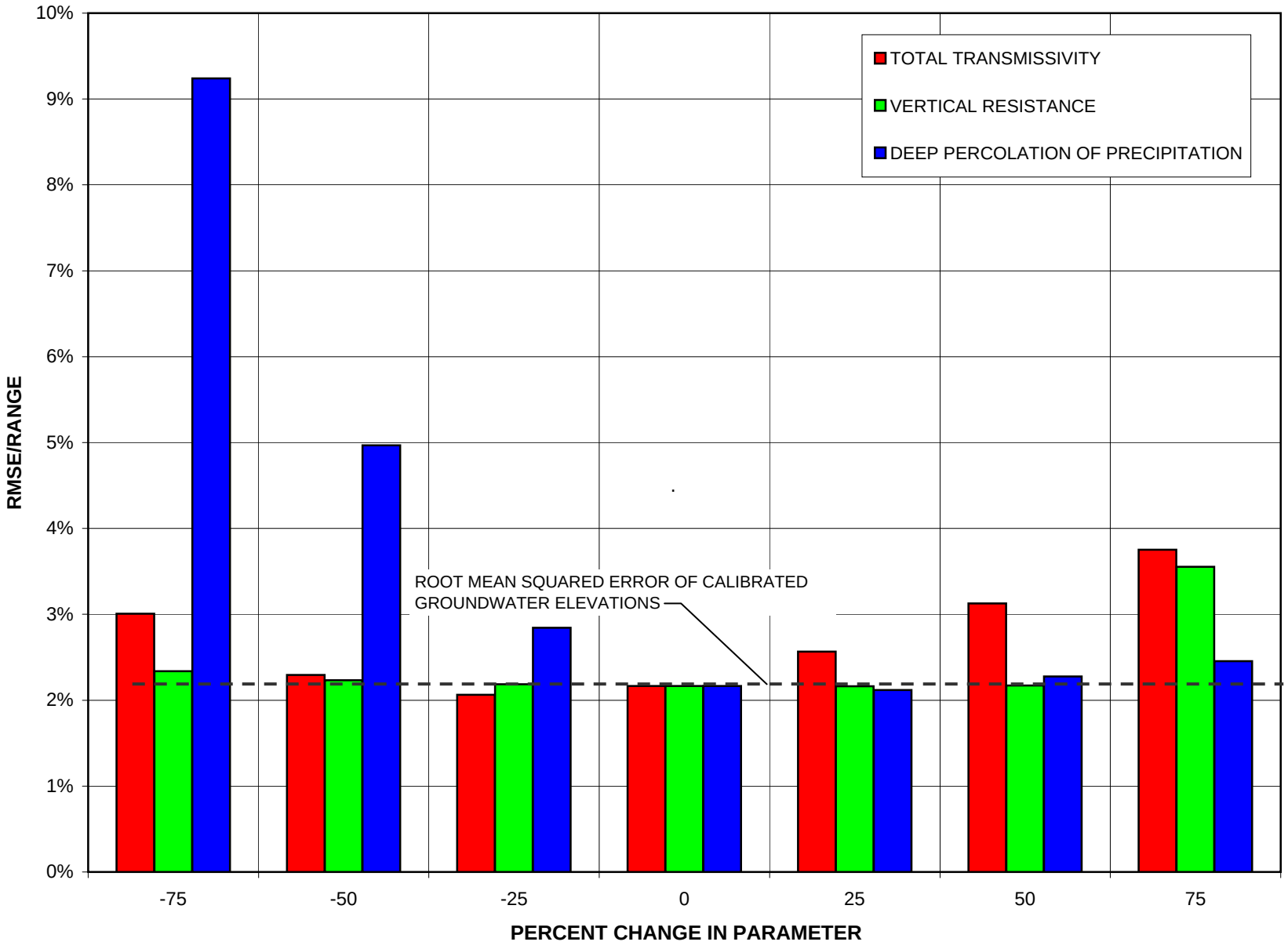


FIGURE G-6
SIMULATED VERSUS OBSERVED GROUNDWATER ELEVATIONS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

\\ODIN\PROJ\USEPA\184646LC02RIFS\Figures\Grapher\OU2_RI\OU2_RI_FIG_G-06.grf



NOTE:
RMSE/RANGE = ROOT MEAN SQUARED ERROR DIVIDED BY THE RANGE IN MEASURED GROUNDWATER ELEVATIONS

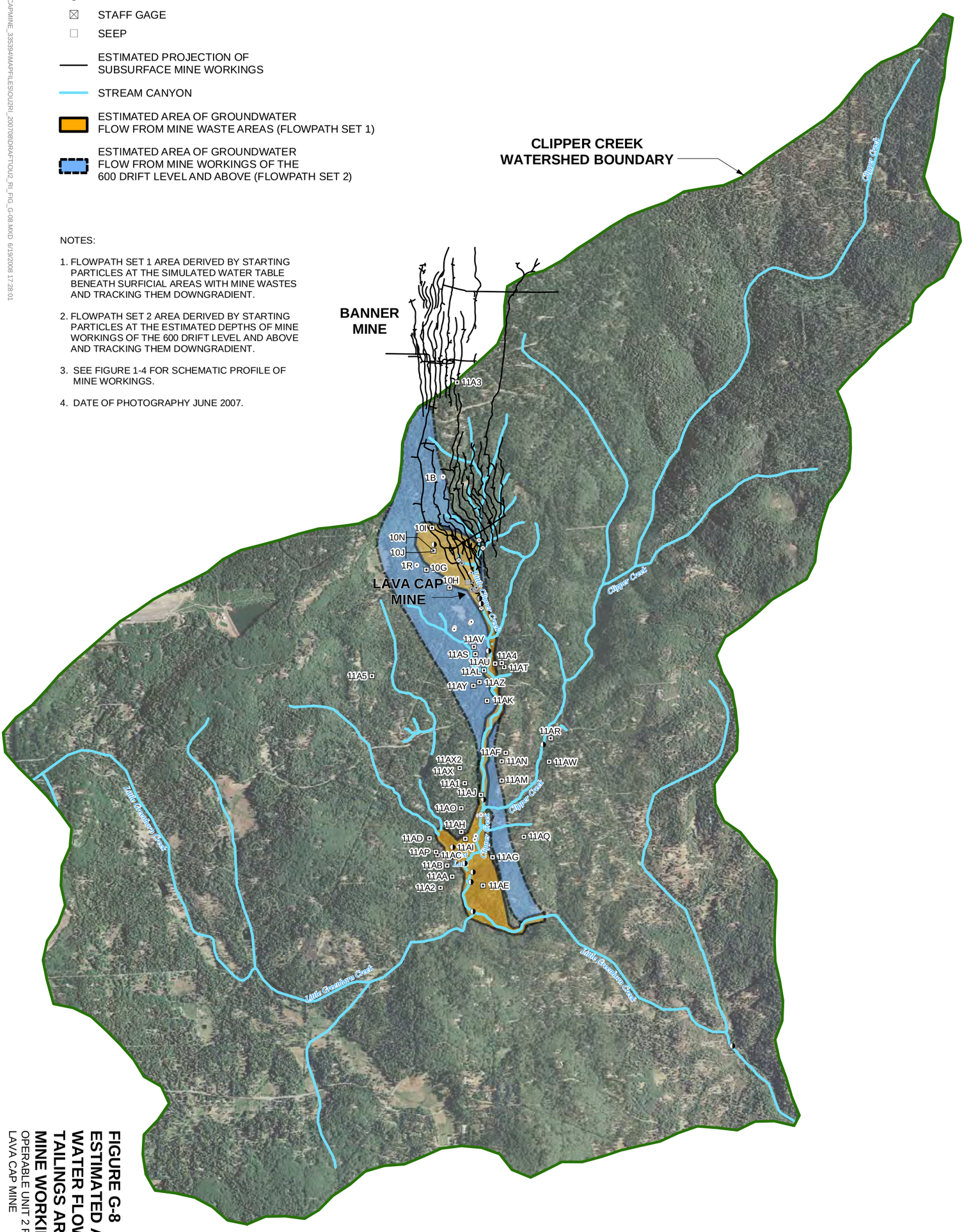
FIGURE G-7
SENSITIVITY ANALYSIS RESULTS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

LEGEND

- MONITORING WELL
- PIEZOMETER
- RESIDENTIAL WELL
- SURFACE WATER SAMPLE LOCATION
- STREAM GAGE AND SURFACE WATER SAMPLE LOCATION
- STAFF GAGE
- SEEP
- ESTIMATED PROJECTION OF SUBSURFACE MINE WORKINGS
- STREAM CANYON
- ESTIMATED AREA OF GROUNDWATER FLOW FROM MINE WASTE AREAS (FLOWPATH SET 1)
- ESTIMATED AREA OF GROUNDWATER FLOW FROM MINE WORKINGS OF THE 600 DRIFT LEVEL AND ABOVE (FLOWPATH SET 2)

NOTES:

1. FLOWPATH SET 1 AREA DERIVED BY STARTING PARTICLES AT THE SIMULATED WATER TABLE BENEATH SURFICIAL AREAS WITH MINE WASTES AND TRACKING THEM DOWNGRADIENT.
2. FLOWPATH SET 2 AREA DERIVED BY STARTING PARTICLES AT THE ESTIMATED DEPTHS OF MINE WORKINGS OF THE 600 DRIFT LEVEL AND ABOVE AND TRACKING THEM DOWNGRADIENT.
3. SEE FIGURE 1-4 FOR SCHEMATIC PROFILE OF MINE WORKINGS.
4. DATE OF PHOTOGRAPHY JUNE 2007.



N

0 2,400 4,800 FEET

FIGURE G-8
ESTIMATED AREA OF GROUND-WATER FLOW FROM SURFICIAL TAILINGS AREAS AND SHALLOW MINE WORKINGS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

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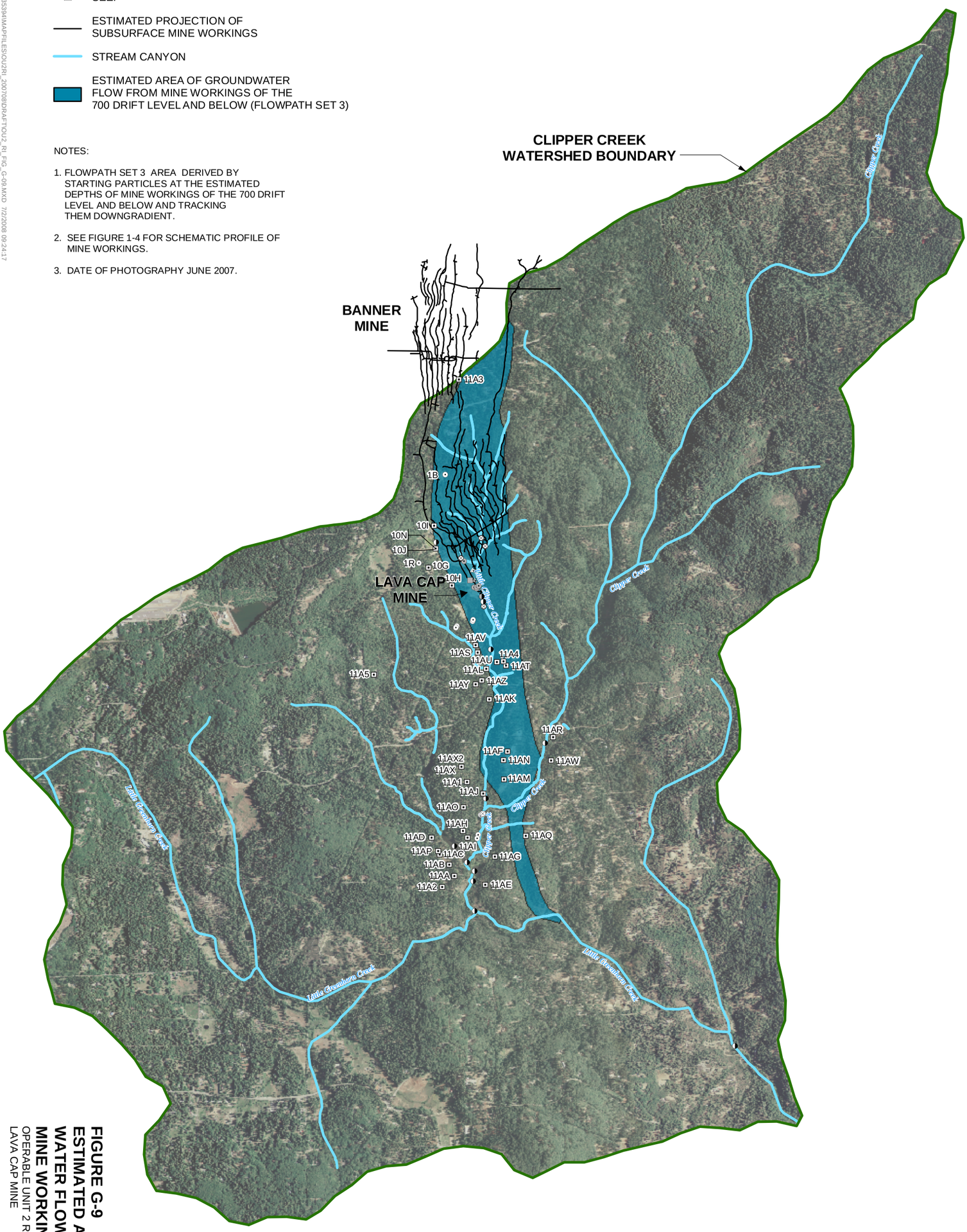
LEGEND

- MONITORING WELL
- PIEZOMETER
- RESIDENTIAL WELL
- SURFACE WATER SAMPLE LOCATION
- STREAM GAGE AND SURFACE WATER SAMPLE LOCATION
- STAFF GAGE
- SEEP
- ESTIMATED PROJECTION OF SUBSURFACE MINE WORKINGS
- STREAM CANYON
- ESTIMATED AREA OF GROUNDWATER FLOW FROM MINE WORKINGS OF THE 700 DRIFT LEVEL AND BELOW (FLOWPATH SET 3)

NOTES:

1. FLOWPATH SET 3 AREA DERIVED BY STARTING PARTICLES AT THE ESTIMATED DEPTHS OF MINE WORKINGS OF THE 700 DRIFT LEVEL AND BELOW AND TRACKING THEM DOWNGRADIENT.
2. SEE FIGURE 1-4 FOR SCHEMATIC PROFILE OF MINE WORKINGS.
3. DATE OF PHOTOGRAPHY JUNE 2007.



N

0 2,400 4,800 FEET

FIGURE G-9
ESTIMATED AREA OF GROUND-WATER FLOW FROM DEEP MINE WORKINGS
OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT
LAVA CAP MINE

\\LOKI\PROJECTS\RDDG\SLAVACAPMINE_335394\MAPFILES\OU2\RI_2007\08\DRAFT\OU2_RI_FIG_G-09.MXD 7/2/2008 09:24:17

Appendix H
Arsenic Concentration Tables

TABLE H-1
Arsenic Concentrations in Background Area Monitoring Wells
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		**1B**		**1R**	
Event	**Date**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**
4Q99	Oct/Nov-99	55	21.7		
1Q00	Dec-99/Jan-00	36.7			
2Q00	May/Jun-00	29			
3Q00	Sep-00	22.6			
3Q01	Aug-01	16.8	16.4		
4Q01	Nov-01	17.3	16		
1Q02	Feb-02	18	18	9.7 (13)	10.0
2Q02	May-02	16	16	21	19
3Q02	Aug-02	14	14	25	24
4Q02	Nov-02	14	12	27	24
1Q03	Feb-03	11 (11)	12 (12)	17	18
2Q03	May-03	13	13	24	23
3Q03	Aug-03	12	11	21	17
4Q03	Dec-03				
1Q04	Mar-04	11	10	20	18
2Q04	Jun-04				
3Q04	Sep-04	13	12	22	22
4Q04	Dec-05				
1Q05	Apr-05				21.4
2Q05	Jun/Jul-05				
3Q05	Sep/Oct-05		24.2 J		19.1 J
2Q06	Apr-06		1.2		19.8
4Q06	Oct-06		2.9 J (2.6 J)		18.9 J

Notes:

Units are µg/L.
Results in parenthesis are field duplicates.
J = estimated value

TABLE H-2
Arsenic Concentrations in Source Area and Mine Area Monitoring Wells
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		5A		5D		5E		5I		5J		5PZ-1		5PZ-2		5PZ-3		5K-S	5K-D	5L-S	5L-D
Event	**Date**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unfiltered**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Filtered**	**Filtered**	**Filtered**	**Filtered**
4Q99	Oct/Nov-99	356 (362)	393 (369)	18.8	12.5	391	399														
1Q00	Dec-99/Jan-00	262		15.3 (15.9)		448															
2Q00	May/Jun-00	300		186		441		160 (157)	151												
3Q00	Sep-00	382		90.3		434		168													
3Q01	Aug-01	321 J	322 J	46.1 J (42.9 J)	28.8 J (28.2 J)	610 J	466 J	1,080 J	181 J												
4Q01	Nov-01			40.1	29.3	272	88.3	173 (163)	84.2 (81.7)	64.9	44.6										
1Q02	Feb-02	220	220	24	12	330	280	0.5 U	61	47	77										
2Q02	May-02			22	14			110	42	59 (21)	52 (44)										
3Q02	Aug-02	180	190	95	25	470	320	130	25	87 (88)	70 (76)										
4Q02	Nov-02			27	20	210 (190)	150 (140)	89	58	69	64										
1Q03	Feb-03	260	250	13	3.8	460	380	220	25	77	74										
2Q03	May-03			12	4.3	420	410	180	40	92	91										
3Q03	Aug-03																				
4Q03	Dec-03																				
1Q04	Mar-04	230 (240)	230 (230)	12	5.5	3,200	430	220	23	82	82										
2Q04	Jun-04					520	470	130	49												
3Q04	Sep-04	650	610	36 (36)	28 (28)	460	450	330	73	92	95			270	270	640	610				
4Q04	Dec-05		305		28.5		306		11.8 (11.7)		93.2	411	1.0 U	163	151	969	841				
1Q05	Apr-05		226		3.8		389		34.8		97.6 (100[a])		9.3[a]		280[a]		871[a]				
2Q05	Jun/Jul-05		208		6.7 (5.6)		380		23.4		190		0.43 J		244		824	1.4 (1.3)	33.8		
3Q05	Sep/Oct-05		316 J (305 J)		22.6 J		404 J		58.5 J		166 J		1.7 J		373 J		501 J	5.8	27.5		
2Q06	Apr-06		210				430		21.7		192 (235)						703	4.7	19.5		
4Q06	Oct-06		AB		AB		AB		AB		AB				AB		AB	6.7 J	10.9 J		
1Q07	Mar-07		AB		AB		AB		AB		AB		9.4		AB		AB	7.1	8.6	85.4	21.3
2Q07	May/June-07		AB		AB		AB		AB		AB				AB		AB	3.3	8.2	30.8	30.2

[a]Field filtered using a 0.1-micron filter instead of a 0.45-micron filter as were other filtered samples.

Notes:

Units are µg/L.
Results in parenthesis are field duplicates.
AB = abandoned between June and July 2006 as part of the OU-1 remedial activities
J = estimated value
U = nondetect at the specified concentration
Unf. = unfiltered

TABLE H-3
Arsenic Concentrations in Lost Lake/Deposition Area Monitoring Wells
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		**13Q**		**13R**		**13S**		**13T**	
Event	**Date**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**
4Q99	Oct/Nov-99								
1Q00	Dec-99/Jan-00								
2Q00	May/Jun-00	411	235	2,180	1,810				
3Q00	Sep-00	235		2,430 (2,350)					
3Q01	Aug-01	199	171	2,330	2,270				
4Q01	Nov-01	228	218	2,000	2,010	3.9 (3.5)	3.5 (3.2)		
1Q02	Feb-02	200	82	1,200	1,100	6.0	6.0		
2Q02	May-02	100	100	1,400	1,500	4.5	4.6		
3Q02	Aug-02	130 (140)	95 (94)	1,700	1,500	2	2		
4Q02	Nov-02	110	120	1,800	1,700	4.5	3.6		
1Q03	Feb-03	200	95	1,400	1,100	2.7	3.1		
2Q03	May-03	150	130	1,900 (1,600)	1,800 (1,700)	5.4	2.9		
3Q03	Aug-03								
4Q03	Dec-03								
1Q04	Mar-04	210	110	1,700	1,700	3.1	3.0		
2Q04	Jun-04								
3Q04	Sep-04	160 J	160	1,700	1,600	4.2	4.1		
4Q04	Dec-05						3.8		
1Q05	Apr-05		96.9		975		3.3 (3.8)		
2Q05	Jun/Jul-05						3.7		
3Q05	Sep/Oct-05		113 J		961 J		3.4 J (3.7 J)		
2Q06	Apr-06		63.7		529		5.2		
4Q06	Oct-06		174 J		759 J		5.1 J		
1Q07	Mar-07		154		1,140		5.5		104 (106)
2Q07	May/June-07				627				35.4 (34.6)

Notes:

Units are µg/L.
Results in parenthesis are field duplicates.

J = estimated value

TABLE H-4
Arsenic Concentrations in Background Area Residential Wells
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		**11A3**		**11AR**		**11AW**		**11A5**	
Event	**Date**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**
4Q99	Oct/Nov-99								
1Q00	Dec-99/Jan-00								
2Q00	May/Jun-00			0.1 J					
3Q00	Sep-00								
3Q01	Aug-01								
4Q01	Nov-01								
1Q02	Feb-02								
2Q02	May-02								
3Q02	Aug-02								
4Q02	Nov-02								
1Q03	Feb-03								
2Q03	May-03					0.41 J			
3Q03	Aug-03					0.5 U (0.5 U)			
4Q03	Dec-03								
1Q04	Mar-04								
2Q04	Jun-04								
3Q04	Sep-04								
4Q04	Dec-05								
1Q05	Apr-05								
2Q05	Jun/Jul-05	1.0 U							
3Q05	Sep/Oct-05	1.0 U							
2Q06	Apr-06	1.0 U				0.22 J			
4Q06	Oct-06	1.0 U				0.20 J		1.0	

Notes:

Units are µg/L.
Results in parenthesis are field duplicates.
J = estimated value
U = nondetect at the specified concentration
Unf. = unfiltered

TABLE H-5
Arsenic Concentrations in Mine Area Residential Wells
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		10G		10H		10I		10J		10N	
Event	**Date**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**
4Q99	Oct/Nov-99	33.4		17.6		528					
1Q00	Dec-99/Jan-00					377		55.1			
2Q00	May/Jun-00	11.2						56.8			
3Q00	Sep-00										
3Q01	Aug-01	28.5	40.7[a]	16 U	15.9 U			41.9	28.6[a]		
4Q01	Nov-01	33.2	32.8	21.1	21.9			42.7	42.6		
1Q02	Feb-02		24		25				52		
2Q02	May-02	35		31							
3Q02	Aug-02	38		20				49 (47)			
4Q02	Nov-02	41 [37.5]		20 (21) [20 (19.7)]				AB		43 [43.4]	
1Q03	Feb-03	11 (12)		7.1						52	
2Q03	May-03	10		7.2						41 (42)	
3Q03	Aug-03	34									
4Q03	Dec-03	35		7.3							
1Q04	Mar-04	13		22						52	
2Q04	Jun-04	18		30						34	
3Q04	Sep-04	30		22						35	
4Q04	Dec-04	31.5		31.7						36.3	
1Q05	Apr-05	13.8		23.5 (22.8)						54.7	
2Q05	Jun/Jul-05	7.1		NA						28.9	
3Q05	Sep/Oct-05	28.9 J		20.4 J						33.5 J	
2Q06	Apr-06	14.6 (15.1)	15[b]	2.5	2.6[b]					40.8	39[b]
4Q06	Oct-06	34.9 (32.7)	0.88[b] J (0.56[b] J)	20.4	3.4[b]					41.9	27[b]

[a]The field crew might have reversed the labels on the bottles from the filtered samples for 10G and 10J, however this could not be confirmed.

[b]Filtered arsenic result is from arsenic speciation analysis (Method 200.8).

Notes:

Units are µg/L.
Results in parenthesis are field duplicates.
Results in brackets are laboratory split samples.
AB = abandoned
J = estimated value
U = nondetect at the specified concentration

TABLE H-6
Arsenic Concentrations in Downgradient Area Residential Wells along Little Clipper Creek, below the Mine and above Greenhorn Road
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		11AL		11AS		11AT		11AU		11AV		11AY		11AZ		11A4	
Event	**Date**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**
4Q99	Oct/Nov-99	31.7 (32.4)															
1Q00	Dec-99/Jan-00	28.5															
2Q00	May/Jun-00	46.3															
3Q00	Sep-00																
3Q01	Aug-01	34.3 (34.1)	34.2 (33.1)	144	137	0.2 J	0.2 J	2.8	2.7	37.5	34.3						
4Q01	Nov-01	30.3	29.5	171	152	0.2 J	0.3 J	3.1	3.3	87.6	88.7						
1Q02	Feb-02		42		120 (120)				6.4		14 (14)						
2Q02	May-02	40		160				4.9 (5.1)		28							
3Q02	Aug-02	31		140				2.9		40							
4Q02	Nov-02	30 [32.9]		270 [178]				3.4 [3.4]		120 [124]							
1Q03	Feb-03	42		110				3.0		12							
2Q03	May-03	47 (47)						2.7		890							
3Q03	Aug-03	35								30							
4Q03	Dec-03	33															
1Q04	Mar-04	90		2.1 (2.1)				5.7		3.5							
2Q04	Jun-04	40		88		0.5 U		2.8		33 (32)							
3Q04	Sep-04	35		62				2.9		55							
4Q04	Dec-04	18.7		46.0				3.0		19.1							
1Q05	Apr-05	36.2		117.0				1.9 (1.9)		4.4							
2Q05	Jun/Jul-05											1.2		1.4			
3Q05	Sep/Oct-05	32.9		111 (107)				2.5		14.8 J		1.5		2.4			
2Q06	Apr-06	30.9	28[a]	55.9	48[a]	1 U		1.4	1.5[a]		0.5[a] U	0.98 J		2.1			
3Q06	Sept-06	31		100		0.5 U		2.9 (2.1)		23						2	
4Q06	Oct-06	29.1	22[a]	86.9	15[a]	0.23 J		2.6	0.65[a] J	29.3	13[a]	1.1		2.3		2.1 (2.3)	
1Q07	Mar-07	40.2		93		0.31 UJ		2.5		9.1						0.84 UJ (0.68 UJ)	
2Q07	May/June-07															2 (2)	

[a]Filtered arsenic result is from arsenic speciation analysis (Method 200.8).

Notes:

Units are µg/L.
Results in parenthesis are field duplicates.
Results in brackets are laboratory split samples.
J = estimated value
U = nondetect at the specified concentration

TABLE H-7
Arsenic Concentrations in Downgradient Area Residential Wells along Little Clipper Creek, between Greenhorn Road and the Deposition Area
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		11AF		11AJ		11AK		11AM		11AN		11AO		11AQ		11AX/11AX2		11A1	
Event	**Date**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**
4Q99	Oct/Nov-99	1		0.2 U		1.2		0.2 U		0.2 U		0.4 J		0.3 J					
1Q00	Dec-99/Jan-00																		
2Q00	May/Jun-00	1.8		0.1 J		1.2		0.3 J		0.3 J		0.3 J		0.5 J					
3Q00	Sep-00																		
3Q01	Aug-01	1.9J	1.4							0.3 J	0.3 J								
4Q01	Nov-01	1.8 (1.1)	0.6 (0.7)	0.2 U	0.2 U														
1Q02	Feb-02											**	**						
2Q02	May-02	**		**															
3Q02	Aug-02	1.4 [1.5]										0.5 U [0.5 U]							
4Q02	Nov-02	1.3 [1.5]		0.5 U [0.2]				0.5 [0.7]		0.6 [0.6]		0.5 U (0.5 U) [0.2 (0.3)]							
1Q03	Feb-03	1.3		0.3 J															
2Q03	May-03	1.7								9.8		0.42 J		0.35 J					
3Q03	Aug-03													0.5 U					
4Q03	Dec-03																		
1Q04	Mar-04			0.29 J						0.25U (0.25U)						0.67			
2Q04	Jun-04	1.5 (1.4)						0.54		0.56		0.49 J				2.7			
3Q04	Sep-04			0.36 J (0.25 U)						0.65		0.37 J							
4Q04	Dec-04	1.8						2.0 U						1.0 U		3.5 (3.3)			
1Q05	Apr-05			0.21 J						1 U		0.28 J							
2Q05	Jun/Jul-05																	1 U	
3Q05	Sep/Oct-05			1 UJ						1 UJ		1 UJ						1 U	
2Q06	Apr-06	1.2						0.29 J								0.6 J		0.24 J	
4Q06	Oct-06	0.89 J (0.81 J)						0.37 J								16.8[a] {1.0[b] U}		0.44 J	
1Q07	Mar-07															0.59[b] UJ			
2Q07	May/June-07															0.54[b] UJ			

[a]Well is no longer in operation, sampled water was stagnant and not representative of true groundwater conditions. This well was replaced by new Well 11AX2.
[b]Result from new Well 11AX2.

Notes:
Units are µg/L.
Results in parenthesis are field duplicates.
Results in square brackets [ ] are laboratory split samples.
Results in curly brackets { } are from samples collected in December 2006.
J = estimated value
U = nondetect at the specified concentration
** = Data values removed; previously reported detections are erroneous because of interference problems in the laboratory.

TABLE H-8
Arsenic Concentrations in Lost Lake/Deposition Area Residential Wells
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		11AA		11AB		11AC		11AD		11AE		11AG		11AH		11AI		11AP		11A2	
Event	**Date**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**
4Q99	Oct/Nov-99	0.4 U		0.2 J		0.2 U (0.2 U)		0.2 U		0.2 U		0.2 U		0.2 U		0.2 U		0.3 J			
1Q00	Dec-99/Jan-00																				
2Q00	May/Jun-00	0.64		0.5 J		0.2 U		0.1 J		0.1 U		0.1 U		0.1 U		0.1 U		0.2 J (0.2 J)			
3Q00	Sep-00																				
3Q01	Aug-01	0.2 U	0.2 U							0.2 U	0.2 U					0.2 U	0.2 U	0.2 U	0.2 U		
4Q01	Nov-01	0.2 U	0.2 U							0.2 U	0.2 U										
1Q02	Feb-02			**	**							**	**								
2Q02	May-02							**										**			
3Q02	Aug-02			2 U [0.5 U]						0.5 U		0.5 U [0.5 U]				0.5 U [0.5 U]					
4Q02	Nov-02	0.5 U [0.2 U]		0.4 J [0.6]				0.3 J [0.6]		0.5 U [0.2]		0.5 U [0.2 U]				0.5 U [0.3]		0.5 U [0.3]			
1Q03	Feb-03			0.5 U				0.5										5 U			
2Q03	May-03							0.35 J		0.5 U		0.5 U		0.5 U		0.5 U					
3Q03	Aug-03																				
4Q03	Dec-03																				
1Q04	Mar-04			0.56 (0.52)				0.3 J										0.5 U			
2Q04	Jun-04	0.25 J								0.5 U				0.5 U							
3Q04	Sep-04							0.48 J				0.5 U				0.5 U					
4Q04	Dec-04	1.0 U		1.0 U										1.0 U				2.0 U			
1Q05	Apr-05											1 U				1 U					
2Q05	Jun/Jul-05																			1 U	
3Q05	Sep/Oct-05	0.09 UJ								1 U		0.27 UJ				1 UJ				1 U	
2Q06	Apr-06			0.25 J				0.23 J												1 U	
4Q06	Oct-06			0.24 J				0.12 J												1 U	

Notes:
Units are µg/L.
Results in parenthesis are field duplicates.
Results in brackets are laboratory split samples.
J = estimated value
U = nondetect at the specified concentration
Unf. = unfiltered
** = Data values removed; the previously reported detections are erroneous because of interference problems in the laboratory.

TABLE H-9
Arsenic Concentrations in Residential Wells Equipped with U.S. Environmental Protection Agency Treatment Units
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		**10G**		**10H**		**11AL**		
Event	**Date**	**Wellhead**	**Treated**	**Wellhead**	**Treated**	**Wellhead**	**Guest House**	**Main House**
4Q03	Dec-03	35	0.25 U	7.3	0.25 U	33		1.5
1Q04	Mar-04	13	0.5 U	22	0.41 J	90		1.3
2Q04	Jun-04	18	0.5 U	30	1.0	40		7.2
3Q04	Sep-04	30	0.5 U	22	NA	35	6.9	
4Q04	Dec-04	31.5	1.0 U	31.7		18.7	1.7	3.2
1Q05	Apr-05	13.8		23.5 (22.8)		36.2		
2Q05	Jun/Jul-05	7.1	0.2 J				0.43 J	6.5
3Q05	Sep/Oct-05	28.9 J	28.9 J	20.4 J		32.9	0.3 UJ	3.6
2Q06	Apr-06	14.6 (15.1)	1 U	2.5		30.9	3.4	2.5
4Q06	Oct-06	34.9 (32.7)	0.14 J			29.1	2.0	1.9
1Q07	Mar-07	14.3	0.55 UJ			40.2	1.8	24.8

Notes:
Units are μg/L.
Results in parenthesis are field duplicates.
J = estimated value
U = nondetect at the specified concentration
NA = Not applicable; EPA moved the residents out in 2004 and the treatment system was shut down. The residence was subsequently demolished as part of the OU-1 remedial action.

TABLE H-10
Arsenic Concentrations in Background Area Surface Water
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		1J (LCC)		1U (LCC side channel)		2G (CC)	
Event	**Date**	**Unf.**	**Filtered**	**Unf.**	**Filtered**	**Unf.**	**Filtered**
4Q99	Oct/Nov-99						
1Q00	Dec-99/Jan-00	0.5					
2Q00	May/Jun-00	0.3 J				0.1 J	
3Q00	Sep-00						
3Q01	Aug-01	Dry				0.2 J	0.2 U
4Q01	Nov-01	Dry				0.2 U	0.2 U
1Q02	Feb-02	0.9	0.8			0.7	0.8
2Q02	May-02	0.9	0.7			0.9	0.9
3Q02	Aug-02	Dry				3.8	0.5 U
4Q02	Nov-02	Dry				0.5 U	0.5 U
1Q03	Feb-03	0.3 J	0.4 J			0.5 U	0.5 U
2Q03	May-03	0.34 J	0.31 J			0.5 U	0.5 U
3Q03	Aug-03	Dry				Dry	
4Q03	Dec-03	Dry				Dry	
1Q04	Mar-04	0.5 U	0.26 J			0.5 U	0.5 U
2Q04	Jun-04	Dry				0.5 U	0.5 U
3Q04	Sep-04	Dry				Dry	
4Q04	Dec-04	Dry				Dry	
1Q05	Apr-05	0.22 J				0.08 J	
2Q05	Jun/Jul-05	Dry				Dry	
3Q05	Sep/Oct-05	Dry				1 UJ	
2Q06	Apr-06	0.23 J				1 U	
4Q06	Oct-06	Dry				0.09 J	
1Q07	Mar-07	0.31 UJ		0.35 UJ			

Notes:
Units are µg/L.
Results in parenthesis are field duplicates.
CC = Clipper Creek
J = estimated value
LCC = Little clipper Creek
U = nondetect at the specified concentration
Unf. = unfiltered

TABLE H-11
Arsenic Concentrations in Source Area and Mine Area Surface Water
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		3A (adit)		3B (seep)		4A/4A2 (base of dam)	
Event	**Date**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**
4Q99	Oct/Nov-99	567				146	
1Q00	Dec-99/Jan-00	199		50		112	
2Q00	May/Jun-00	489		27.2		146	
3Q00	Jul-00			383			
3Q00	Sep-00	584				532	
3Q01	Aug-01	557J (556J)	530J (514J)	dry		252J	96.2J
4Q01	Nov-01	481	441	dry		213	180
1Q02	Feb-02	400	440	120	41	84	83
2Q02	May-02	440	390	45 (42)	38 (34)	100	96
3Q02	Aug-02	700	410	dry		270 (260)	170 (170)
4Q02	Nov-02	910	510	dry		230	160
1Q03	Feb-03	580	440			78	77
2Q03	May-03	520	470	60	42	78	70
3Q03	Aug-03	480 (480)	390 (390)	dry		200	170
4Q03	Dec-03	230	150	dry		110	100
1Q04	Mar-04	520	470	32	31	71	68
2Q04	Jun-04	530	480	dry		150 (160)	120 (130)
3Q04	Sep-04	570		dry		270	
4Q04	Dec-04	464		38.4		112	
1Q05	Apr-05	438 (468)		29.1		49.8	
2Q05	Jun/Jul-05	425				81	
3Q05	Sep/Oct-05	542 J		80.2 J		115 J	
2Q06	Apr-06	466 (464)	360[a] (390[a])			144	
4Q06	Oct-06	809	130[a]	NA		46[b] [pipe] 29.7[b] [seep]	
1Q07	Mar-07	468 (470)				16.5[b] [combined flow] 208[b] [pipe]	
2Q07	May/June-07	503				186[b] [pipe]	

[a]Filtered arsenic result is from arsenic speciation analysis (Method 200.8).

[b]Sample collected from Location 4A2 after completion of the Rock Buttress.

Notes:
Units are µg/L.
Results in parenthesis are field duplicates.
J = estimated value
NA = Not applicable; sampling location no longer exists (the spring's source water was diverted or blocked as part of the OU-1 remedial action).

TABLE H-12
Arsenic Concentrations in Downgradient Area Surface Water
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		**12J (LCC)**		**19M (LGC)**	
Event	**Date**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**
4Q99	Oct/Nov-99	110			
1Q00	Dec-99/Jan-00	68			
2Q00	May/Jun-00	66.2			
3Q00	Sep-00				
3Q01	Aug-01	102	56.8	4.1	3.9
4Q01	Nov-01	274	68.8	1.8	1.8
1Q02	Feb-02	82 (68)	34 (35)	6.7	5.6
2Q02	May-02	65	52	8.7	8.0
3Q02	Aug-02	110	68	3.1	2.8
4Q02	Nov-02	110	77	3.8	3.0
1Q03	Feb-03	52	50	6.8 (6.8)	5.7 (6.0)
2Q03	May-03	62	52	11	9.4
3Q03	Aug-03			4.5	4.2
4Q03	Dec-03	56	54	9.2	7.5
1Q04	Mar-04	53 (53)	46 (47)	8.9	6.6
2Q04	Jun-04			3.7	3.1
3Q04	Sep-04	91		1.8	
4Q04	Dec-04	44.6		5.3	
1Q05	Apr-05	42		6.7	
2Q05	Jun/Jul-05				
3Q05	Sep/Oct-05	62.3 J (56.2 J)		2.8	
2Q06	Apr-06	21.9	20[a]	4.3	
4Q06	Oct-06	164	50[a]	3.1	
1Q07	Mar-07	43.6			
2Q07	Jun-07				

[a]Filtered arsenic result is from arsenic speciation analysis (Method 200.8).

Notes:
Units are µg/L.
Results in parenthesis are field duplicates.
LCC = Little Clipper Creek
LGC = Little Greenhorn Creek

TABLE H-13
Arsenic Concentrations in Lost Lake/Deposition Area Surface Water
Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site, Nevada City, California

Location		**14E (LCC)**		**16B (Lost Lake)**		**16C (Lost Lake)**		**19B (CC)**	
Event	**Date**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**	**Unfiltered**	**Filtered**
4Q99	Oct/Nov-99			42.7		70.6		72.3J	
1Q00	Dec-99/Jan-00			6		21.5		64.9	
2Q00	May/Jun-00			24.7		32.3		68	
3Q00	Sep-00								
3Q01	Aug-01			99.7	47.6	121	45.8	95.5	77.3
4Q01	Nov-01			100 (101)	22.3 (23.5)	44.4	8.5	310	6.5
1Q02	Feb-02			6.2	5.6	11	9.8	46	9.7
2Q02	May-02			28	20	23	21	340	20
3Q02	Aug-02			97	38	66	32	180J	24
4Q02	Nov-02			44	18	42 (42)	29 (28)	100	16
1Q03	Feb-03			6.5	3.7	17	12	97	12
2Q03	May-03			11	9.7	30	22	340 (210)	10 (13)
3Q03	Aug-03			78	33	61	51	2,200	13
4Q03	Dec-03			14 (14)	8.3 (7.4)	54	24	71	30
1Q04	Mar-04			16	6.4	25	16	24	19
2Q04	Jun-04			54	20	37	28	51	40
3Q04	Sep-04			120		430 (540)		94 J	
4Q04	Dec-04			14.1		20.5		307 (640)	17.1 (11.2)
1Q05	Apr-05			4.9 (4.8)		18		279	
2Q05	Jun/Jul-05			22.4		20.9		145	
3Q05	Sep/Oct-05			26.5 J		33.2		55.9	
2Q06	Apr-06								
4Q06	Oct-06			22.3		34.6		164 J (427 J)	
1Q07	Mar-07		12.6					126	
2Q07	Jun-07		65.9						

Notes:
Units are µg/L.
Results in parenthesis are field duplicates.
CC = Clipper Creek
J = estimated value
LCC = Little Clipper Creek
U = nondetect at the specified concentration

Appendix I
Data Quality Summary

Appendix I is included on the CD-ROM provided with this report.