SWMU 13 - Granulated Slag Pile

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5.5.13 SWMU 13 – Granulated Slag Pile

The location of Solid Waste Management Unit (SWMU) 13 is shown on Figure 5.5.13-1a and SWMU 13 monitoring stations and sample locations are provided on Figure 5.5.13-1b. SWMU 13, the Granulated Slag Pile, is located in the southeast portion of the Rhodia Silver Bow Plant (Site), east of the Coarse Slag Pile (SWMU 12) and south of the Roaster Solids Area (SWMU 14) and the Raw Materials Area (SWMU 6). SWMU 13 is bisected, from the north to south by railroad tracks #8 and #9. Molten slag from the furnaces was first granulated with high pressure water in the early 1980s, and stockpiled in the present area. There are no underground utilities, pipes, or process pipes in the area. High voltage aerial lines are located just south of the pile. The nearest water monitoring well is MW-97-5, 100 feet south of the pile.

Slag is a rock-like material formed from the minerals in the nodulized phosphate ore, silica, and coke feedstocks in the phosphorus production furnace. Slag (primarily calcium silicate) was drawn off the furnace as a liquid through the flush hole in the furnace. This molten material was cooled (i.e., solidified) via water emersion in the slag pit. From the mid-1980s until the end of furnace operations in 1995, approximately 50 percent of the slag was granulated with a high pressure water spray to a sand particle size and stockpiled separately at the Granulated Slag Pile. The Granulated Slag Pile contains approximately 4 million cubic yards of slag, and a small amount of course slag throughout the pile,

Coarse and granulated slags were generated from the same furnaces and have the same chemical characteristics. Therefore, the radiation studies discussed in Section 5.5.12.1 are pertinent to the Granulated Slag Pile.

The Granulated Slag Pile has a similar gamma exposure rate of 140 micro-Roentgens per hour (µR/hr) compared to the Coarse Slag Pile (145 µR/hr) (*see* Figure 5.5.13-2). This exposure rate is less than the applicable OSHA limit as detailed in Section 5.5.12, but a site-specific risk assessment is needed to evaluate potential risk associated with exposure to radiation from the Granulated Slag Pile.

Available analytical data for granulated slag samples include:

- Extraction procedure toxicity method (EPTOX) – metals
- General and Site-specific parameters (total and ASTM water leach)

- Metals (total and ASTM water leach)

- Radionuclides (total and ASTM water leach)

Granulated slag data from SWMU 13 were compared to the background/reference area concentrations. Concentrations above the 95% upper confidence limit of the mean background/reference area concentrations are highlighted on the constituent delineation figures presented in this section. Where a 95% upper limit could not be calculated, the maximum detected concentration or the maximum detection limit was selected.

Constituent concentrations are described in this report as above background/reference area concentrations if the mean and maximum concentrations of the SWMU data exceed both of the mean and maximum background/reference area values. All data will be retained for evaluation in the human health and ecological risk assessments. The definitive background comparison will be conducted in the risk assessment using a statistical approach consistent with EPA guidance (U.S. EPA 2002).

The EPTOX data demonstrates that granulated slag does not leach metals at concentrations that are considered hazardous (*see* Table 5.5.13-1). Fluoride, several metals and certain radionuclides are present in granulated slag at concentrations above the background/reference area soil concentrations (*see* Table 5.5.13-2 thru 5.5.13-4). Metals and radionuclides were not detected in the ASTM D3987 leach test (*see* Table 5.5.13-5). Fluoride, calcium, potassium and phosphorus were detected in the ASTM leachate. The analytical results are summarized in Figures 5.5.13-3, 5.5.13-4 and 5.5.13-5 for the general and site-specific parameters, radionuclides and metals, respectively.

5.5.13.1 RFI Investigation Activities

The Phase 1 RFI Work Plan concluded that the previous reports and analytical database were sufficient to characterize the nature of the coarse slag material, with the exception of the leaching potential (Barr, 2009). To further characterize the leaching potential of the coarse slag material, leachate analyses were conducted on two composite coarse slag samples using EPA Method 1312 – Synthetic Precipitation Leaching Procedure (SPLP). Each composite sample was composed of 5 subsamples that were collected as described in the Field Sampling Plan. Sample locations were near the perimeter of the pile (i.e. toe of the slope of the pile) because slag at the center and top of the pile was too coarse to sample. The location of each subsample and the centroid of the composite subsample locations are shown on Figure 5.5.13-1b. The resulting leachate from the submitted samples was analyzed for site-specific parameters, general parameters, metals, and radionuclides.

In the event that the Granulated Slag Pile is moved as part of the final corrective measure, confirmatory soil sampling will be conducted in the area that was occupied by the pile.

5.5.13.2 RFI Investigation Results

The objective of the RFI work for SWMU 13 was to further characterize the leaching potential of the granulated slag material. The analytical results of the leachate analyses are summarized in Tables 5.5.13-6, 5.5.13-7, and 5.5.13-8 for the general and site-specific parameters, metals and radionuclides, respectively. Fluoride and total phosphorus are the only general and site-specific parameters detected in the leachate (Table 5.5.13-6). Elemental phosphorus was not detected (DL = 0.000023 ug/L) in the leachate. The only metals detected in the leachate were arsenic, barium, calcium, magnesium, potassium, selenium, sodium, uranium and vanadium (*see* Table 5.5.13-7). Although radium 226 is present at about 28 pCi/g in the slag, it was not detected in the SPLP leachate. Gross alpha was detected at 2.6 pCi/L in the leachate (*see* Table 5.5.13-8).

5.5.13.3 Conclusions

- Slag is a rock-like material formed from the minerals in the nodulized phosphate ore, silica, and coke feedstocks in the phosphorus production furnace. Slag consists primarily of calcium silicate and was granulated to a sand sized particle.

- The Granulated Slag Pile contains approximately 4 million cubic yards of slag, and does not contain any furnace dig-out materials, carbon bricks or blocks, construction debris or garbage.

- Phosphate ore contains naturally occurring radioactive materials (NORM), which are retained in the slag after the ore is processed. The radioactivity of phosphate ore is almost exclusively due to trace levels of uranium and its decay products (Lloyd, 1983). As shown on the U-238 decay chain sequence, the long lasting radionuclides at U-238, U-234, Th-230, Ra-226, and Pb-210. Although these radionuclides are present in the slag above background/reference concentrations, and gamma exposure rates from the slag pile were higher than for facility soils that did not contain slag, exposure rates are estimated to be below the OSHA limit. Although certain metals are present in the slag at concentrations above the background/reference area concentrations, the concentrations are not likely to represent a public health hazard (*see* Appendix 5.5.12-A).

- Fluoride is the only parameter detected in the SPLP leachate at a concentration above its maximum contaminant level for drinking water.

- There is sufficient information to conduct the risk assessment for this SWMU. The risk assessment will identify which parameters, if any, are present at concentrations that warrant corrective measures. The dataset would be reviewed at that time and additional sampling may be necessary to inform the corrective measures study or later during the corrective measures design phase.

- Rhodia will prepare a technical memorandum that summarizes the investigation activities that have evaluated the potential for downward migration (e.g., leaching) of radionuclides from slag. The technical memorandum will be submitted to EPA on or before May 22, 2013.

5.5.13.4 References

Barr 2009. Final Phase 1 RCRA Facility Investigation Work Plan, Corrective Action Order on Consent, Docket No. RCRA-08-2004-0001 Rhodia Silver Bow Plant Butte, Montana March 25, 2009.

Lloyd, L.L. June 1983. Evaluation of Radon Sources and Phosphate Slag in Butte, Montana. Occupational Health Bureau, Montana Department of Health and Environmental Sciences.

U.S. EPA. 2002. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. U.S. Environmental Protection Agency. EPA 540-R-01-003. OSWER 9285.7-41. September 2002.

Tables

Table 5.5.13-1

Granulated Slag Analytical Data - EPTOX Metals
Rhodia Silver Bow Plant

Station ID	Slag		Slag	
Sample Date	11/4/1980		11/14/1989	
Sample ID	Granulated Slag		Granulated Slag	
Lab Name	Ford			
Lab ID	80-001429		100857	
Report	Material Charac		Material Charac	
Arsenic, EPTOX	0.31	mg/L	0.009	mg/L
Barium, EPTOX	60.8	mg/L	0.2	mg/L
Cadmium, EPTOX	0.135	mg/L	0.005	mg/L
Chromium, EPTOX	0.5	mg/L	0.08	mg/L
Lead, EPTOX	0.296	mg/L	0.02 U	mg/L
Mercury, EPTOX	0.0002	mg/L	0.001 U	mg/L
Selenium, EPTOX	0.017	mg/L	0.005	mg/L
Silver, EPTOX	0.001 U	mg/L	0.02 U	mg/L

Table 5.5.13-2
Granulated Slag Data - General and Site-Specific Parameters
SWMU 13
Rhodia Silver Bow Plant
[concentrations in mg/kg]

Chemical Name			Fluoride	Fluoride by Bellack	Orthophosphate as P	Phosphorus, total
Background Mean, Exceedances **Bold**			**4.1**			
Background Maximum, Exceedances Underline			37			
Background 95% UCL, Exceedances *Italic*			*7.6*			
Location ID	**Sample Date**	**Sample Type**				
ESI-GSP-1	7/21/2003	N	***44***	--	2.9	11000 J
ESI-GSP-2	7/21/2003	N	***52***	--	5.2	10000 J
		FD	***30 J***	--	7.3 J	12000 J
GSP 0109	6/29/2009	N	--	11200	--	--
GSP 0209	6/29/2009	N	--	4950	--	--

Table 5.5.13-3
Granulated Slag Data - Metals
SWMU 13
Rhodia Silver Bow Plant
[concentrations in mg/kg]

Chemical Name / Analysis Location			Aluminum Lab	Antimony Lab	Arsenic Lab	Barium Lab	Beryllium Lab	Cadmium Lab	Calcium Lab	Chromium Lab	Cobalt Lab	Copper Lab	Iron Lab	Lead Lab	Magnesium Lab	Manganese Lab	Mercury Lab	Nickel Lab	Phosphorus, total Lab	Potassium Lab	Selenium Lab	Silicon Lab	Silver Lab	Sodium Lab	Thallium Lab	Vanadium Lab	Zinc Lab
Background Mean, Exceedances **Bold**				**0.50**	23	**150**	**0.51**	**1.6**	**3900**	**11**	**5.9**	**35**	19600	17	**3500**	540	0.021	**5.3**		**3000**	**0.41**		0.73 (1)	**140**	**0.35**	**41**	**59**
Background Maximum, Exceedances Underline				3.9	120	290	1.3	8.9	14000	48	9.5	301	35300	190	5700	1100	0.20	21		5300	0.70		1.7 (1)	620	1.0	83	380
Background 95% UCL, Exceedances *Italic*				*1.0*	40	*170*	*0.55*	*1.1*	*4500*	*12*	*6.1*	*64*	20600	35	*3700*	570	0.038	*6.0*		*3200*	*0.47*		0.35 (1)	*220*	*0.46*	*43*	*98*
Location ID	**Sample Date**	**Sample Type**																									
ESI-GSP-1	7/21/2003	N	18200	***21.7 J***	11.2	127	***2.3***	***3.3***	***298000***	***1140***	***7.5 J***	***235***	14000	< 2.0	***4550***	93.1	< 0.10	***249***	--	***5800***	***2.1 J***	--	< 2.0	***2800***	***1.6 J***	***1410***	35.3
ESI-GSP-2	7/21/2003	N	18900	***4.6 J***	5.7	137	***2.5***	***15.8***	***311000***	***156***	2.1 J	**49.2**	820	< 1.9	***4070***	76.4	< 0.10	***6.4 J***	--	***7250***	***1.1 J***	--	< 1.9	***3130***	< 4.9	***161***	***144***
		FD	18900	***4.7 J***	5.6	137	***2.5***	***11.5***	***316000***	***153***	2.0 J	**46.9**	701	< 2.0	***4080***	74.7	< 0.10	4.3 J	--	***7500.0***	***1.5 J***	--	< 2.0	***3440***	< 5.0	***156***	***109***
GSP 0109	6/29/2009	N	--	--	< 300	***218***	--	< 20	***326000***	***366***	--	--	--	< 300	--	--	0.02 J	--	11800	--	< 300	438000	< 30	--	--	--	--
GSP 0209	6/29/2009	N	--	--	< 300	***222***	--	< 20	***330000***	***326***	--	--	--	< 300	--	--	< 0.02 J	--	11200	--	< 300	442000	< 30	--	--	--	--

12/27/2012
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Table 5.5.13-4
Granulated Slag Data - Radionuclides
SWMU 13
Rhodia Silver Bow Plant
[concentrations in pCi/g]

		Chemical Name	Bismuth 214	Cesium 137	Gross Alpha (radiation)	Gross Beta (radiation)	Lead 210	Lead 212	Lead 214	Potassium 40	Protactinium-234	Radium 223	Radium 226	Thallium 208	Thorium 227	Thorium 232	Thorium 234	Uranium 235	Uranium 238
Background Mean, Exceedances **Bold**													**3.6**						**0.78**
Background Maximum, Exceedances Underline													12						2.7
Background 95% UCL, Exceedances *Italic*													*5.0*						*1.6*
Location ID	**Sample Date**	**Sample Type**																	
ESI-GSP-1	07/21/2003	N	39.7 +/- 3.15	< 0.148	124 +/- 11.6 J	73.7 +/- 7.58 J	--	0.670 +/- 0.196	41.3 +/- 4.06	5.81 +/- 1.14	51.0 +/- 12.0	6.36 +/- 1.61	***33.1 +/- 1.95***	--	3.41 +/- 1.55	--	34.2 +/- 3.92	3.48 +/- 1.31	--
ESI-GSP-2	07/21/2003	N	40.8 +/- 3.23	< 0.158	125 +/- 10.9	61.3 +/- 10.00	4.18 +/- 1.94	0.566 +/- 0.186	42.4 +/- 4.17	6.20 +/- 1.17	44.4 +/- 11.8	5.57 +/- 1.59	***36.8 +/- 2.02***	--	4.16 +/- 1.31	--	34.8 +/- 4.02	--	--
		FD	38.2 +/- 3.02	< 0.145	122 +/- 10.8 J	72.9 +/- 8.63 JB	--	--	41.2 +/- 4.04	4.96 +/- 1.08	39.4 +/- 10.8	8.07 +/- 2.17	***51.5 +/- 2.21***	0.180 +/- 0.0829	4.20 +/- 1.61	--	33.6 +/- 3.94	--	--
FSL1	01/01/1999	N	--	--	--	--	--	--	--	--	--	--	***38 +/- 0.85***	--	--	1.2 +/- 0.85	--	--	< 18
FSL2	01/01/1999	N	--	--	--	--	--	--	--	--	--	--	***38 +/- 0.84***	--	--	0.49 +/- 0.82	--	--	***52 +/- 29.00***

Table 5.5.13-5

Slag Analytical Data - ASTM Leachate
Rhodia Silver Bow Plant

Station ID	Slag-1	
Sample Date	10/14/1997	
Sample ID	Slag-1	
Lab Name	Energy	
Lab ID	97-63416	
Report	Voluntary Clean	
Aluminum, ASTM	0.1 U	mg/l
Antimony, ASTM	0.05 U	mg/l
Arsenic, ASTM	0.005 U	mg/l
Barium, ASTM	0.1 U	mg/l
Beryllium, ASTM	0.001 U	mg/l
Cadmium, ASTM	0.001 U	mg/l
Chromium, ASTM	0.01 U	mg/l
Cobalt, ASTM	0.01 U	mg/l
Copper, ASTM	0.01 U	mg/l
Iron, ASTM	0.03 U	mg/l
Lead, ASTM	0.01 U	mg/l
Manganese, ASTM	0.01 U	mg/l
Mercury, ASTM	0.001 U	mg/l
Nickel, ASTM	0.01 U	mg/l
Selenium, ASTM	0.005 U	mg/l
Silver, ASTM	0.005 U	mg/l
Thallium, ASTM	0.1 U	mg/l
Vanadium, ASTM	0.1 U	mg/l
Zinc, ASTM	0.01 U	mg/l
Calcium, ASTM	20	mg/l
Magnesium, ASTM	1 U	mg/l
Sodium, ASTM	1 U	mg/l
Potassium, ASTM	2	mg/l
Chloride, ASTM	1 U	mg/l
Fluoride, ASTM	4.61	mg/l
Phosphorus, ASTM	1.43	mg/l
Sulfate, ASTM	1 U	mg/l
Gross Alpha, ASTM	1 U	pCi/l
Radium-226, ASTM	0.2 U	pCi/l
Radium-228, ASTM	1 U	pCi/l
Uranium, ASTM	0.0003 U	pCi/l
Strontium, ASTM	2 U	pCi/l
Alkalinity, Total, ASTM	40	mg/l
Nitrate, ASTM	0.05 U	mg/l
Nitrite, ASTM		
Total Dissolved Solids, ASTM	113	mg/l

Table 5.5.13-6
Granulated Slag Data - SPLP General and Site-Specific Parameters
SWMU 13
Rhodia Silver Bow Plant
[concentrations in mg/l]

		Chemical Name	Fluoride	Phosphorus, elemental (white)	Phosphorus, total	Sodium
Location ID	Sample Date	Sample Type				
GSP-01	05/28/2009	N	**6.9**	< 0.000023	**0.21**	**2.29**
GSP-02	05/28/2009	N	**7.0**	< 0.000023	**0.11**	--

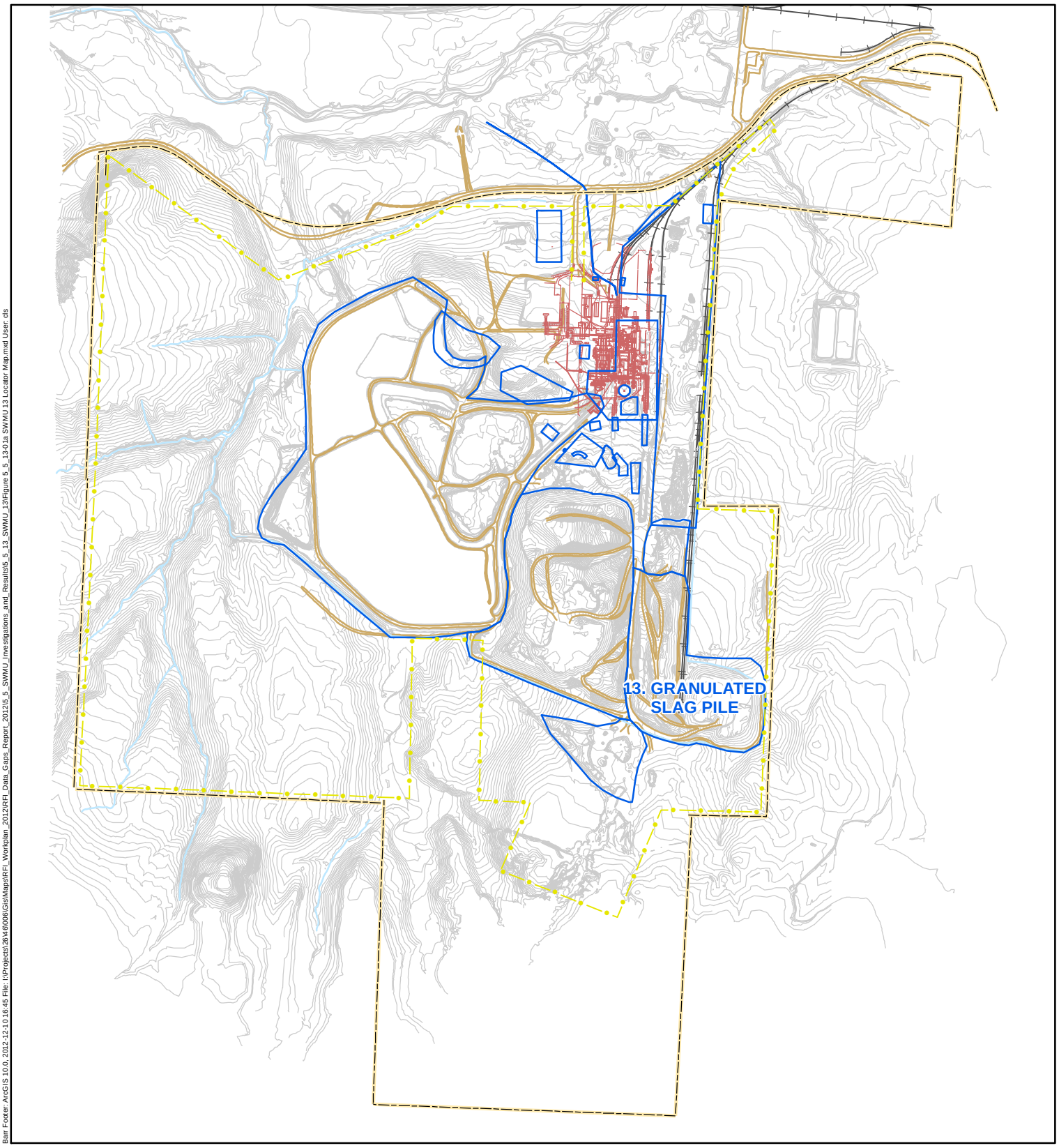
Table 5.5.13-7
Granulated Slag Data - SPLP Metals
SWMU 13
Rhodia Silver Bow Plant
[concentrations in mg/l]

Chemical Name			Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Uranium	Vanadium
Location ID	**Sample Date**	**Sample Type**																						
GSP-01	05/28/2009	N	< 0.010	**0.0013**	< 0.146	< 0.0002	< 0.0005	**12.6**	< 0.002	< 0.0010	< 0.002	< 0.01	< 0.01	**0.466**	< 0.0006	< 0.0010	< 0.002	**2.5**	**0.0010**	< 0.002	--	< 0.010	**0.00036**	**0.014**
GSP-02	05/28/2009	N	< 0.010	**0.0014**	**0.277**	< 0.0002	< 0.0005	**13.6**	< 0.002	< 0.0010	< 0.002	< 0.01	< 0.01	**0.467**	< 0.0006	< 0.0010	< 0.002	**3.3**	< 0.0010	< 0.002	**3.25**	< 0.010	**0.00042**	**0.021**

Table 5.5.13-8
Granualted Slag Data - SPLP Radionuclides
SWMU 13
Rhodia Silver Bow Plant
[concentrations in pCi/l]

		Chemical Name	Gross Alpha (radiation)	Gross Beta (radiation)	Radium 226	Radium 228
Location ID	Sample Date	Sample Type				
GSP-01	05/28/2009	N	**1.9**	< 3.9	< 1.1	< 2.9
GSP-02	05/28/2009	N	**2.6**	< 4	< 1.1	< 3

Figures



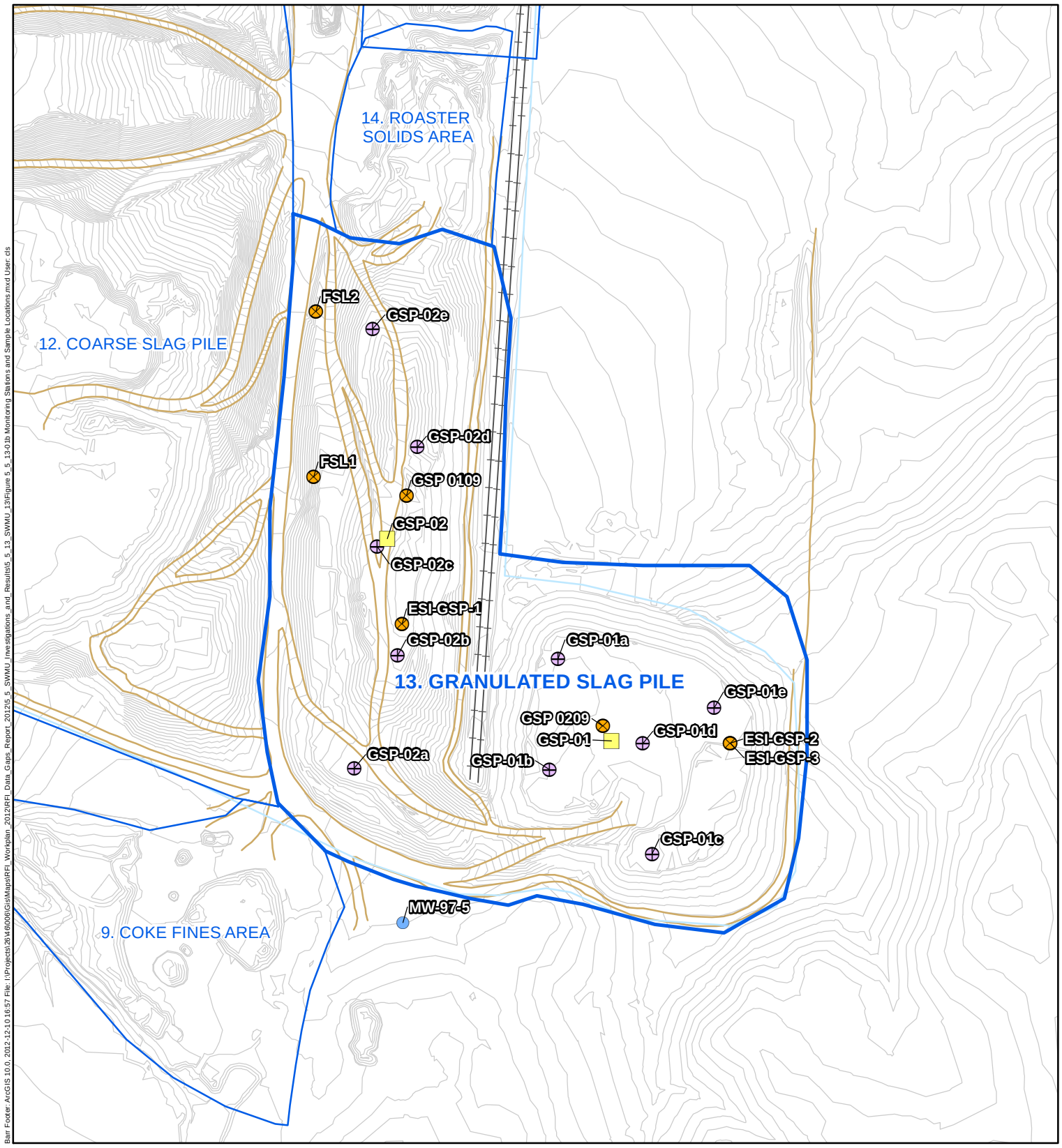
SWMU 13
Other SWMUs
Elevation Contour
Drainage
Railroad
Road
Former Plant Structures
Property Boundary
Fence Line

N

Feet
1,000 0 1,000

Figure 5.5.13-1a

SWMU 13 LOCATION
Rhodia Silver Bow Plant
Montana



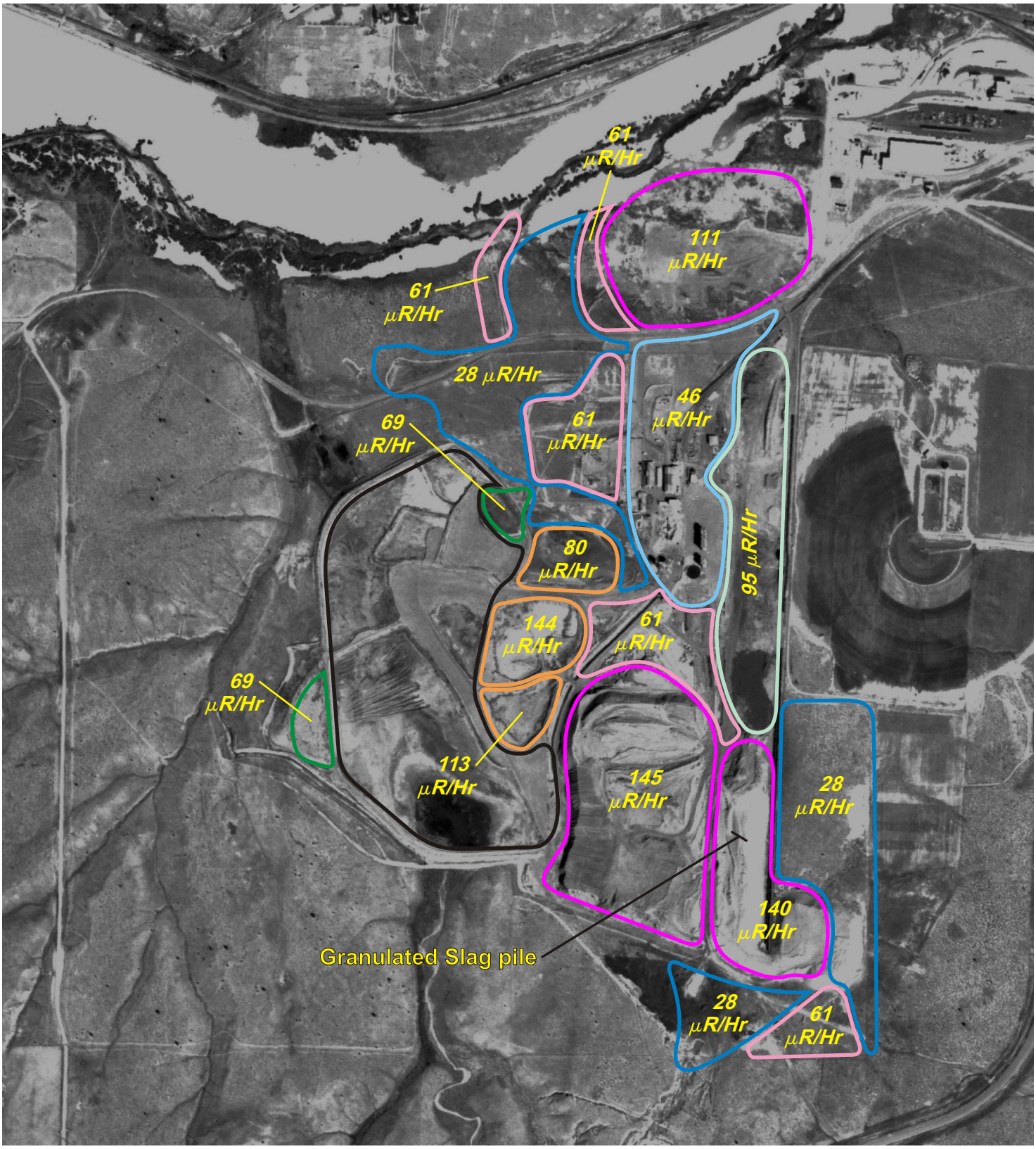
Monitoring Well
Slag Sample
Composite Sample Centroid Location
Slag Sample (2009)
SWMU 13
Other SWMUs
Former Plant Structures
Elevation Contour
Drainage
Railroad
Road

N

Feet
300 0 300

Figure 5.5.13-1b

SWMU 13
MONITORING STATIONS
AND SAMPLE LOCATIONS
Rhodia Silver Bow Plant
Montana



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N

0 1000 2000

Approximate Scale in Feet

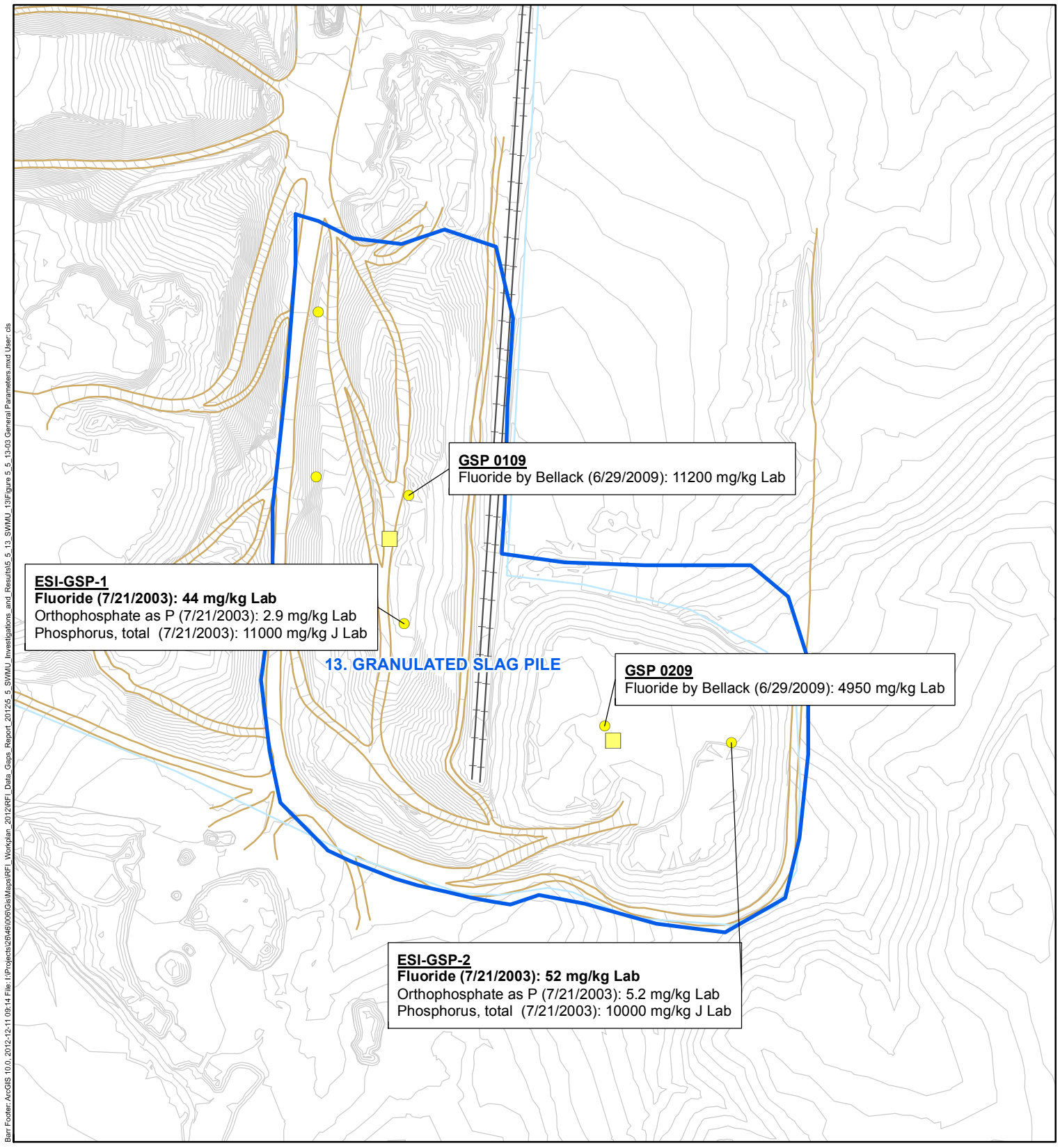
LEGEND

28 µR/Hr Average Gamma Radiation Exposure Rates (microroentgens per hour) for Survey Area

Background Gamma Radiation Exposure Rates - 19 µR/Hr

Figure 5.5.13-2

GAMMA RADIATION EXPOSURE RATES
Rhodia Silver Bow Plant
Montana



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Sample Location
Composite Sample Centroid Location
SWMU 13
Former Plant Structures
Elevation Contour
Drainage
Railroad
Road

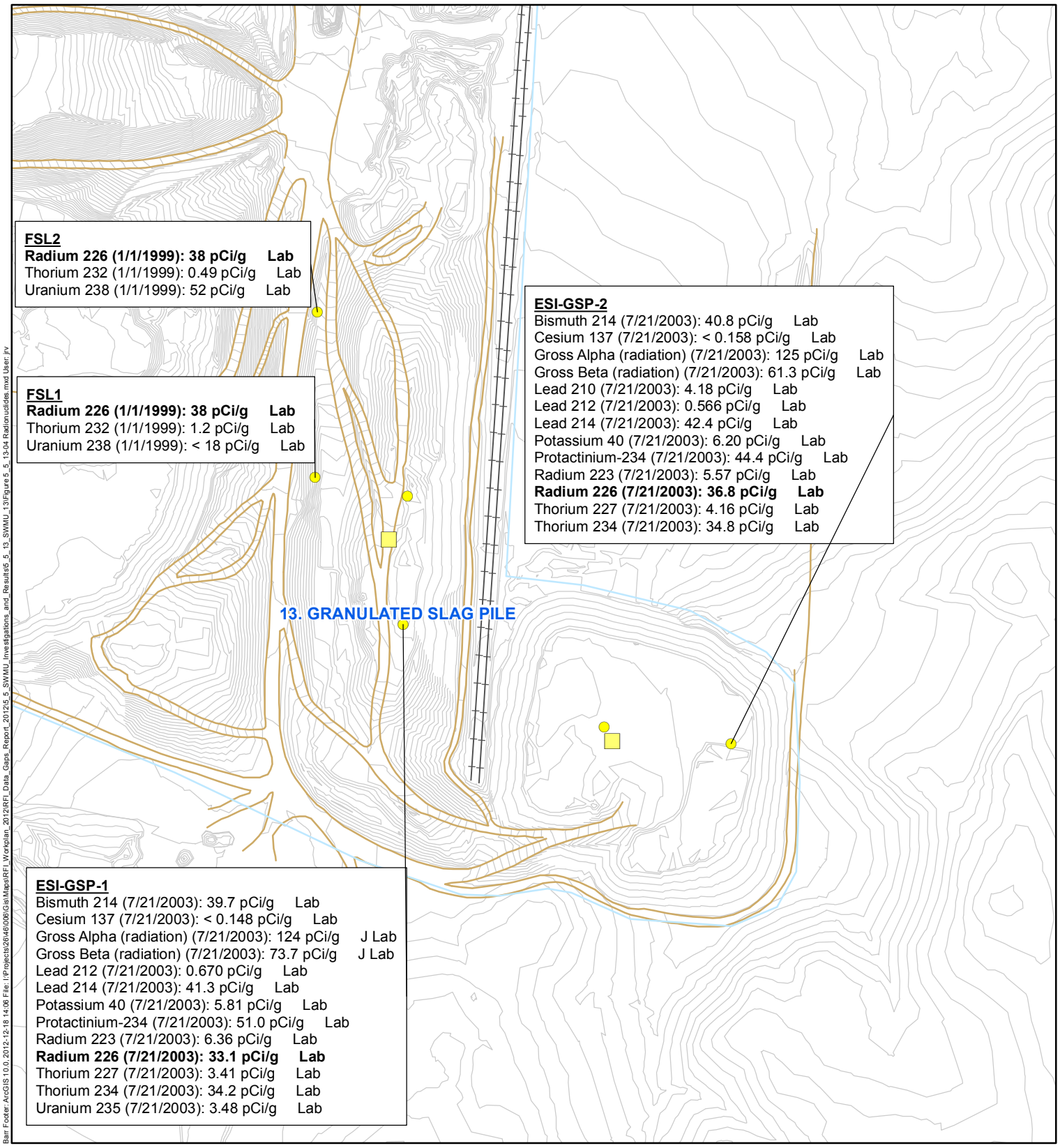
N

Feet
300 0 300

Bold font indicates that sample concentration is greater than the 95% UCL of mean Reference Area Concentration.

Figure 5.5.13-3

SWMU 13
GENERAL PARAMETERS
Rhodia Silver Bow Plant
Montana



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Sample Location
Composite Sample Centroid Location
SWMU 13
Former Plant Structures
Elevation Contour
Drainage
Railroad
Road

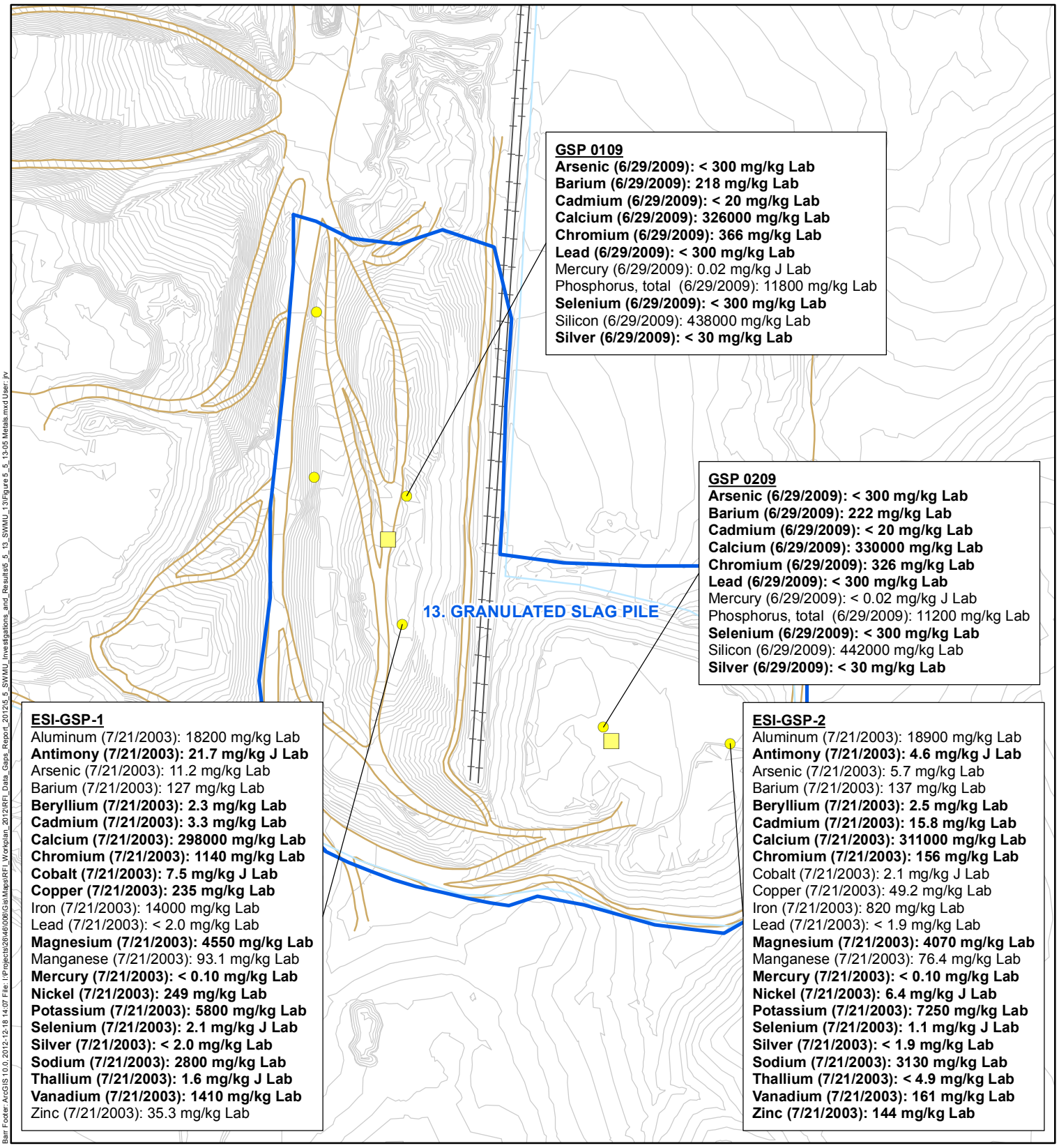
N

Feet
300 0 300

Bold font indicates that sample concentration is greater than the 95% UCL of mean Reference Area Concentration.

Figure 5.5.13-4

SWMU 13
RADIONUCLIDES
Rhodia Silver Bow Plant
Montana



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Sample Location
Composite Sample Centroid Location
SWMU 13
Former Plant Structures
Elevation Contour
Drainage
Railroad
Road

N

Feet
300 0 300

Bold font indicates that sample concentration is greater than the 95% UCL of mean Reference Area Concentration.

Figure 5.5.13-5

SWMU 13
METALS
Rhodia Silver Bow Plant
Montana