4.0 Nature and Extent of Affected Materials

In the 2004 RI/FS, which is incorporated by reference, Section 4 described the Site conditions as they existed in 2003. This section now describes Site conditions after the halted 2004 remedial action as the starting point, Site conditions during the 2006 Site characterization excavation work, and current Site conditions as of April 2007. It includes the main Site final survey results as well as the characterization of the stockpiles of contaminated soil. Characterization of the flood plain and clay pits conducted in 2007 is also addressed.

Historical activities left deposits of mining research waste over a large portion of the Site. This section characterizes the nature and extent of affected material on the Site. Contaminants of concern include:

- Metals – Arsenic, lead, mercury, molybdenum, and vanadium
- Radionuclides – Radium, thorium, and uranium

4.1 Summary of Soil Characterization from 2004 RI/FS

The results of New Horizons Site characterization efforts were presented in Section 4 of the 2004 RI/FS. These are incorporated by reference. Summaries and maps of these data are presented in Sections 3.1 and 3.6.1 of this report.

4.2 Applicable Regulatory Classification

A lengthy discussion of the applicable regulatory classification of Site soils was presented in Section 4.1.11 of the 2004 RI/FS. The conclusion of this section was that the soil is "solid waste" that may be disposed of at a solid waste disposal facility that can demonstrate the ability to safely accept and dispose of the soil. The conclusion remains the same in this RI/FS. The 2004 discussion has been updated to include more recent events, and this update is included as Appendix D.

4.3 2006 Site Characterization Results

As described in Section 3, 2006 characterization activities identified soil with radionuclides and/or metals above tentative Site action levels, and these soils were excavated in incremental layers and placed in onsite stockpiles to assist with determining extent of contamination. At the conclusion of characterization activities, all contaminated soil was located in the stockpiles and the material remaining at the main Site met cleanup action levels. This approach allowed determination of the nature of the material (based on *in-situ* and stockpile sampling) and extent of material (based on excavated or stockpile volume and final surveys showing the Site now meets tentative Site action levels).

4.3.1 Nature of Impacted Soil

As described in Section 3.6.4, the 2006 Site characterization was conducted by sampling materials and excavating soils with elevated metals and/or radionuclides above the tentative Site action levels and transporting these materials to the onsite soil stockpiles. This characterization effort was an iterative process where each area was resampled after excavation of material until the tentative action levels were achieved. This section presents the results of the *in-situ* samples that were taken from material that was excavated and transported to the stockpiles after sampling. This does not include samples taken from the stockpiles themselves. It supplements the stockpile samples for determining the nature of affected materials. These sample results demonstrate that only materials that exceeded the tentative Site action levels for radionuclides, metals, or both were excavated and moved to the stockpiles. Appendix E includes laboratory sample results from both the onsite and offsite laboratories.

4.3.1.1 Excavated Material Radionuclide Results

Thirty soil samples were submitted to the offsite laboratory for radionuclide analysis from locations that were excavated and transported to Stockpile B (not including duplicates or stockpile samples). Table 4-1 shows the results. The mean value for Ra-226 exceeded the tentative Site cleanup level. It should be noted that some samples that did not exceed the action levels for radionuclides were excavated because they exceeded a tentative action level for metals.

Table 4-1
Offsite Laboratory Radionuclide Results (pCi/g) Excavated Material

Sample ID	Lab Ra-226	Lab Ra-228	Lab Th-228	Lab Th-230	Lab Th-232	Lab U-234	Lab U-235	Lab U-238
1	2.64	1.39	1.76	2.58	1.49	1.62	-0.17	1.6
2	7.13	2.1	10.3	5.45	11	3.69	-0.48	3.8
4	26.7	2.54	2.85	26.4	2.75	13.6	1.1	14.5
5	20.7	4.31	5.6	24.1	4.63	18.5	2	18.9
6	2.13	1.48	1.51	1.42	1.49	1.15	-0.61	1.11
11	2.79	1.25	1.34	2.21	1.29	1.86	0.4	2.05
12	7.2	1.57	1.29	4.47	1.22	3.88	0.6	3.78
13	8.6	1.67	2.3	7.3	2	3.64	-0.72	3.85
14	5.88	1.21	1.42	4.74	1.31	2.73	0.41	3.25
15	13.2	3.04	2.41	5.48	2.44	4.04	0	3.88
568	7.09	1.18	1.17	5.5	1.12	5.55	0.33	5.73
587	12.8	1.66	1.53	1.74	1.42	1.1	0.66	1.1
596	5.57	1.79	1.79	1.05	1.65	1.35	-0.61	1.25
610	40.7	1.36	1.7	2.51	1.69	1.13	0	1.1
622	14.1	2.1	2.21	3.49	2.1	2.55	0.58	2.65
738	8	1.55	1.5	5.54	1.28	6.05	0.34	6.3
749	7.6	2.85	2.71	8.1	2.44	3.75	0.15	4.09
759	3.85	3.09	2.91	3.18	2.92	3.49	0.32	3.48
768	18	3.33	3.21	19.4	3.27	14.4	0.74	14.6
798	3.56	1.69	1.29	2.15	1.28	2.22	0.095	2.13
832	5.56	1.17	1.33	5.09	1.3	4.59	0.22	5.15
842	17.8	1.6	1.31	9.2	1.32	9.8	0.5	9.6
871	11.1	1.08	1.26	7.9	1.44	5.02	0.15	5.02
895	43.7	2.76	3.08	88	2.95	26	1.09	27.6
912	4.58	4.56	4.19	3.38	3.53	2.62	-0.01	2.6
924	1.98	1.12	0.82	1.01	0.89	1.28	0.26	1.13
944	31.8	2.91	2.34	12.2	2.33	4.4	0.2	4.59

Table 4-1
Offsite Laboratory Radionuclide Results (pCi/g) Excavated Material

Sample ID	Lab Ra-226	Lab Ra-228	Lab Th-228	Lab Th-230	Lab Th-232	Lab U-234	Lab U-235	Lab U-238
956	14.4	2.03	1.81	8.4	1.84	3.94	0.2	3.76
989	14.4	2.77	2.02	9	1.85	5.67	1.2	5.57
1099	3.08	4.24	3.65	1.98	3.54	1.83	-0.01	1.74
Mean*	12.2	2.2	2.4	9.4	2.3	5.4	0.3	5.5
Std Dev.	11.0	1.0	1.8	16.1	1.9	5.7	0.6	6.0

* arithmetic mean

There were a total of 635 soil samples of excavated material with onsite NaI data (not including duplicates or stockpile samples). Table 4-2 shows the results and to which stockpile the material was excavated.

Table 4-2
Onsite Field Laboratory NaI Ra-226 Results Excavated Material

Excavated to Stockpile	Number of Samples	Onsite NaI Data Range (pCi/g)	NaI Mean* (pCi/g)	Standard Deviation
To Stockpile A	2	151 – 733	442.0	411.5
To Stockpile B	633	2 – 532	18.8	41.1

* arithmetic mean

4.3.1.2 Excavated Material Metals Results

A total of 45 soil samples were sent to the offsite laboratory for metals analysis from *in-situ* soils that were excavated (not including duplicates or stockpile samples). As shown in Table 4-3, the mean values for arsenic and lead both exceeded the Site cleanup levels. As noted above, some samples that did not exceed the tentative action levels for metals were excavated because they exceeded an action level for radionuclides.

Table 4-3
Offsite Laboratory Metals Results (mg/kg) Excavated Material

Sample ID	Lab Arsenic	Lab Lead	Lab Mercury	Lab Molybdenum	Lab Vanadium
1	18	78	3.4	24	43
2	21	150	0.99	13	49
4	37	200	0.54	16	58
5	26	150	0.53	25	57
6	12	41	0.24	4	36
11	45	330	1.3	9.3	38
12	230	1,300	3.9	22	40
13	56	1,400	2.7	23	42
14	28	810	12	24	70
15	27	210	2.1	31	41
33	45	320	3.1	190	35

Table 4-3
Offsite Laboratory Metals Results (mg/kg) Excavated Material

Sample ID	Lab Arsenic	Lab Lead	Lab Mercury	Lab Molybdenum	Lab Vanadium
36	29	520	1.9	60	39
39	120	380	3.5	61	25
44	43	240	3.5	190	37
46	47	290	2.7	100	56
47	29	240	5.2	55	37
48	52	120	1.8	1,900	29
49	59	210	2.5	500	42
50	43	150	0.93	23	45
51	33	110	0.3	7.2	40
52	5.5	35	0.4	2.8	29
53	51	230	3.1	48	87
54	27	180	0.88	32	51
450	12	99	3.4	15	44
503	8.3	120	1.5	3.8	36
568	39	330	2.8	6.1	66
587	20	65	0.9	60	47
596	4.1	13	0.23	5.2	22
610	13	150	0.97	120	65
622	11	81	1.6	13	55
738	24	300	2.6	17	45
749	14	140	2.3	24	48
759	5.6	38	0.1	1.7	30
768	9.3	79	2.8	18	94
798	23	1,100	0.45	6	83
832	320	11,000	11	66	45
842	21	450	4.4	25	46
871	26	420	2.1	5.2	25
895	9.2	87	0.27	21	30
912	7.5	110	0.3	2.8	38
924	18	99	0.23	3.5	15
944	49	650	2.4	150	16
956	23	640	2.8	70	28
989	61	250	1.2	28	53
1099	4.6	33	0.045	1.3	28
Mean*	40.1	532.2	2.3	89.4	44.1
Std deviation	56.2	1627.2	2.4	288.2	17.1

* Arithmetic mean

There were a total of 625 soil samples of excavated material with field XRF data (not including duplicates or stockpile samples). Raw XRF data were adjusted for bias (see instrument correlation summary), and results reported as less than the level of detection (<LOD) were

replaced with the lowest observed field XRF reading (also corrected for bias). Table 4-4 shows that the mean values for arsenic and lead both exceeded the Site cleanup levels.

Table 4-4
Field XRF Metals Results (mg/kg) Excavated Material

Metal	XRF Data Range	XRF Mean*	Standard Deviation	Tentative Site Action Level
Arsenic	7 – 3,694	90.8	267.9	39
Lead	19 – 119,710	1372.8	5,568.3	400
Mercury	9.5 - 884	17.4	46.8	23
Molybdenum	15 – 38,321	122.2	1,538.4	390
Vanadium	40 – 4,927	89.2	237.1	550

* Arithmetic mean

4.3.2 Radionuclide Extent

After excavation of soils that exceeded tentative Site action levels, a final gamma surface soil survey was conducted to ensure no areas with elevated activity remained on the Site. To support this survey, final confirmatory sampling was completed following the guidelines in MARSSIM and using the Visual Sampling Plan software.

Fifty-four of the CSMRI soil samples sent to the offsite laboratory (Paragon Analytics) were from sample locations that were not excavated, and thus form part of the basis for the final status survey. This sample set includes 46 samples plus 8 duplicates. These samples were evaluated using EPA's *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media* (EPA 1989). Statistical tests were applied in accordance with Chapter 6 of the referenced document, *Determining Whether the Mean Concentration of the site is Less Than a Cleanup Standard*, Equation 6.8, Computing the Upper One-sided Confidence Limit.

Upper One-Sided Confidence Limit $\mu_{U\alpha} = \bar{x} + t_{1-\alpha,df} \frac{s}{\sqrt{n}}$

Where: $\bar{x}$ = mean level of contamination

s = standard deviation

α = desired false positive rate (the probability that the sample area will be declared to be clean when it is actually dirty), set at 0.05 for CSMRI

df = degrees of freedom, equal to n-1

n = final sample size (i.e., the number of data values available for statistical analysis)

$t_{1-\alpha,df}$ = value from Appendix A in referenced EPA document, Table A-1 of t for selected alpha and degrees of freedom

Table 4-5 shows the results of this statistical test for the radioisotopes of concern at the Site. All computed values are below the tentative Site action levels, thus we can conclude that the Site meets the cleanup standards based on the offsite laboratory results.

Table 4-5
CSMRI Radionuclide Statistics Summary

Radioisotope	Mean ($\bar{x}$) (pCi/g)	Standard Deviation (s)	Upper One-Sided Confidence Limit	Tentative Site Action Level (pCi/g)
Ra-226	3.52	2.28	4.09	4.14
Ra-228	1.95	0.66	2.10	4.6
Th-228	1.88	0.60	2.02	6.47
Th-230	2.27	1.75	2.66	11.53
Th-232	1.76	0.58	1.89	3.88
U-234	2.08	1.84	2.50	254.9
U-235	0.24	0.33	0.32	4.97
U-238	2.14	1.91	2.58	21.8

The main Site was divided into four survey units in accordance with MARSSIM criteria. At the end of the excavation activities, all Class 1 material had been moved to either Stockpile A or B, and the remainder of the Site was classified as a Class 2 area. The maximum size of a Class 2 area is 10,000 square meters. Therefore, the Site required a minimum of three survey units; four survey units were used based on Site topography. Figure 4-1 shows the location of the four survey units, labeled as Zones 1 through 4.

Table 4-6 shows Ra-226 by survey unit (Zones 1 through 4) using all non-excavated field laboratory NaI data points and using field laboratory plus offsite laboratory samples. The data are also shown on Figure 4-2. The survey identified two locations in Zone 2 with elevated activity that were adjacent to sanitary sewer lines and could not be excavated and one location with elevated activity at the edge of a steep slope. However, these three elevated data points were included in the calculations of mean, standard deviation, and upper one-sided confidence limits, demonstrating that the Site cleanup criteria have been achieved.

Table 4-6
CSMRI Ra-226 Statistics by Survey Unit

Zone and Sample Population	Mean (pCi/g)	Standard Deviation	No. of samples (n)	Upper One-sided Confidence Limit
Zone 1 all field samples	3.58	0.96	79	3.76
Zone 1 field plus lab samples	3.48	1.06	79	3.68
Zone 2 all field samples	3.89	1.70	140	4.13
Zone 2 field plus lab samples	3.88	1.87	140	4.14
Zone 3 all field samples	3.35	1.46	112	3.58
Zone 3 field plus lab samples	3.38	1.59	112	3.63
Zone 4 all field samples	3.63	1.27	81	3.87
Zone 4 field plus lab samples	3.56	1.47	82	3.83

Notes:
1. Duplicate samples were not included in the mean and standard deviation calculations.
2. All field samples means all non-excavated field measurements were included in calculation of the mean and standard deviation.
3. Field plus lab samples means all non-excavated field measurements were included except at locations where a sample was sent to the lab, the field value was replaced with the Ra-226 lab value for calculating the mean and standard deviation.
4. Two locations in zone 2 could not be excavated due to sewer line proximity. These were included in the mean and standard deviation. Sample 909 measured 17 pCi/g and sample 976 measured 11 pCi/g.

4.3.3 Metals Extent

Fifty-three of the CSMRI soil samples sent to the offsite laboratory (Paragon Analytics) for metals analysis were from sample locations that were not excavated, and thus form part of the basis for the final status survey. These samples were evaluated using EPA's *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media* (EPA 1989). Statistical tests were applied in accordance with Chapter 6, *Determining Whether the Mean Concentration of the site is Less Than a Cleanup Standard*, Equation 6.8, Computing the Upper One-sided Confidence Limit.

Upper One-Sided Confidence Limit $\mu_{U\alpha} = \bar{x} + t_{1-\alpha,df} \frac{s}{\sqrt{n}}$

Where: $\bar{x}$ = mean level of contamination

s = standard deviation

α = desired false positive rate (the probability that the sample area will be declared to be clean when it is actually dirty), set at 0.05

df = degrees of freedom, equal to n-1

n = final sample size (i.e., the number of data values available for statistical analysis)

$t_{1-\alpha,df}$ = value from Appendix A in referenced EPA document, Table A-1 of t for selected alpha and degrees of freedom

Table 4-7 shows the results of this statistical test for the metals of concern at the Site. All computed values are below the tentative Site action levels, thus we can conclude that the Site meets the cleanup standards based on the offsite laboratory results.

Table 4-7
CSMRI Metals Confirmatory Samples Statistics Summary

Metal	Mean ($\bar{x}$) (ppm)	Standard Deviation (s)	Upper One-Sided Confidence Limit	Tentative Site Action Level (ppm)
Arsenic	14.8	20.2	19.4	39
Lead	99.5	121.1	127.4	400
Mercury	0.6	0.9	0.8	23
Molybdenum	6.6	6.0	8.0	390
Vanadium	32.0	9.2	34.2	550

Table 4-8 shows the metals by survey unit (Zones 1 through 4) using all non-excavated field XRF data points (corrected for bias relative to the laboratory). For XRF data points that were below the instrument detection limit, the detection limit was used, which was based on the lowest observed XRF reading for each metal (corrected for instrument bias). For example, the lowest observed arsenic XRF reading was 5.55 ppm, and the instrument bias was 1.3; therefore, a value of 7 was used for data points reported as <LOD. The cited EPA guidance document recommends using the detection limit (rather than one-half the detection limit, as is often used) for simplicity and because it errs conservatively in favor of health and environmental protection.

Table 4-8
CSMRI Metals Confirmatory Samples Statistics by Survey Unit

Zone and Constituent		Mean (ppm)	Standard Deviation	Number of Samples (n)	Upper One-sided Confidence Limit	Tentative Site Action Level
Zone 1	As	13.24	9.56	79	15.03	39
	Pb	169.08	135.77	79	194.55	400
	Hg	9.51	2.45	79	9.97	23
	Mo	28.80	34.45	79	35.26	390
	V	59.02	22.74	79	63.29	550
Zone 2	As	15.41	15.19	138	17.55	39
	Pb	155.40	139.20	138	175.00	400
	Hg	10.35	4.31	138	10.96	23
	Mo	18.27	5.50	138	19.04	390
	V	58.65	30.11	138	62.89	550
Zone 3	As	15.68	16.87	110	18.35	39
	Pb	208.59	213.65	110	242.41	400
	Hg	10.50	4.82	110	11.26	23
	Mo	23.32	16.85	110	25.99	390
	V	51.38	16.44	110	53.98	550
Zone 4	As	10.64	7.12	77	12.00	39
	Pb	107.08	73.70	77	121.09	400
	Hg	9.82	1.33	77	10.07	23
	Mo	27.80	28.65	77	33.37	390
	V	61.99	50.81	71	72.05	550

Notes:
1. Duplicate samples were not included in the mean and standard deviation calculations.
2. All non-excavated field XRF measurements were included in calculation of the mean and standard deviation. Raw XRF results were corrected for XRF bias as described in Section 3.4.3.2.
3. Only Zone 4 would have met the arsenic action level under the 2004 RI/FS

The following figures present these data.

Figure 4-3 Final Arsenic confirmatory sample results
Figure 4-4 Final Lead confirmatory sample results
Figure 4-5 Final Mercury confirmatory sample results
Figure 4-6 Final Molybdenum confirmatory sample results
Figure 4-7 Final Vanadium confirmatory sample results

4.3.4 CSMRI Mercury Speciation by Sequential Extraction

At the request of CDPHE, four soil samples were submitted to an offsite laboratory to determine mercury speciation. The tentative Site action level for total mercury was set at 23 ppm in the approved Site Characterization Work Plan. In the 2004 ROD, the Site action level was listed as 1.1 ppm for elemental mercury and 23 ppm for mercury compounds. The goal of this analysis was to determine the nature of the mercury at the Site.

Mercury in environmental samples such as soil and groundwater is typically measured as total mercury after acid digestion. However, mercury compounds differ greatly in their toxicity and environmental mobility. Thus, total mercury is a poor indicator of the toxicological and environmental hazard associated with mercury-contaminated sites. The sequential extraction method of mercury speciation is designed to separate a mixture of mercury compounds into five behavioral classes, including water soluble, "stomach acid" soluble, organo-chelated, elemental (metallic) mercury, and mercuric sulfide (cinnabar). Table 4-9 provides a description of the five stages of sequential extraction.

Table 4-9
Sequential Extraction Method Summary

Fraction	Extractant	Description	Typical Compounds
F1	DI water	Water soluble	$HgCl_2$, $HgSO_4$
F2	pH 2 HCl/HOAc	"Stomach acid"	HgO
F3	1N KOH	Organo complexed	Hg-humics, Hg_2Cl_2
F4	12N HNO_3	Strong complexed	Mineral lattice, $Hg2Cl_2$, Hg^0
F5	Aqua regia (HCl, HNO_3)	Cinnabar	HgS, HgSe, HgAu

Four soil samples were submitted to Battelle Marine Sciences Laboratory on September 11, 2006, for mercury speciation analysis. A total mercury analysis was also run as a comparison by cold vapor atomic absorption using EPA Method 245.5. Table 4-10 presents the results.

Table 4-10
Sample Results (µg/g)

Sample	F1	F2	F3	F4	F5	Sum of Fractions	Total Hg	Sum Frac/ Total Hg
1193-r1	0.0072	0.0007	0.0870	0.3642	1.2310	1.690	0.240	704%
1193-r2	0.0051	0.0008	0.0930	0.1049	0.0021	0.206	0.242	85%
1194	0.0010	0.0005	0.0405	0.0265	0.0080	0.076	0.073	104%
1195	0.0091	0.0006	0.0824	1.7980	0.1960	2.086	1.815	115%
1196	0.0022	0.0011	0.0508	0.0829	0.0132	0.150	0.154	98%

The samples were extracted following the sequential extraction procedure of Bloom *et al.,* 2003. One sample, 1193, was run in duplicate, and it was noted that the replicate precision was poor; therefore, the samples were re-extracted and re-analyzed. The replicate precision was still poor for sample 1193, but the replication between the two extractions for the other three samples was good, indicating that the sample randomly chosen for replication is not homogeneous while the other three are. The locations for these samples are shown on Figure 4-8.

The results presented above indicate that on average, about 50 percent of the total mercury is in the fraction containing elemental mercury (Fraction F4). The tentative Site action level for total mercury was set at 23 ppm in the approved Characterization Work Plan, and the previous action level of 1.1 ppm for elemental mercury found in the ROD was not included, due to the high cost of the laboratory speciation method for this element. However, a review of the laboratory total mercury data (presented in Table 4-7 for non-excavated sample locations and in Tables 4-15 and 4-16 for excavated sample locations) shows that the majority of the excavated locations (70 percent) had total mercury values greater than 1.1 ppm and the majority of the non-excavated locations (86 percent) had total mercury values less than or equal to 1.1 ppm.

4.3.5 Trench Sample Results

At the request of CDPHE, eleven 3-foot-deep trenches were dug in areas of the Site that had not required remediation based on radionuclide and metals sampling to demonstrate that contaminated material was not present at depth. The results of this sampling are shown in Table 4-11. One arsenic reading was above the tentative Site action level, but this sample result was included in the Zone 4 data presented in Tables 4-7 and 4-8, and the mean and 95% UCL for arsenic are well below the Site action level. Locations of these trenches are shown in Figure 4-9.

Table 4-11
Trench Sample Results

Sample ID	Onsite Lab NaI (pCi/g)	Notes	XRF Corrected Field Data (ppm)				
			As	Pb	Hg	Mo	V
1046	3	trench by N fence	7	43.4	9.5	15	40
1047	4	dup 1046	7	37.7	9.5	15	71.0
1048	4	trench far NW road	7	141.9	9.5	15	63.4
1052	3	trench by stockpile C	17.4	24.2	9.5	15	40
1053	3	dup 1052	17.4	24.2	9.5	15	40
1069	5	trench far east end	49.6	164.2	9.5	48.2	389.9
1070	4	trench mid east end	7	66.7	9.5	15	40
1084	2	trench in road	7	33.4	9.5	15	40
1085	2	trench by equip. parking	12.4	19.0	9.5	15	40
1086	2	trench site of big dirt pile	7	121.6	9.5	15	40
1087	2	trench by gate w of trailer	7	33.6	9.5	15	40
1088	4	trench by N fence	7	296.0	9.5	17.0	60.3
1089	2	trench by S fence	17.2	82.5	14.8	18.9	57.2

4.3.6 Stockpile Sampling Results

Two soil stockpiles were established for excavated materials: Stockpile A contains material from locations identified by New Horizons as having over 100 pCi/g total activity and contains approximately 200 cubic yards of material. Stockpile B contains the majority of the excavated material (less than 100 pCi/g total activity) and contains approximately 12,500 cubic yards of material. The 12,500-cubic-yard estimate is based on truckloads placed in the pile (uncompacted yards). A survey of the pile after all loads were placed in the pile and the pile was repeatedly traversed by a dozer, indicated 9,700 compacted cubic yards. Figure 2-1 in Section 2 of this RI/FS showed the location of the stockpiles relative to Site features.

The two stockpiles were sampled and analyzed for waste acceptance criteria purposes for the remedy. Table 4-12 shows the sample numbers, sample locations, and the Ra-226 data from both the field laboratory NaI and the offsite laboratory. As described in Section 3.6.4.8, composite samples were collected from five random points on Stockpile B corresponding with each 500-cubic-yard interval, which was the working face or top of the pile at the time the sample was collected.

Table 4-12
Stockpile Sample Summary

Sample Date	Sample ID	Field Laboratory NaI (pCi/g)	Offsite Laboratory Ra-226 (pCi/g)	Location	Stockpile Interval (cubic yards)
14-Jun-06	21	4	5.25	Stockpile B	0 - 0.5 K
15-Jun-06	22	8	11.6	Stockpile B	0.5 - 1 K
20-Jun-06	23	6	7.7	Stockpile B	1 - 1.5 K
22-Jun-06	31	6	8.5	Stockpile B	1.5 - 2 K
23-Jun-06	38	4	7.08	Stockpile B	2 - 2.5 K
5-Jul-06	200	3	5.82	Stockpile B	2.5 - 3 K
5-Jul-06	201	7	12.8	Stockpile B	3 - 3.5 K
5-Jul-06	202	9	15.3	Stockpile B	3.5 - 4 K
7-Jul-06	311	6	8.2	Stockpile B	4 - 4.5 K
7-Jul-06	312	6	10.3	Stockpile B	4.5 - 5 K
7-Jul-06	313	7	8.9	Stockpile B	5 - 5.5 K
8-Jul-06	344	16	39.6	Stockpile B	5.5 - 6 K
12-Jul-06	496	4	6.32	Stockpile B	6 - 6.5 K
14-Jul-06	557	5	4.77	Stockpile B	6.5 - 7 K
17-Jul-06	637	10	13.8	Stockpile B	7 - 7.5 K
17-Jul-06	638	4	11.2	Stockpile B	7.5 - 8 K
21-Jul-06	884	20	40.9	Stockpile B	8 - 8.5 K
21-Jul-06	885	9	18	Stockpile B	8.5 - 9 K
21-Jul-06	886	10	23.3	Stockpile B	9 - 9.5 K
26-Jul-06	964	7	9.7	Stockpile B	9.5 - 10 K
26-Jul-06	965	8	10.6	Stockpile B	10 - 10.5 K
26-Jul-06	966	9	19.2	Stockpile B	10.5 - 11 K
28-Jul-06	1025	10	16.6	Stockpile B	11 - 11.5 K
2-Aug-06	1129	16	12.8	Stockpile B	11.5 - 12 K
2-Aug-06	1130	6	10.5	Stockpile B	12 - 12.5 K
2-Aug-06	1131(dup 1130)	8	9.6	Stockpile B	12 - 12.5 K
26-Jun-06	43	27	39.5	Stockpile A	NA
7-Aug-06	1187	50	130	Stockpile A	NA
21-Feb-07	1238	N/A	46	Stockpile A	NA

Tables 4-13 and 4-14 provide summaries of offsite laboratory radionuclide results for Stockpiles A and B, respectively.

Table 4-13
Stockpile A Laboratory Results – Radionuclides
(all values in pCi/g)

Sample ID	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-234	U-235	U-238
43	39.5	3.21	2.7	39.3	2.53	50.5	2.87	50.4
1187	130	2.06	1.76	36.4	1.62	31.6	3.6	32.1
1238	46	NA	NA	NA	NA	NA	NA	NA
Mean	71.83	2.64	2.23	37.85	2.08	41.05	3.24	41.25
Std Dev	50.48	0.81	0.66	2.05	0.64	13.36	0.52	12.94
Geo Mean	61.82	2.57	2.18	37.82	2.02	39.95	3.21	40.22

Table 4-14
Stockpile B Laboratory Results – Radionuclides
(all values in pCi/g)

Sample ID	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-234	U-235	U-238
21	5.25	1.7	1.44	3.15	1.41	2.5	0.07	2.53
22	11.6	2.23	2.06	14.8	1.9	7.3	1.19	7.4
23	7.7	2.13	2.09	5.26	1.85	5.55	0.6	5.42
31	8.5	2.04	1.59	4.56	1.39	2.56	0.46	2.53
38	7.08	1.32	1.36	5.73	1.24	4.41	0.19	4.76
200	5.82	1.2	1.53	4.87	1.41	3.79	0.24	3.74
201	12.8	2.63	2.32	7.7	2.03	5.24	0.9	5.14
202	15.3	3.08	2.27	10.2	2.28	7.8	0.64	8.4
311	8.2	1.75	1.53	5.77	1.27	4.65	0.85	4.33
312	10.3	2.22	2.25	7.9	1.94	5.66	1	5.59
313	8.9	2.02	1.81	8	1.58	5.58	0.72	5.77
344	39.6	2.61	2.32	14.9	2.1	7.3	0.72	7.9
496	6.32	1.85	1.67	4.9	1.54	3.04	-0.1	2.89
557	4.77	2.41	2.28	3.52	1.96	5.36	-0.16	5.45
637	13.8	2.01	1.8	28.7	1.67	17.1	0.91	18.5
638	11.2	1.72	1.79	12.5	1.63	8.1	0.4	8.4
884	40.9	2.07	2.61	16.1	2.52	11.7	1.9	11.7
885	18	2.03	1.99	5.06	1.89	5.2	0.39	5.49
886	23.3	3.42	3.8	7.5	3.69	10.2	1.4	10.4
964	9.7	2.72	2.2	7.4	2.15	15.3	0.93	15.7
965	10.6	1.97	2.15	8.9	1.96	27.2	1.9	27.5
966	19.2	3.31	2.62	8.8	2.32	8.8	0.9	9.1
1025	16.6	1.8	1.96	14.9	1.82	10.4	0	11.1
1129	12.8	2.52	2.51	10.3	2.31	16	1.5	16.9
1130	10.5	2.42	2.23	7.1	2.02	5.9	0.54	6
1131	9.6	2.52	2.33	7.7	2.26	6.5	0.6	7
Mean	13.55	2.21	2.09	9.14	1.92	8.27	0.72	8.51
Std Dev	9.24	0.55	0.51	5.54	0.51	5.64	0.56	5.86
Geo Mean	11.51	2.14	2.03	7.94	1.86	6.91	0.67	7.05

Notes: NA = Not Analyzed
Mean, standard deviation, and geometric mean did not include sample 1131, which was a duplicate of 1130.
Geometric Mean of U235 did not include the negative and zero values

Tables 4-15 and 4-16 provide summaries of offsite laboratory metals results for Stockpiles A and B, respectively.

Table 4-15
Stockpile A Laboratory Metals Results
(all values in mg/kg)

Sample ID	Arsenic	Lead	Mercury	Molybdenum	Vanadium
43	0.1	0.03	0.002	26	140
1187	77	1700	6.4	46	33
Mean	38.55	850.02	3.201	36	86.5
Std Dev	54.38	1202.06	4.52	14.14	75.66
Geo Mean	2.77	7.14	0.11	34.58	67.97

Table 4-16
Stockpile B Laboratory Metals Results
(all values in mg/kg)

Sample ID	Arsenic	Lead	Mercury	Molybdenum	Vanadium
21	27	120	1	31	40
22	54	460	0.97	21	37
23	35	150	1.1	7.8	35
31	13	1400	5.5	27	34
38	30	1500	6.6	24	41
200	120	1200	4.4	25	36
201	23	240	4.5	38	47
202	24	430	4.1	20	50
311	22	330	4.1	15	31
312	63	280	6.5	28	44
313	15	190	2.1	21	38
344	54	850	2.5	57	39
496	17	180	1.3	6	32
557	13	90	0.39	8.1	30
637	44	2300	6.6	24	27
638	58	770	4.3	2200	37
884	33	1600	9.5	25	47
885	19	210	2.2	45	44
886	15	210	2.3	34	38
964	16	210	5.3	15	46
965	20	190	2.8	24	41
966	15	130	7.2	12	35
1025	44	3.5	10	66	42
1129	26	290	2.1	49	27
1130	24	190	4.1	28	29
1131 (dup 1130)	27	270	3.4	25	31
Mean	33.3	494.7	4.3	137.0	38.0
Std Deviation	25.6	585.9	2.6	485.8	7.1
Geo Mean	27.28	268.32	3.49	30.08	37.35

Notes:
The mean and standard deviation did not include sample 1131, which was a duplicate of 1130.

4.3.7 Statistical Comparison of CSMRI Stockpile B Soil and Bagged Soil

As noted earlier in this RI/FS, Stoller performed a risk assessment for the bagged soils stored on the Site during the 2004 halted remedial program. The risk assessment demonstrated that the bagged soils could safely be disposed of at the Foothills Landfill near Golden. At CDPHE's request, Stoller included a volume of 30,000 cubic yards of similarly contaminated soil to see if the Foothills Landfill could also accept up to 30,000 cubic yards of similarly impacted soils from the Site, if such soils existed. The Stoller risk assessment demonstrated that Foothills Landfill could do so. Therefore, Stoller compared the Stockpile B soils to the data used in the risk assessment for the hypothetical 30,000 cubic yards to see if Stockpile B could be disposed of safely at the Foothills Landfill.

Table 4-17 shows radionuclide sample data from the two data sets with the geometric mean, arithmetic mean, and the maximum and minimum concentrations.

Table 4-17
Comparison of Bagged Soil Data and Stockpile B Data

	Bagged Soil Data (pCi/g)				Stockpile B Data (pCi/g)			
Radionuclide	**Maximum**	**Minimum**	**Geo Mean**	**Arith. Mean**	**Maximum**	**Minimum**	**Geo Mean**	**Arith. Mean**
Ra-226	43.9	3	10.46	12.60	40.9	4.77	11.51	13.55
Ra-228	4.1	0.81	1.62	1.73	3.42	1.2	2.14	2.21
Th-228	3.90	1.01	1.62	1.69	3.8	1.36	2.03	2.09
Th-230	35.10	1.55	6.76	9.34	28.7	3.15	7.94	9.14
Th-232	3.88	0.94	1.57	1.65	3.69	1.24	1.86	1.92
U-234	44.20	1.74	5.87	8.40	27.2	2.5	6.91	8.27
U-235	2.71	0.07	0.32	0.47	1.9	-0.16	0.67	0.72
U-238	45.80	1.77	5.95	8.57	27.5	2.53	7.05	8.51

A Student's t-test was used to determine if the sample data from Stockpile B collected from June through August 2006 are statistically the same or different from the sample data from the bagged soil collected during December 2004. The results are shown in Table 4-18.

Table 4-18
Student's t-test comparison of Bagged Soil Data and Stockpile B Data

Radionuclide	T value	P value
Ra-226	-0.384	0.70
Ra-228	-2.85	0.0062
Th-228	-2.68	0.0097
Th-230	0.105	0.92
Th-232	-1.80	0.077
U-234	0.065	0.95
U-235	-1.66	0.10
U-238	0.0289	0.98

If $p>0.05$ the sample populations are considered statistically equivalent. The null hypothesis is that the mean values of the two sample populations are equivalent. The most commonly used level of significance is 0.05. When the significance level is set at 0.05, any test resulting in a p-value under 0.05 would be significant and the null hypothesis would be rejected in favor of the alternative hypothesis. Six of the eight radionuclides satisfied the condition that the p value is greater than 0.05, so the null hypothesis is assumed to be true and the sample populations are determined to be statistically equivalent. It should be noted that the problem of multiple tests occurs when two groups are compared with respect to many variables. The fact that multiple tests are performed makes it much more likely than 5 percent that something will be statistically significant at a nominal 0.05 level when there is no real underlying difference between the two groups. Statistical procedures such as Hotelling's T^2 statistic could be used to test the hypothesis that the means of all variables are equal; however, this was determined to be unnecessary in this case. As the risk assessment report showed, the primary risk driver for the CSMRI soil is from the Ra-226, and the results of the statistical test shown above determined that the p value is 0.70 for this radionuclide.

The risk assessment report prepared to allow shipment of the bagged soil to BFI landfill, *Dose Assessment for the Emplacement of the CSMRI Site Containerized and Remaining Subsurface Soil into a RCRA Subtitle D Solid Waste Landfill* (Stoller 2005a) was approved by CDPHE for shipment of up to 30,000 cubic yards of contaminated material from the CSMRI Site. The data presented above demonstrate that the soil in Stockpile B is statistically equivalent to the bagged soil, and thus is already approved for disposal at BFI. Approval letters from BFI and CDPHE for disposal of this material are included in Appendix F.

4.4 Flood Plain Characterization

Based on initial characterization data presented in Section 3.7, Stoller prepared the *CSMRI Site Flood Plain Characterization Work Plan* dated November 21, 2006. Based on previous characterization, Ra-226 is the only constituent of concern in this area. Characterization activities on the flood plain began in December 2006 and included vegetation removal, temporary access road construction, installation of silt fencing, and initial segregation of contaminated soil to Stockpile B. Inclement weather resulted in delays following the initial soil segregation. Approximately 150 cubic yards of soil were excavated and placed in Stockpile B.

In February 2007, the previously excavated areas were resampled to determine if additional soil needs to be excavated. The results showed Ra-226 levels ranging from 3 to 89 pCi/g. Approximately three-quarters of the area previously excavated require further soil excavation to achieve the tentative Site action level of 4.14 pCi/g for Ra-226. When the flood plain dries out enough in the spring of 2007 to allow heavy equipment access, excavation of remaining contaminated soils will continue, followed by confirmation sampling. It is estimated that up to another 200 cubic yards of soil could be excavated from this area. This small additional soil volume added to Stockpile B will not impact the alternatives assessment or remedy selection.

4.5 Clay Pits Characterization

Six boreholes were cored within and immediately north of the reported 1973 burial site of the CSMRI pond sediment. Five boreholes were cored within the relocated surveyed rectangular area, and one borehole was cored immediately adjacent to and north of the rectangular area. Figure 3-13 presented a series of views of the final coring and sample interval pattern at the Clay Pits site. Three subsurface samples were selected from each of the six boreholes and submitted for analytical testing of metals and radioisotopes that have been identified as COCs at the CSMRI Site.

The analytical results indicate concentrations of metals and radioisotopes that are generally unremarkable for debris and fill material except for sample CP6-35, which was collected from borehole CP6 at a depth of 35 feet bgs. Lead was detected at a concentration of 30,000 milligrams per kilogram (mg/kg) at this sampled interval and location. This sample was collected near the base of the debris layer, and material within the core run included ash, scrap wire, dirt, and industrial hose. The presence of the ash and scrap wire and other material may have biased the analytical results for this compound. The average concentration of lead in the samples submitted for analytical testing is 234 mg/kg if this particular elevated detect is excluded from the data set. Excessive concentrations of lead were not detected in any other samples nor were significantly elevated concentrations of other analyzed metals.

Radioisotope activity is near background levels, with the highest activity detected in soil sample CP2-19, which showed Ra-226 at 11.7 pCi/g and Th-230 at 12.4 pCi/g. The borehole log for CP-2 at this interval identifies the material as fill with abundant gravel. Field scanning for gamma activity within this interval and also above and below the sample interval depth indicates radioactivity within background ranging from 15,000 counts per minute (cpm) to 18,500 cpm. Statistical evaluation of these data is summarized in Table 4-19.

Table 4-19
Clay Pits Data Statistical Summary

	As	Pb w/outlier	Pb w/o outlier	Mo	V	Hg	Ra-226
Mean	142.6	1,800.7	234.1	10.9	37.8	1.63	2.7
Median	26	130	102.5	2.7	39	0.29	1.7
Std Deviation	329.0	6,834.8	294.6	21.1	16.1	4.6	2.8
Minimum	1.5	11	11	1.1	20	0.036	0.91
Maximum	1,400	30,000	1,100	93	90	20	11.7
Count	19	19	18	19	19	19	19
Upper One-Sided Confidence Limit*	273.5	4519.6	354.9	19.3	44.3	3.4	3.8

*calculated using equation in Section 4.3.2

In all cases, elevated data were defined by clean samples (below Site action levels) beneath the elevated sample. Appendix G contains a summary table of the analytical results of the sampling of the debris that was encountered during the Clay Pits investigation.

Buried sediment material that could be attributed to the CSMRI pond or ore-like material used to cover the sediment was not observed during this subsurface drilling and sampling program. The concentration and activity of tested analytes in the buried debris poses a minimal risk at its present location. The Clay Pits investigation results were reported to the CDPHE in the report titled, *Clay Pits Area Remedial Site Investigation Report, Colorado School of Mines Research Institute,* dated April, 2007. The report concluded that no further action was required at this site, and that no material was located that could be tied to the CSMRI Pond sediment. For the purpose of the remainder of this RI/FS, this portion of the site is considered closed and is not discussed further, consistent with the NCP 40 CFR 300.420(5)(v).

4.6 Groundwater Characterization

Stoller has collected quarterly groundwater samples since February 2005 from monitoring wells CSMRI-1, CSMRI-2, CSMRI-4, and CSMRI-5; and quarterly surface water samples SW-1 and SW-2 from Clear Creek. Previous consultants have collected periodic samples from these monitoring wells plus monitoring well CSMRI-3 until 2003.

Well CSMRI-1 is located along Clear Creek upstream from the Site, and well CSMRI-2 is located offsite on the southeast corner of the freshman parking lot on West Campus Drive. Well CSMRI-3 is located downgradient of the Clay Pits Area; and is not sampled on a quarterly basis. Wells CSMRI-4 and CSMRI-5 are located downgradient from the Site near Clear Creek. Figure 4-10 shows the monitoring well locations and the two surface water sample locations. In February 2007, monitoring wells CSMRI-1B, -6B, -7B, -8, -9, -10, and -11 were installed by Stoller to further characterize the groundwater at the CSMRI Site for post-excavation success purposes.

Appendix H presents summary tables of groundwater and surface water data at the CSMRI Site. Tables H-1 and H-2 present the most recent (first quarter 2007) radioisotope and dissolved metals groundwater results, respectively. During the first quarter of 2007, wells 6B and 7B were dry and no samples were collected. Tables H-3 and H-4 present the most recent (first quarter 2007) radioisotope and dissolved metals surface water results, respectively. Tables H-5 and H-6 present historical quarterly groundwater data collected by Stoller from February 2005 (first quarter 2005) through September 2006 (third quarter 2006) for radioisotope and dissolved metals, respectively. Tables H-7 and H-8 present historical quarterly surface water sample data collected by Stoller from February (first quarter 2005) through December 2006 (fourth quarter 2006) for radioisotopes and metals, respectively. There is no December 2006 (fourth quarter 2006) groundwater analytical data because the ice chest containing a significant portion of the groundwater samples was lost during shipment; only the surface water samples arrived as a complete sample suite.

Table H-9 presents historical analytical results for monitoring wells CSMRI-1, -2, -3, -4, and -5 from a series of previous environmental consultants dating sporadically from 1991 to 2003.

The analytical results indicate no EPA drinking water maximum contaminant level (MCL) exceedances for tested dissolved metals at any of the groundwater monitoring wells on the CSMRI Site. Exceedances of the EPA MCL for radioisotopes have historically occurred only in monitoring well CSMRI-4, and only for uranium. However, with the February 2007 installation of monitoring well CSMRI-8, uranium in groundwater has also been detected for the initial sampling event at a concentration of 1,100 micrograms per liter (μg/l), which exceeds the MCL of 30 μg/l.

Historically, monitoring well CSMRI-4 has had elevated concentrations of uranium, but the values have been declining steadily since 1991 to the first quarter 2007 concentration of 48 μg/l. Figure 4-11 illustrates the decreasing concentration of uranium in CSMRI-4 since 1991. The spike in the concentration of uranium in 2003 was attributed to precipitation effects at the CSMRI Site after removal of the Site asphalt and concrete as discussed in Section 4.2.2 of the previous RI/FS (New Horizons 2004). Figure 4-12 presents the dissolved uranium concentration and water table elevation from 2005 through the first quarter of 2007 for monitoring well CSMRI-4. There are no analytical data for this monitoring well for the fourth quarter 2006 monitoring event. This figure indicates the presence of uranium has fluctuated seasonally slightly above to below the MCL of 30 µg/l for the past seven quarterly sampling events in 2005 and 2006.

There are several possible reasons for the observed concentration of 1,100 µg/l measured at monitoring well CSMRI-8. These reasons may include:

- The well contains residual uranium from the former Pond area on the flood plain.
- There was a QC error in the sample collection or analysis.
- Uranium was disturbed and introduced into the well during well installation.
- The well contains residual uranium from the former Building 101 area at the top of the slope above the well.
- Uranium is naturally occurring in the Fox Hills bedrock formation.
- The well is located in a zone where strong mixing between creek water and groundwater occurs, and the oxidizing conditions associated with creek water cause uranium to dissolve more readily.

A review of the water chemistry from the sampling event in March 2007 indicates that there is evidence of mixing between creek water and groundwater in the flood plain wells, as indicated by lower water temperatures, higher conductivity, higher total dissolved solids, and higher pH than the upland wells.

Monitoring well CSMRI-8 will continue to be sampled on a quarterly basis with the other Site wells, and the reason for the elevated level of uranium will be evaluated. Continued elevated uranium readings at this well may indicate the need for taking some further remedial action.

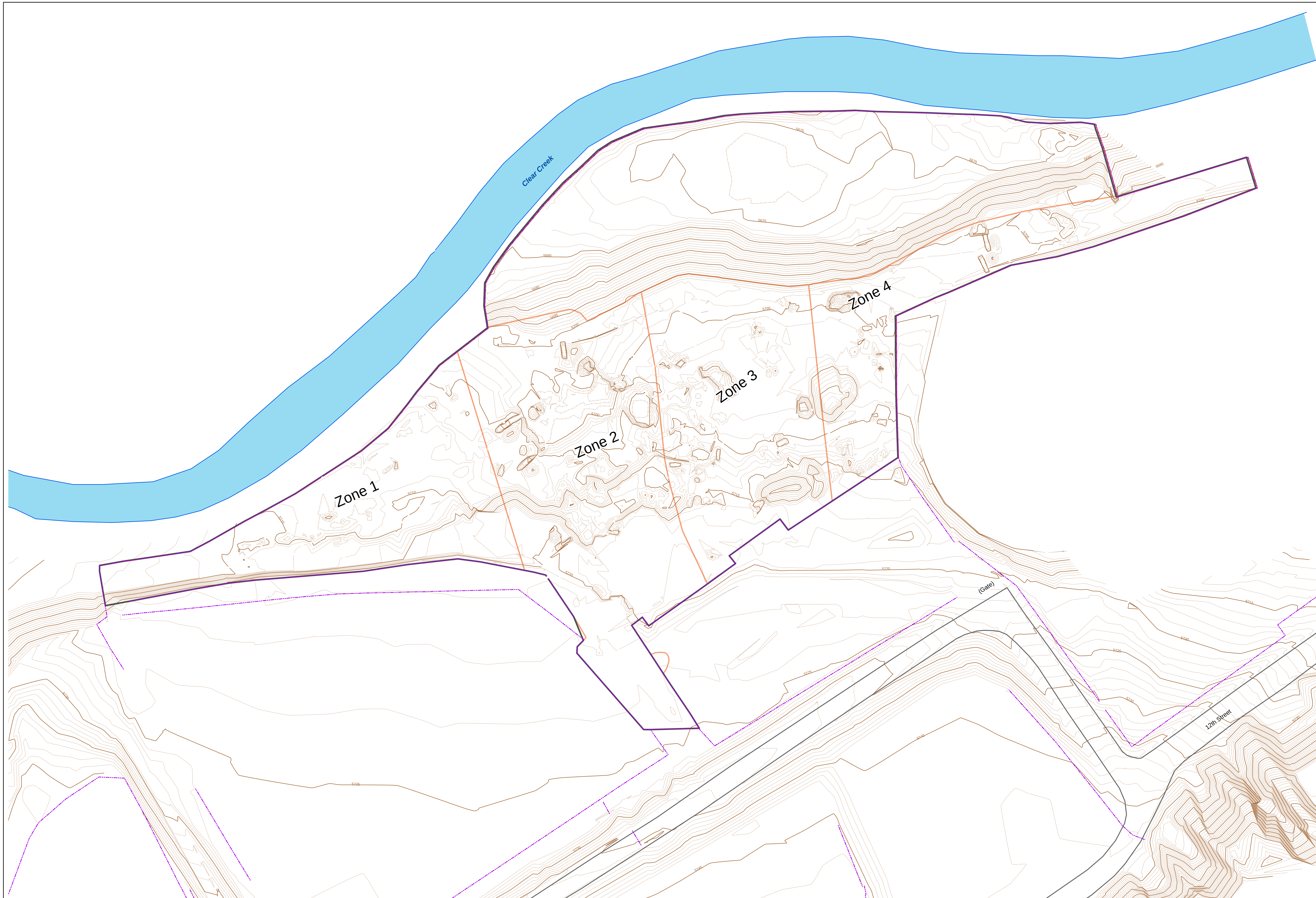

Figure 4-1

Location of the Four Survey Units

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Zone Boundaries

N E S W

Scale: 1" = 50'

Feet

0 25 50 100

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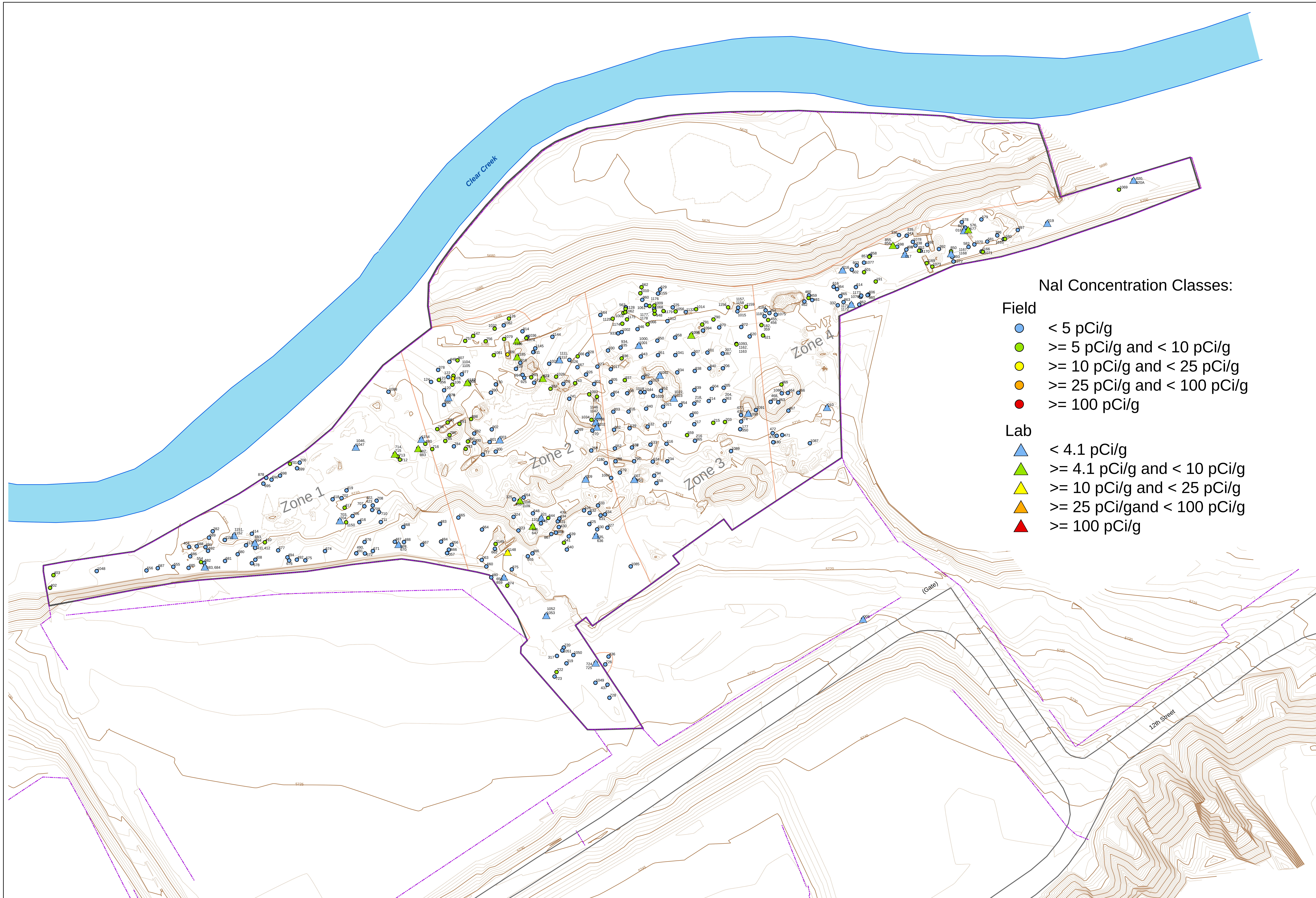
Figure 4-2

Final Ra-226 Confirmatory Sample Locations and Results



Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Zone Boundaries

N W E S

Scale: 1" = 50'

Feet

0 25 50 100

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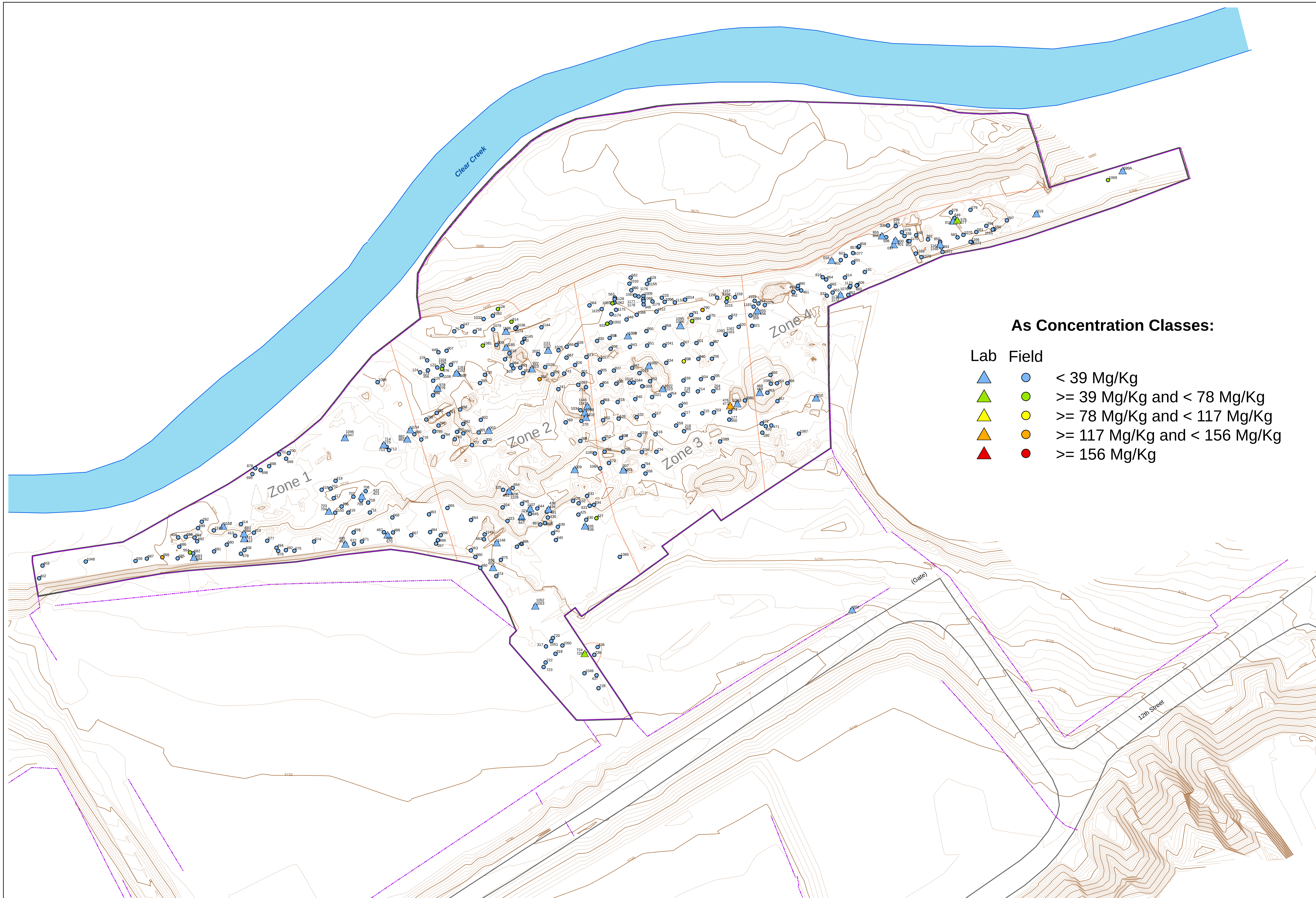
Figure 4-3

Final As Confirmatory Sample Locations and Results



Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Zone Boundaries

Scale: 1" = 50'

Feet

0 25 50 100

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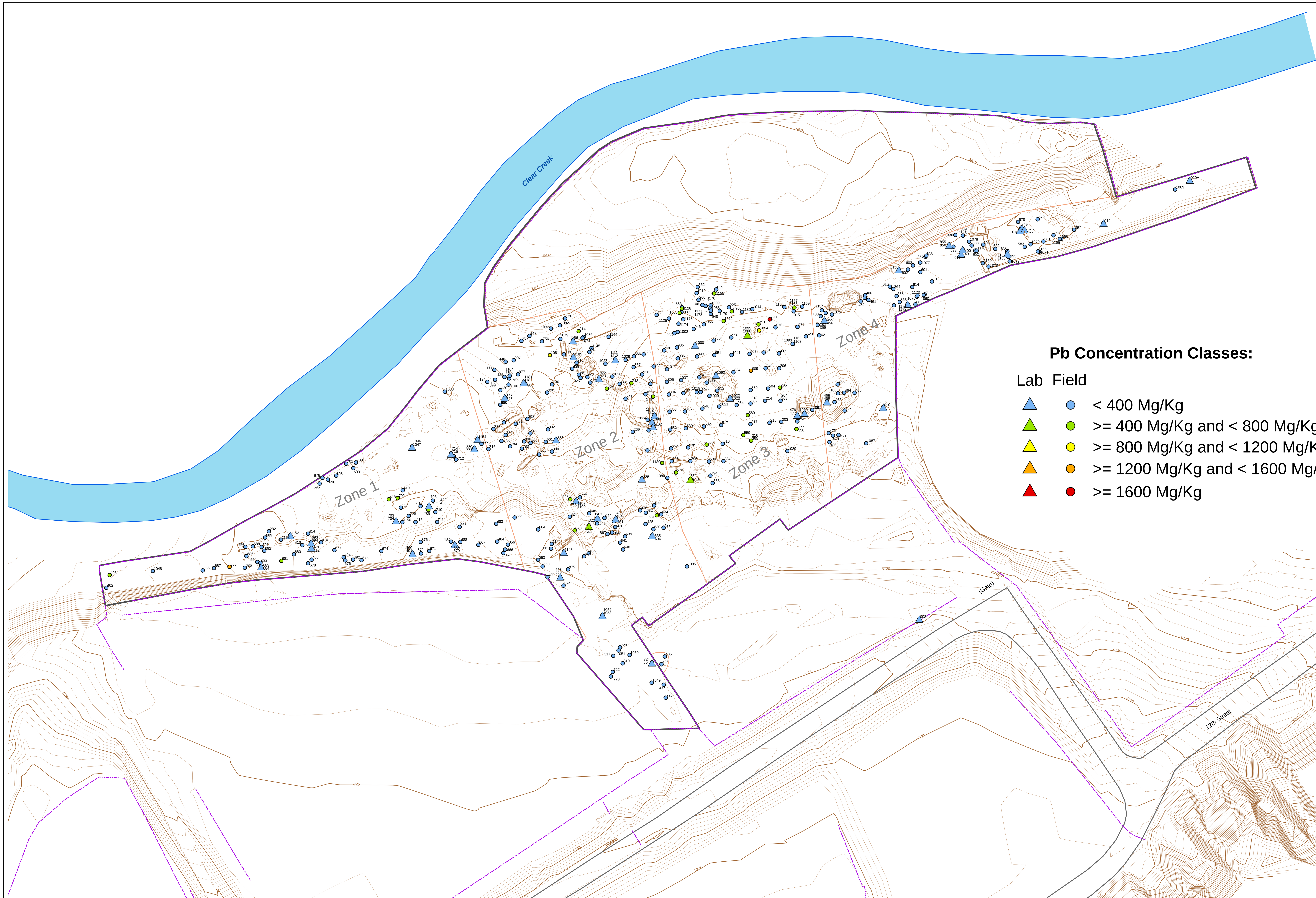

Figure 4-4

Final Pb Confirmatory Sample Locations and Results

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Zone Boundaries

N / W / E / S

Scale: 1" = 50'

Feet

0 25 50 100

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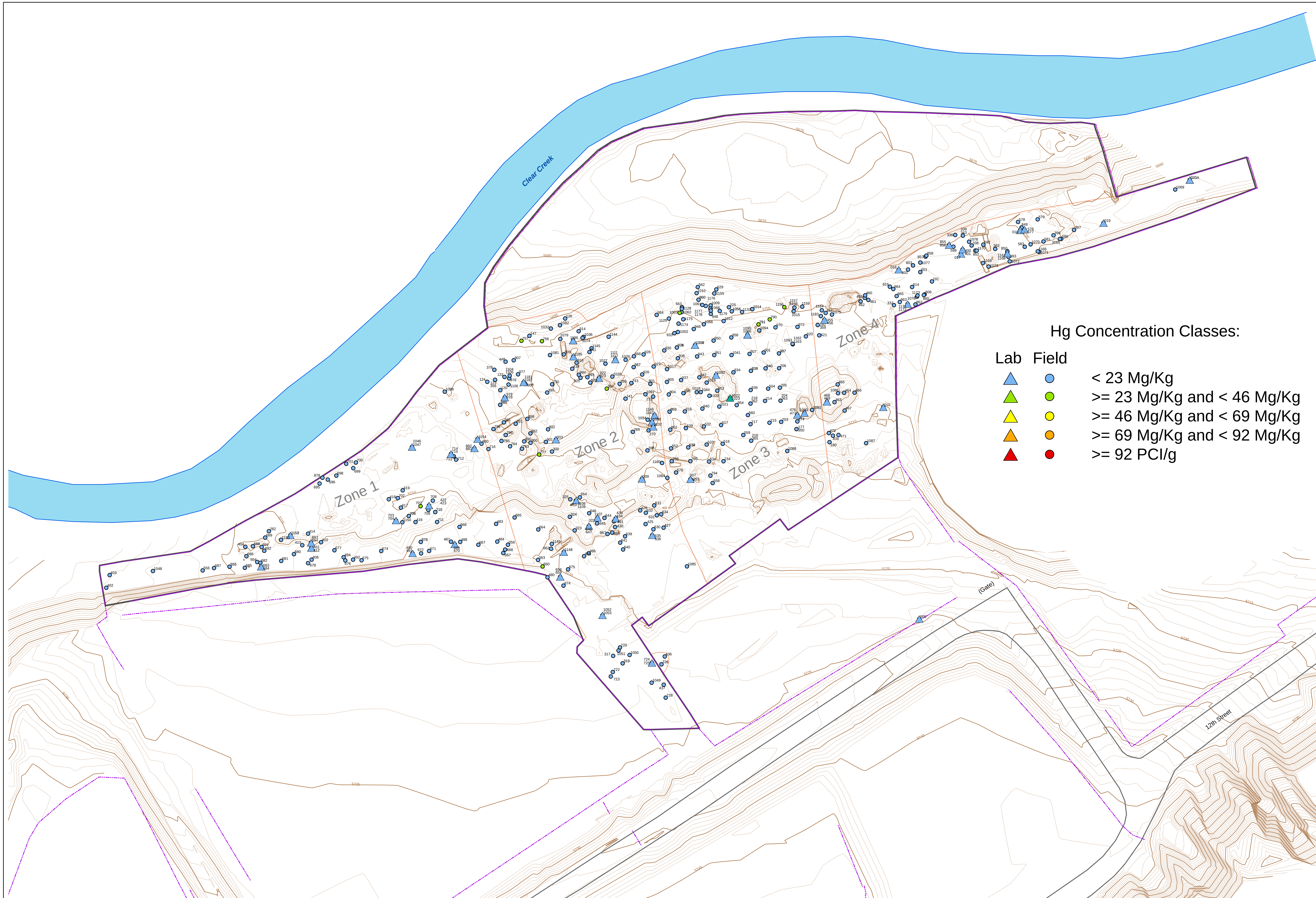

Figure 4-5

Final Hg Confirmatory Sample Locations and Results

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Zone Boundaries

Scale: 1" = 50'

Feet

0 25 50 100

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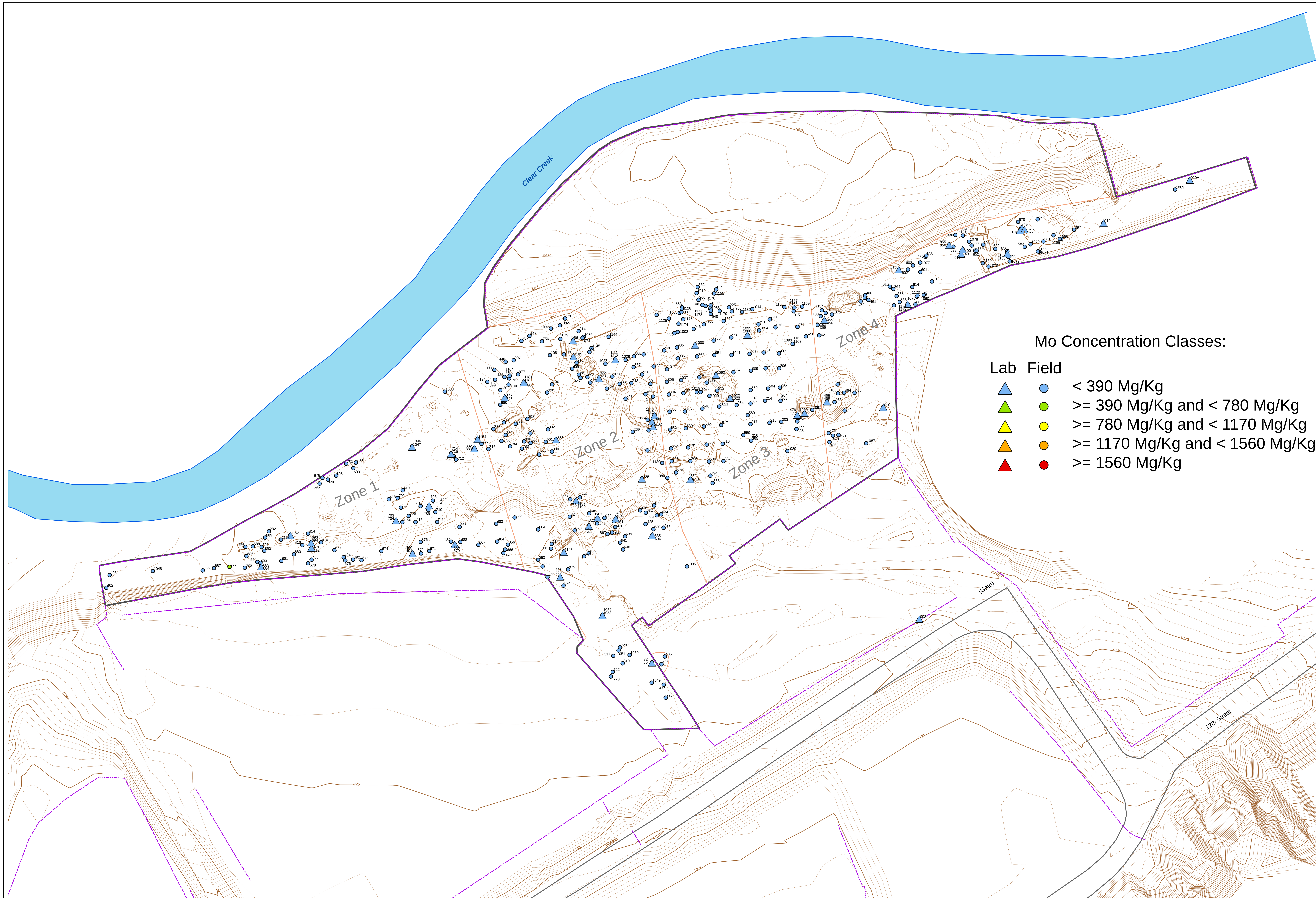


Figure 4-6

Final Mo Confirmatory Sample Locations and Results

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Zone Boundaries

N
W E
S

Scale: 1" = 50'

Feet

0 25 50 100

CSMRI
2007 Revised
Remedial Investigation /
Feasibility Study

Stoller

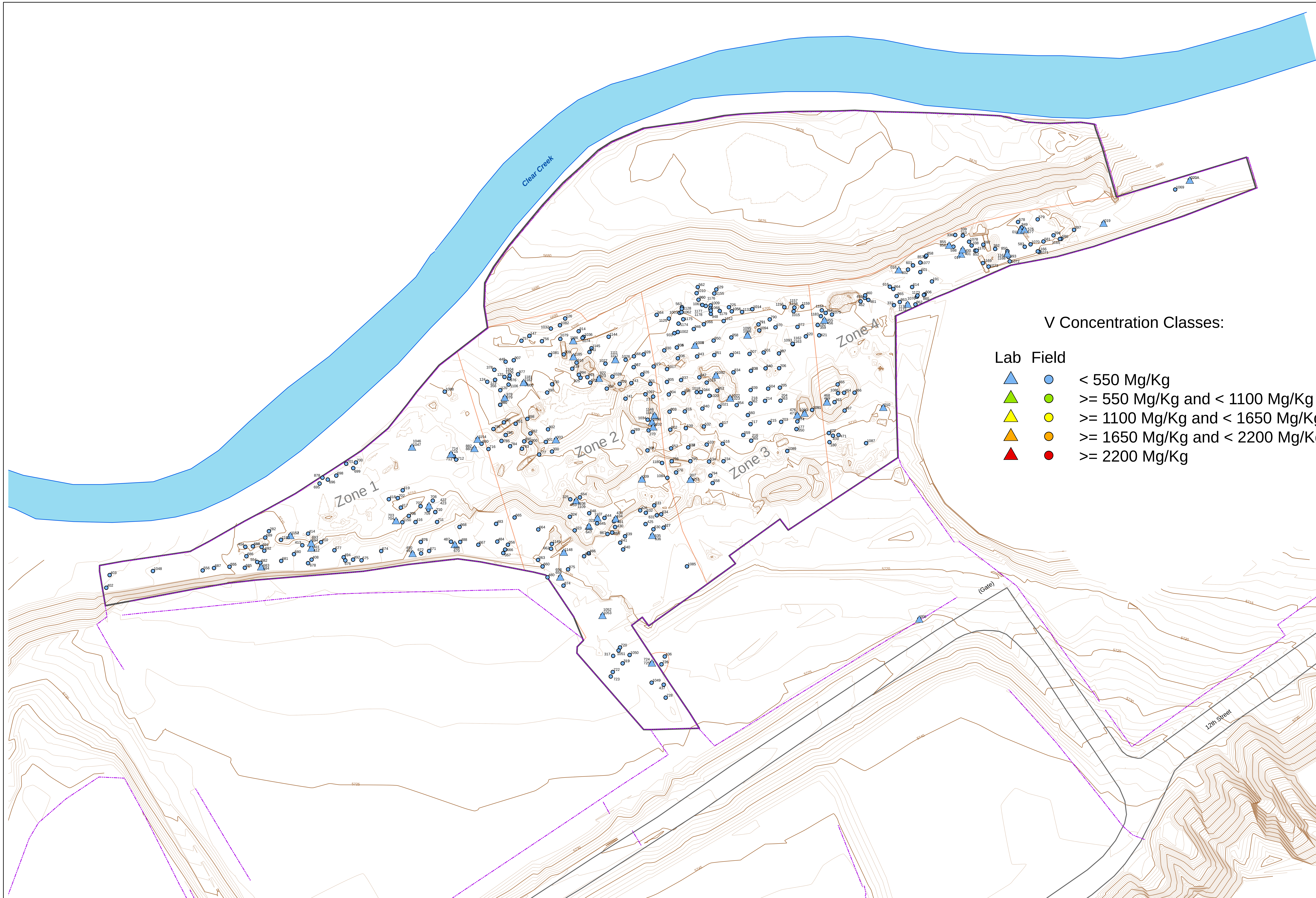


Figure 4-7

Final V Confirmatory Sample Locations and Results

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Zone Boundaries

N
W E
S

Scale: 1" = 50'

Feet

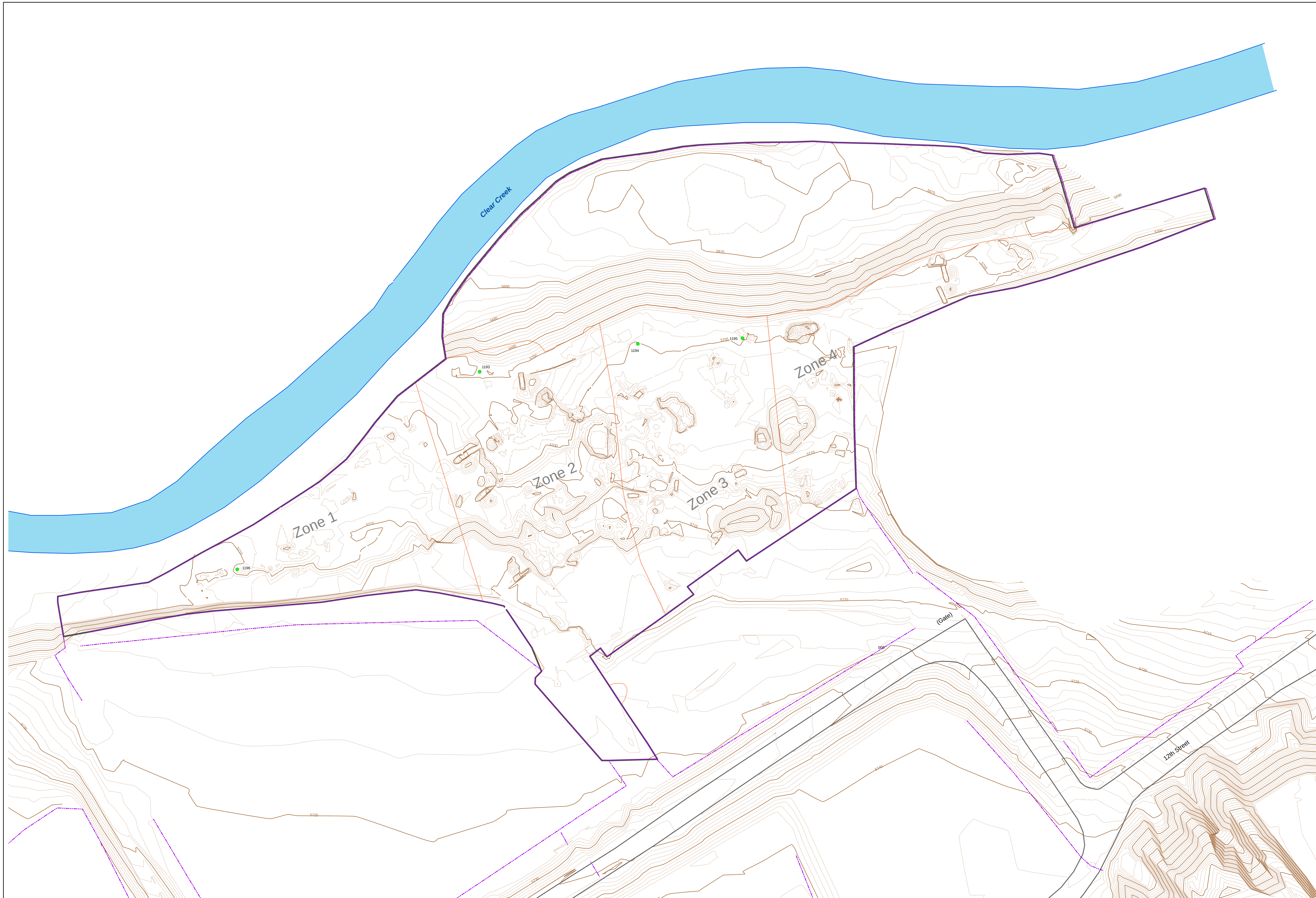
0 25 50 100

CSMRI
2007 Revised
Remedial Investigation /
Feasibility Study

Stoller

Figure 4-8

Speciated Hg Sample Locations



Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Zone Boundaries
- Sample Locations

Scale: 1" = 50'

Feet

0 25 50 100

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Feasibility Study

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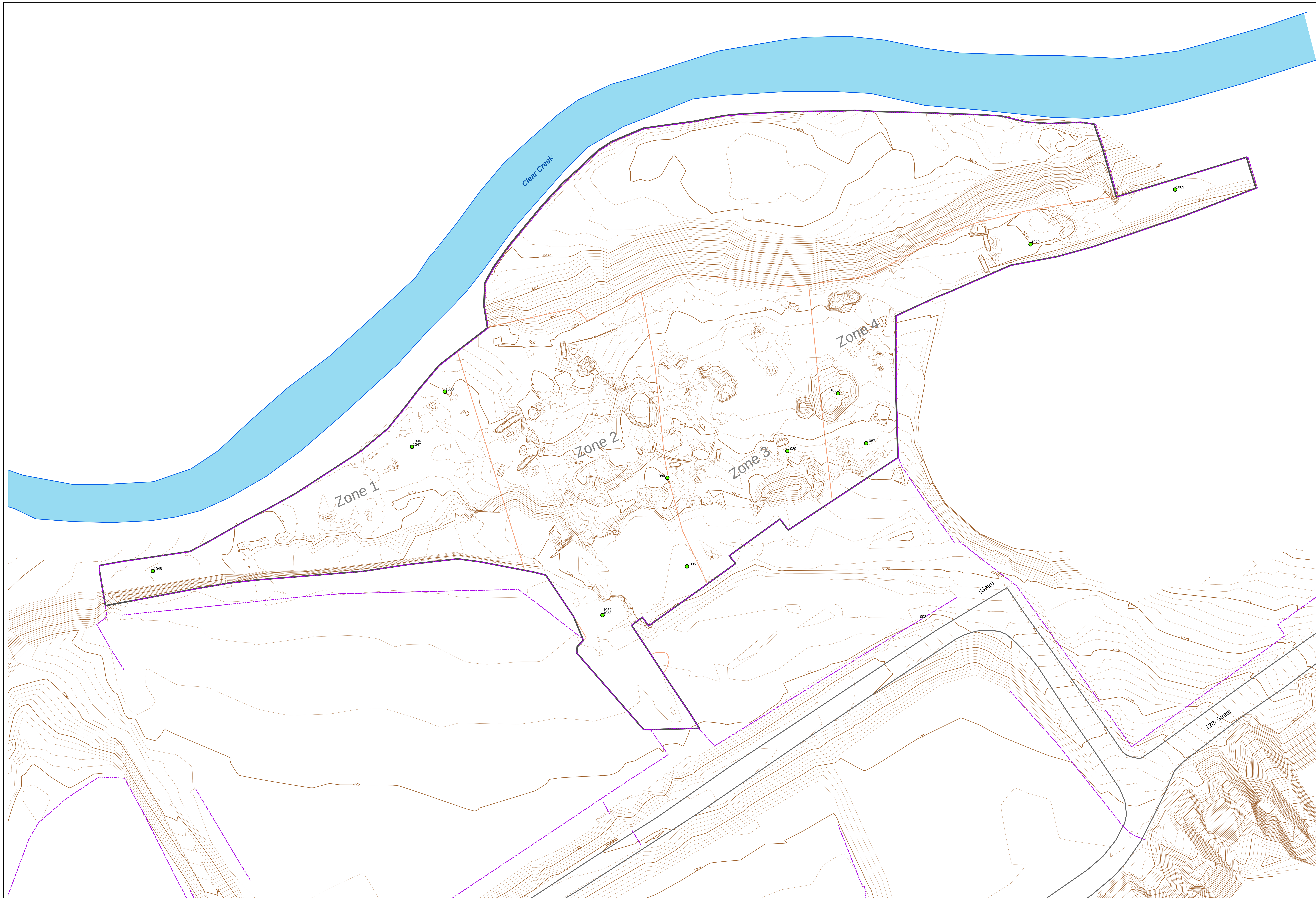

Figure 4-9

Confirmatory Trench Locations
and Sample Identification

Explanation

CSMRI Creekside Site
Fences
Topography (1 ft Intervals)
Topography (5 ft Intervals)
Roads
Zone Boundaries
Trench Sample Locations

N
W E
S

Scale: 1" = 50'

Feet
0 25 50 100

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Explanation

- Wells
- Surface Water Sample Locations
- Ghost Wells
- 1 Foot Contours
- 5 Foot Index Contour
- Property Boundary
- Clear Creek

N

100 0 100 200 Feet

1 inch = 150 feet

Figure 4-10
Groundwater Well Location Map

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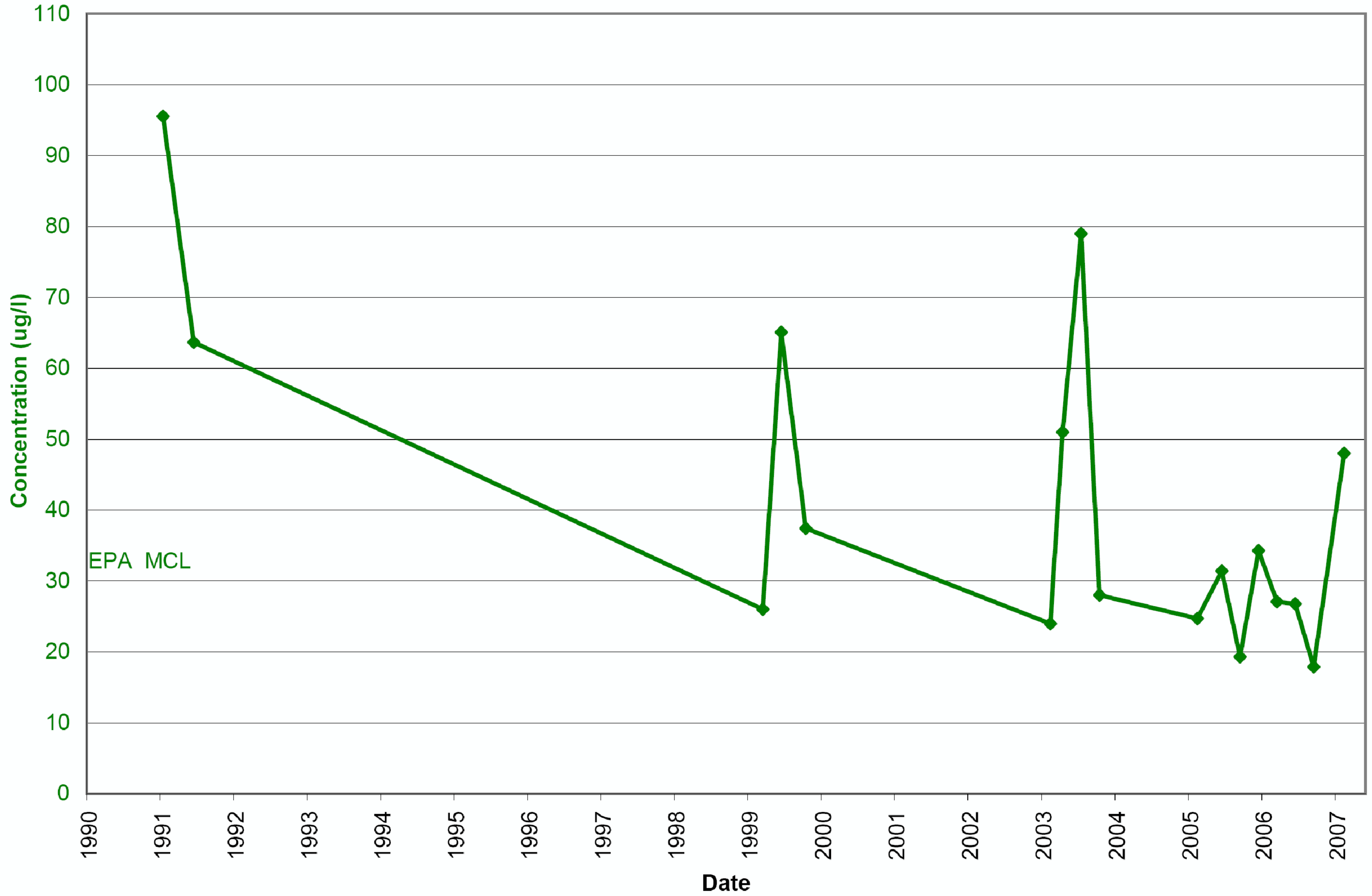

Figure 4-11

Well CSMRI-4
Historical Uranium
Concentration

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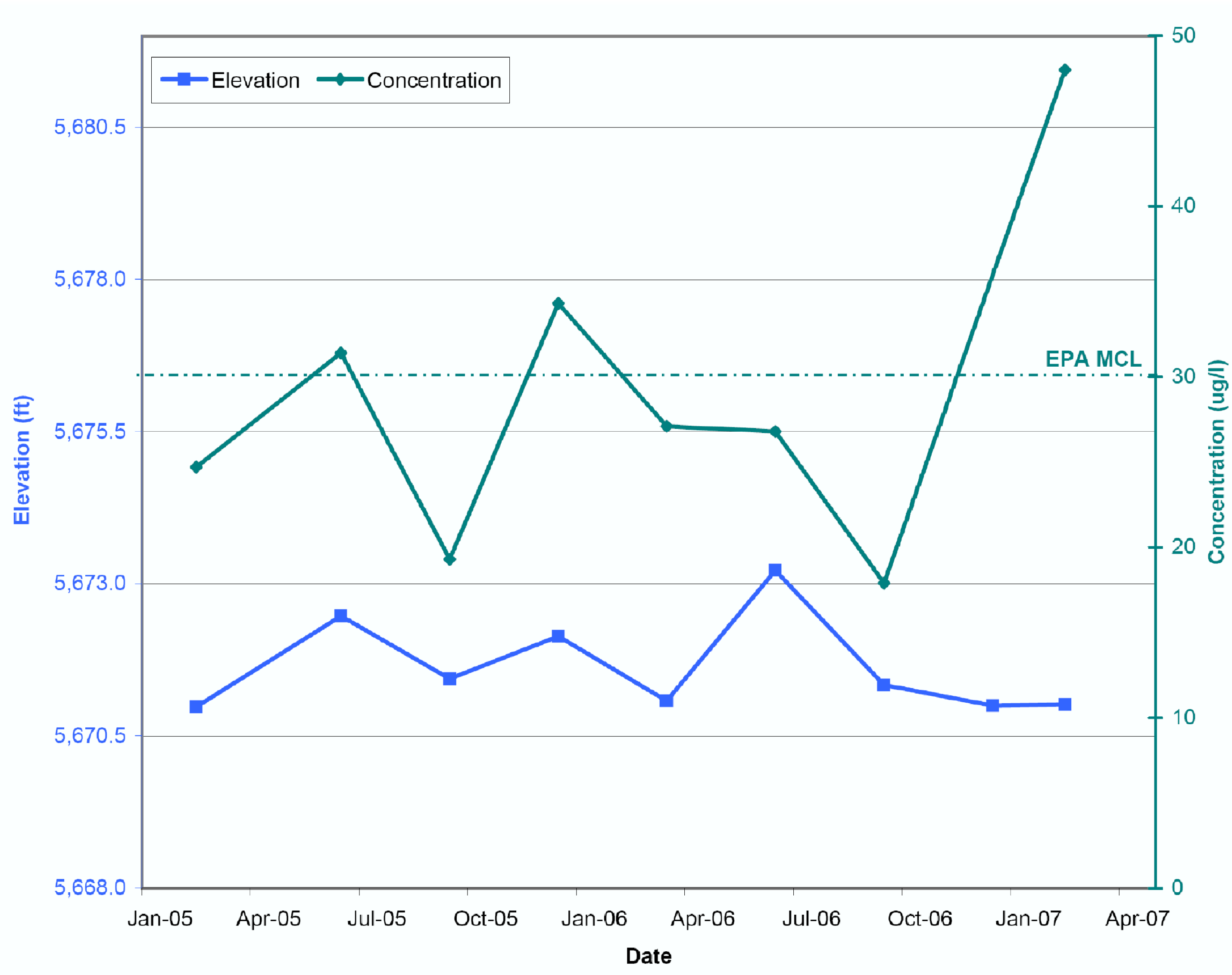

Figure 4-12

Well CSMRI-4
Uranium Concentration
and
Groundwater Elevation

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