CRONIMET Mining and Processing, LLC

RESULTS

Treatability Study of Ferrochrome Slag

Former Satralloy Site, Mingo Junction, OH

Version Control

Version	Date	Author	Change Description
1.0	July 15, 2017	Carlos Garcia Cabral	Original Document

Notes:

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GLOSSARY OF TERMS

Batch Jig — A laboratory scale device that duplicates the separation principles of a full-scale air-pulsed minerals processing plant.

Concentrate — The material layer in the jig that contains a blend of slag and metal due to the incomplete liberation of metal or a mixture of -8 +1 mm materials that were not manually separated for analytical purposes.

COPCs — Chemicals of Potential Concern. Chemicals in environmental media that are potentially site-related and for which laboratory analytical data are of sufficient quality for use in a quantitative risk assessment.

Filter Cake — Suspended solids that are precipitated out of the Process Water and removed and dried in an automated filtration system.

LOQ — Limit of Quantitation. The smallest concentration of a chemical constituent that can be reliably measured by a specific analytical procedure.

Materials — Collectively considered as soil, slag, Baghouse Dust, metal, Concentrate, Processed Slag or Filter Cake.

OhioEPA — Ohio Environmental Protection Agency.

OSHA — Occupational Safety and Health Administration.

PEL — Permissible Exposure Limit; A legal limit established by OSHA for exposure of an employee to a chemical or physical agent.

Processed Slag — Slag that has been processed through a minerals processing plant from which the metal (FeCr) has been removed.

Process Water — Make-up (clean) water is introduced into the jig that serves as the medium in which the materials are fluidized and stratified. The water is classified as Process Water once it comes into contact with the materials in the jig vessel.

RI/FS — Remedial Investigation/Feasibility Study; Guidance developed by the USEPA for conducting site investigations and remediation on CERCLA sites.

SPLP — Synthetic Precipitation Leaching Procedure; Test procedure designed to simulate material sitting in-situ (in or on top of the ground) exposed to rainfall (with the assumption that the rainfall is slightly acidic) to determine the mobility of both organic and inorganic analytes present in liquids, solids,

and wastes from the leachate the material would produce. The TCLP standards developed by the USEPA in November 1986 are generally used to compare the SPLP results against.

TCLP Toxicity Characteristic Leaching Procedure; Test procedure designed to simulate material sitting inside a municipal landfill for a number of years (with an assumption of acidic conditions found in most municipals landfills) to determine the mobility of both organic and inorganic analytes present in liquid, solid and multi-phase wastes from the leachate the material would produce; Used to determine if a chemical or waste is characteristically hazardous, i.e., classified as one of the “D” listed wastes by the USEPA. The USEPA established TCLP standards in November 1986 that are used to compare TCLP test results against.

XRF X-Ray Fluorescence is a non-destructive analytical technique used to determine the elemental composition of materials. XRF analyzers determine the chemistry of a sample by measuring the fluorescent (or secondary) X-ray emitted from a sample when it is excited by a primary X-ray source.

1 Introduction

1.1 Background

CRONIMET and Cyprus Amax Minerals Company (CAMC) agreed to conduct a Treatability Study (TS) to evaluate the effectiveness of the CRONIMET solution in extracting the metals from the Ferrochrome (FeCr) Slag at the former Satralloy Site (the "Site") based in Mingo Junction, Ohio, USA.

According to the Golder Remedial Investigation/Feasibility Study Report for the Former Satralloy Site, Jefferson County, Ohio – Volumes I and II (RI/FS) (Golder RI, December 2016), an estimated 1,300,000 to 1,800,00 cubic yards of slag have been deposited across large tracts of both the upland and lowland areas of the 300 plus acre Site.

1.2 Scope of Work

CRONIMET prepared and submitted a Treatability Study (TS) protocol & work-plan to CAMC on September 30, 2016 for submittal to the OhioEPA, it was approved by the OhioEPA on October 16, 2017.

The purpose of this report is to provide the results of the TS as well as a proposed solution for the construction and operation of full-scale CRONIMET minerals processing and water treatment plant to process all the Materials on the Site.

1.3 Description of TS Test Protocol

The TS test protocol consisted of the following tasks:

- Site evaluation.
- Sample excavation and collection.
- Sample preparation.
- Density separation with an air pulsed pilot jig.
- Density separation with a fine particle gravity concentration table.
- Analysis of Process Water, products and by-products.

Appendix A provides a graphical representation of the TS protocol.

2 Sample Collection, Preparation and Processing

A grid sampling method was applied to obtain 35 samples representative of the on-Site slag. The sample locations are shown in **Appendix B**. Samples 32-35, from the Slurry Tower Area, were not processed through the batch jig due to the nature of the material, which is only suitable for processing through a fine particle separation plant.

2.1 Sample Preparation

Samples 1-31 were screened and crushed to the following fractions:

- +25 mm (Manual Sorting)
- -25 +8 mm
- -8 +1 mm
- -1 mm

The results of the particle size distribution are shown in **Appendix C**.

2.2 Manual Sorting

The +25 mm material that did not pass the screen after crushing was manually sorted and the recovered metal was weighed to determine the metal content. The remaining +25 mm slag was not crushed further and will likely contain entrapped metals that can be liberated with further crushing.

2.3 Batch Jig Tests

Batch jig tests were performed separately on the -25 +8 mm and -8 +1 mm fractions of each sample to determine recoverable metallic yield.

Materials were removed from the batch jig in layers of decreasing density and subsequently dried and weighed. A physical sorting of metal, Concentrate and Processed Slag was performed as part of the detailed material analysis on the -25 +8 mm fractions. The high metal containing Materials recovered from the -8 +1 mm fractions are reported as “Concentrate” and were analyzed by means of water displacement tests to determine the metal content.

The metal recovery results are shown in **Appendix D**.

The Processed Slag is discussed in Section 4.3

2.4 Shaking Table Test

Ten composite samples of the -1 mm fraction were processed over a gravity concentration table (i.e., shaking table) to determine the effectiveness of using density separation on this size fraction.

The -1 mm metal and slag was microscopically analyzed and the photographic results are shown in **Appendix E**. The results indicate that the gravity concentration is effective in separating liberated metals from the slag on the -1 mm fraction.

2.5 Metallurgical Analysis

Ten composite samples were generated from the metals recovered from the -25 +8 mm fractions and were melted and analyzed by X-Ray Refraction (XRF) to determine the total chromium (Cr) content. The recovered -8 +1 mm Concentrate was not subjected to further metallurgical analysis. A composite sample of the -1 mm metals was also melted and analyzed by XRF to determine total Cr content.

The metallurgical results are shown in **Appendix F**.

3 Analysis

Accredited laboratories analyzed samples of the Processed Slag and Process Water as per the parameters presented in the TS protocol & work-plan that was approved by the OhioEPA.

Personal and area air monitoring was also conducted to measure potential fugitive emissions associated with sample excavation and processing (See Section 6).

Description of Material	Analysis	Results
Slag (-25 +8 mm Composite)	TCLP/SCLP	Appendix G
Slag (-25 +8 mm Composite)	Mineralogy	Appendix H
Slag (Slurry Tower Area)	Mineralogy	Appendix I
Slag (-25 +8 mm Composite)	Total Metals	Appendix J
Process Water (-25 +8 mm Composite)	Total Metals	Appendix K
Process Water (-25 +8 mm Composite)	Cr (VI)	Appendix L
Process Water (-8 +1 mm Individual)	Cr (VI)	Appendix L
Process Water (-1 mm Composite)	Cr (VI)	Appendix L
Air Quality Monitoring	PM10, Cr (VI), Cr	Appendix M

4 Findings

4.1 Metal Recovery

The TS demonstrates that the slag can be processed through a CRONIMET minerals processing plant and that the metal and slag can be separated effectively using density separation technology.

XRF metallurgical analysis of the recovered metals, as presented in **Appendix F**, shows that the metals are suitable for repurposing in various industries.

4.2 Process Water

The Process Water analytical results indicate that the excavation and processing of the slag liberates and dissolves Cr (VI) into the Process Water.

Appendix K presents the Process Water (-25 +8 mm materials) total metals analytical results.

Appendix L presents the specific Cr (VI) Process Water analytical results.

In the full-scale CRONIMET solution, the Process Water will be recycled in a closed circuit (i.e., zero effluent) water treatment plant that includes a Cr (VI) neutralization step. After the FeCr is removed from the slag and Cr (VI) dissolved into the Process Water, non-toxic ferrous sulfate is used to reduce the Cr (VI) to Cr (III), which is then precipitated out of solution and collected as Filter Cake.

4.3 Processed Slag

The following analyses were performed on the -25 +8 mm Processed Slag:

1. Toxicity Characteristic Leaching Procedure (TCLP) and Synthetic Precipitation Leaching Procedure (SPLP) – results in **Appendix G**
2. Mineralogy – results in **Appendix H** and **I**
3. Total metals – results in **Appendix J**

The TCLP and SPLP analyses of the Processed Slag are presented in **Appendix G**.

Appendix I represents the mineralogy of the slag collected at the Slurry Tower Area.

5 Site Assessment

A Site survey was conducted to evaluate the availability and condition of existing infrastructure.

The South Mill Building was identified as the ideal location to build and operate the full-scale CRONIMET minerals processing plant. A detailed engineering assessment will need to be conducted to identify potential safety hazards. The building will need to be refurbished for long-term use. Indoor processing will ensure that potential fugitive emissions are adequately controlled.

A three phase, 1200 Amp, 480-volt electrical service is available on the Site with underground conduits installed from the central transformer to the distribution board at the South Mill Building.

The on-site water well is currently out of service and will need to be re-commissioned and piping installed from the well to the South Mill building.

The Site is accessible via two access roads. The bridge on County Road 74 is currently being replaced with a bridge capable of supporting heavy commercial traffic. The railway line into the Site is currently in good operating condition. Site haul roads need to be prepared in line with the excavation requirements.

The former Administration Building is adequate for Site support services; however, it will need to be refurbished for long-term use.

The former Pump House is suitable for use as an on-site laboratory; however, it will need to be refurbished for long-term use. This building has a large water storage cistern beneath it that could serve as back-up water for full-scale operations.

6 Health and Safety

Site activities were conducted in accordance with CRONIMET and Freeport's Health and Safety procedures and standards. Both area and personal air monitoring of PM10, Cr (VI) and total Cr, respectively, was conducted inside the former Pump House, where samples were processed. Personal air monitoring was also conducted of Cr (VI) and total Cr during the sample excavation and collection process. **Appendix M** presents the results of these analyses.

All results were less than the Limit of Quantitation (LOQ) and/or OSHA Permissible Exposure Limit (PEL) for Cr (VI) and total Cr in the personal air monitoring of employees involved in the sample excavation and collection. The total Cr results were all less than the LOQ and the Cr (VI) results were either less than the LOQ and/or the OSHA PEL of 5 ug/m^3 in the area air monitoring sampling in the Pump House. Currently there is no OSHA PEL for PM 10; therefore, the results were conservatively compared to the OSHA PEL for all respirable dust of 5 mg/m3. However, this conservatively assumes that all of the PM 10 is respirable which would not be the case. All of the six PM10 samples were either less than the LOQ and/or the OSHA PEL for respirable dust. Both personal and area air monitoring will continue to be conducted during any future activities associated with the slag excavation and processing operations.

7 Proposed Solution

CRONIMET proposes to construct, commission and operate a full-scale minerals processing plant in the South Mill Building. The processing will consist of the following activities:

- Excavation, crushing and screening
- Minerals processing (separation of metals from slag)
- Water treatment
- Grading, contouring and revegetation

Appendix N shows CRONIMET's conceptual process flow for the minerals processing.

Appendix O shows CRONIMET's conceptual water recycling and treatment facility.

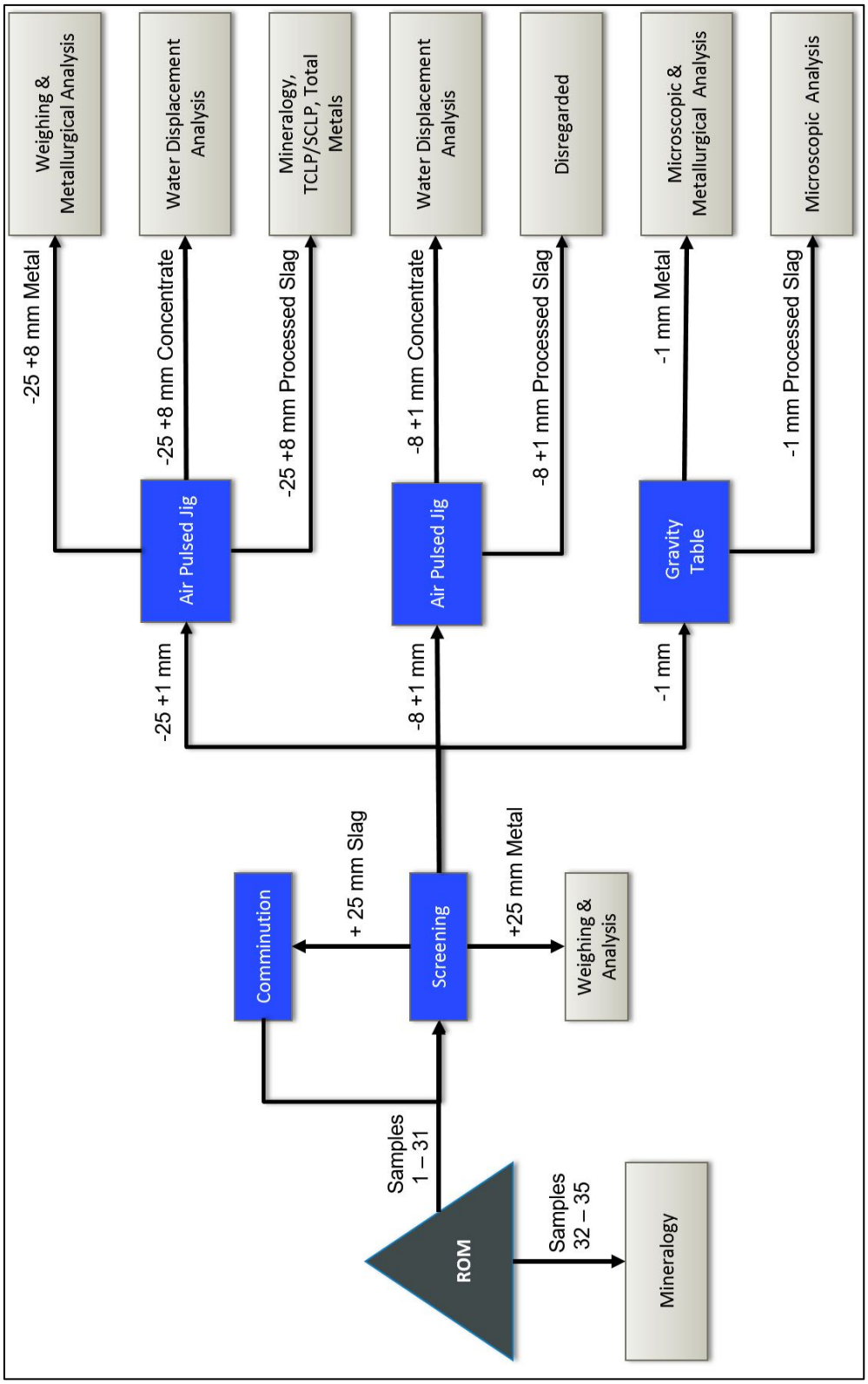
The CRONIMET solution will also be capable of processing the layer of soil in direct contact with the slag.

8 Conclusion

The results from the TS confirm that the CRONIMET process will successfully separate the metals from the slag and that the FeCr can be beneficially reused as a valuable commodity. The Cr (VI) can be processed as part of the CRONIMET solution. The Processed Slag may be considered for other on-Site or off-Site uses.

This TS supports the evaluation of the technical feasibility and economic impact of implementing the CRONIMET solution to recover the metal on the Site and neutralize Cr (VI) as part of the remediation and restoration of the former Satralloy Site.

Appendix A – Process Flow TS Protocol



Appendix B – Sample Locations

Sample	Area	Latitude	Longitude
1	A	40° 18' 19.75" N	80° 40' 38.52" W
2		40° 18' 20.68" N	80° 40' 37.10" W
3		40° 18' 22.01" N	80° 40' 35.67" W
4		40° 18' 23.38" N	80° 40' 32.87" W
5		40° 18' 22.57" N	80° 40' 31.25" W
6		40° 18' 23.99" N	80° 40' 30.31" W
7		10° 18' 23.20" N	80° 40' 28.98" W
8	B	40° 18' 27.26" N	80° 40' 32.21" W
9		40° 18' 28.66" N	80° 40' 30.56" W
10		40° 18' 30.58" N	80° 40' 28.75" W
11		40° 18' 27.81" N	80° 40' 34.99" W
12		40° 18' 29.56" N	80° 40' 33.15" W
13		40° 18' 31.04" N	80° 40' 31.35" W
14		40° 18' 32.78" N	80° 40' 29.88" W
15		40° 18' 29.56" N	80° 40' 36.23" W
16		40° 18' 31.14" N	80° 40' 34.54" W
17		40° 18' 32.75" N	80° 40' 32.41" W
18		40° 18' 34.41" N	80° 40' 30.87" W
19		40° 18' 31.67" N	80° 40' 37.02" W
20		40° 18' 33.67" N	80° 40' 34.90" W
21		40° 18' 35.33" N	80° 40' 33.23" W
22		40° 18' 36.17" N	80° 40' 35.58" W
23		40° 18' 37.67" N	80° 40' 33.38" W
24		40° 18' 36.94" N	80° 40' 31.38" W
25		40° 19' 36.20" N	80° 40' 29.44" W
26		40° 18' 39.29" N	80° 40' 31.23" W
27		40° 18' 38.92" N	80° 40' 28.79" W
28	C	40° 18' 41.34" N	80° 40' 30.07" W
29		40° 18' 40.86" N	80° 40' 28.10" W
30		40° 18' 43.18" N	80° 40' 28.67" W
31		40° 18' 45.37" N	80° 40' 26.07" W
32	D	40° 18' 54.37" N	80° 40' 07.04" W
33		40° 18' 55.93" N	80° 40' 07.12" W
34		40° 18' 56.94" N	80° 40' 08.65" W
35		40° 18' 57.80" N	80° 40' 13.75" W

APPENDIX B - CONTINUED

Sample Locations Overview

APPENDIX B - CONTINUED

Sample Locations Area A

APPENDIX B - CONTINUED

Sample Locations Area B

APPENDIX B - CONTINUED

Sample Locations Area C

APPENDIX B - CONTINUED

Sample Locations Area D (Slurry Tower Area)

Appendix C – Particle Size Distribution

I.D.	+25 mm		-25 +8 mm		-8 +1 mm				-1 mm		Total	%
	Wt (g)	%	Wt (g)	%	Wt (g)	%	Wt (g)*	%	Wt (g)	%	Wt (g)	
1	19,318	23%	16,568	20%	16,750	20%	17,109	21%	12,528	15%	82,273	100%
2	23,273	27%	19,432	23%	16,273	19%	10,241	12%	15,486	18%	84,705	100%
3	14,438	18%	15,705	20%	22,591	29%	14,059	18%	11,668	15%	78,461	100%
4	18,971	26%	17,091	24%	16,091	22%	8,299	11%	11,883	16%	72,335	100%
5	25,523	34%	16,841	23%	19,545	26%	6,176	8%	6,333	9%	74,418	100%
6	26,227	32%	18,091	22%	18,909	23%	11,314	14%	6,822	8%	81,363	100%
7	20,364	26%	16,568	21%	21,045	27%	10,528	13%	10,722	14%	79,227	100%
8	23,568	32%	21,545	29%	19,727	27%	3,933	5%	4,862	7%	73,635	100%
9	19,273	28%	12,841	19%	25,523	37%	6,633	10%	4,503	7%	68,773	100%
10	20,318	26%	14,250	18%	21,886	28%	7,824	10%	14,039	18%	78,317	100%
11	13,636	19%	13,545	19%	23,364	32%	9,477	13%	12,296	17%	72,318	100%
12	23,273	33%	16,705	24%	22,068	31%	4,668	7%	3,832	5%	70,546	100%
13	17,545	27%	15,068	23%	20,364	31%	5,719	9%	6,872	10%	65,568	100%
14	16,341	24%	13,205	19%	20,636	30%	8,511	12%	10,489	15%	69,182	100%
15	25,386	34%	14,091	19%	18,477	24%	6,729	9%	10,908	14%	75,591	100%
16	13,045	22%	10,250	17%	15,409	26%	8,909	15%	11,750	20%	59,363	100%
17	36,227	41%	12,068	14%	17,091	20%	12,723	15%	9,391	11%	87,500	100%
18	30,068	45%	14,705	22%	15,545	23%	4,262	6%	2,874	4%	67,454	100%
19	25,455	32%	15,205	19%	18,341	23%	6,469	8%	12,917	16%	78,387	100%
20	23,386	32%	13,318	18%	15,818	22%	9,691	13%	10,309	14%	72,522	100%
21	30,182	43%	14,477	21%	15,591	22%	3,692	5%	6,195	9%	70,137	100%
22	31,341	34%	13,795	15%	17,364	19%	10,824	12%	18,562	20%	91,886	100%
23	30,545	34%	13,955	15%	16,773	19%	14,689	16%	14,380	16%	90,342	100%
24	23,295	28%	19,250	23%	18,545	23%	10,099	12%	11,174	14%	82,363	100%
25	34,523	36%	16,614	17%	21,045	22%	7,125	7%	16,466	17%	95,773	100%
26	23,636	31%	15,295	20%	24,614	33%	6,318	8%	5,750	8%	75,613	100%
27	36,136	38%	17,455	19%	19,750	21%	11,806	13%	9,103	10%	94,250	100%
28	31,659	37%	15,841	19%	17,568	21%	7,090	8%	13,137	15%	85,295	100%
29	34,000	38%	14,841	17%	18,545	21%	10,667	12%	10,492	12%	88,545	100%
30	26,705	29%	13,977	15%	20,432	23%	15,964	18%	13,718	15%	90,796	100%
31	38,705	43%	15,182	17%	15,955	18%	8,996	10%	10,549	12%	89,387	100%
Total	**776,362**	**32%**	**477,774**	**20%**	**591,635**	**24%**	**280,544**	**11%**	**320,010**	**13%**	**2,446,325**	**100%**

Notes:
Wt (g) – Weight in grams
Wt (g)* – Disregarded -8 +1 mm materials

Appendix D – Metal Recovery

I.D.	+25 mm			-25 +8 mm						-8 +1 mm			
	Wt (g)	Metal (g)	Metal (%)	Wt (g)	Metal (g)	Metal (%)	Conc (g)	Metal (g)	Metal (%)	Wt (g)	Conc (g)	Metal (g)	Metal (%)
1	19,318	175	0.91%	16,568	170	1.03%	785	119	0.7%	16,750	1,946	131	0.8%
2	23,273	210	0.90%	19,432	261	1.34%	1024	187	1.0%	16,273	1,975	154	0.9%
3	14,438	179	1.24%	15,705	244	1.55%	749	155	1.0%	22,591	1,533	219	1.0%
4	18,971	203	1.07%	17,091	264	1.54%	435	91	0.5%	16,091	788	135	0.8%
5	25,523	378	1.48%	16,841	230	1.37%	536	118	0.7%	19,545	1,947	173	0.9%
6	26,227	310	1.18%	18,091	200	1.11%	584	117	0.6%	18,909	1,617	148	0.8%
7	20,364	234	1.15%	16,568	281	1.70%	577	103	0.6%	21,045	2,025	158	0.7%
8	23,568	230	0.98%	21,545	235	1.09%	302	61	0.3%	19,727	2,221	164	0.8%
9	19,273	367	1.90%	12,841	98	0.76%	236	47	0.4%	25,523	1,198	98	0.4%
10	20,318	382	1.88%	14,250	210	1.47%	0	0	0.0%	21,886	1,753	89	0.4%
11	13,636	176	1.29%	13,545	290	2.14%	730	119	0.9%	23,364	1,201	164	0.7%
12	23,273	488	2.10%	16,705	166	0.99%	335	87	0.5%	22,068	986	33	0.2%
13	17,545	360	2.05%	15,068	218	1.45%	374	88	0.6%	20,364	871	2	0.0%
14	16,341	300	1.84%	13,205	241	1.83%	448	26	0.2%	20,636	1,018	42	0.2%
15	25,386	464	1.83%	14,091	254	1.80%	0	0	0.0%	18,477	1,235	61	0.3%
16	13,045	335	2.57%	10,250	123	1.20%	499	11	0.1%	15,409	1,203	109	0.7%
17	36,227	473	1.31%	12,068	168	1.39%	533	76	0.6%	17,091	1,893	199	1.2%
18	30,068	565	1.88%	14,705	156	1.06%	472	76	0.5%	15,545	1,315	12	0.1%
19	25,455	328	1.29%	15,205	344	2.26%	538	121	0.8%	18,341	1,132	138	0.8%
20	23,386	200	0.86%	13,318	250	1.88%	484	0	0.0%	15,818	1,131	32	0.2%
21	30,182	314	1.04%	14,477	280	1.93%	865	193	1.3%	15,591	1,394	124	0.8%
22	31,341	453	1.45%	13,795	175	1.27%	537	98	0.7%	17,364	1,413	150	0.9%
23	30,545	738	2.42%	13,955	209	1.50%	503	89	0.6%	16,773	1,356	2	0.0%
24	23,295	322	1.38%	19,250	180	0.94%	0	0	0.0%	18,545	1,536	48	0.3%
25	34,523	341	0.99%	16,614	298	1.79%	1091	174	1.0%	21,045	1,402	216	1.0%
26	23,636	258	1.09%	15,295	301	1.97%	565	122	0.8%	24,614	1,316	121	0.5%
27	36,136	459	1.27%	17,455	183	1.05%	543	126	0.7%	19,750	1,265	125	0.6%
28	31,659	425	1.34%	15,841	300	1.89%	605	140	0.9%	17,568	1,082	2	0.0%
29	34,000	460	1.35%	14,841	200	1.35%	550	118	0.8%	18,545	1,178	21	0.1%
30	26,705	303	1.13%	13,977	212	1.52%	502	69	0.5%	20,432	1,059	74	0.4%
31	38,705	400	1.03%	15,182	153	1.01%	550	108	0.7%	15,955	1,004	45	0.3%
Total	**776,362**	**10,830**	**1.39%**	**477,774**	**6,894**	**1.44%**	**15,952**	**2,837**	**0.6%**	**591,635**	**42,993**	**3,187**	**0.5%**

APPENDIX D - CONTINUED

Metal Recovery Summary

I.D.	Wt (g)	Processed (g)	+25 mm	-25 +8 mm	-25 +8 mm (Conc)	-8 mm (Conc)	Total Metal (g)	Metal (%)
1	82,273	65,164	175	170	119	131	595	0.9%
2	84,705	74,464	210	261	187	154	812	1.1%
3	78,461	64,402	179	244	155	219	797	1.2%
4	72,335	64,036	203	264	91	135	693	1.1%
5	74,418	68,242	378	230	118	173	899	1.3%
6	81,363	70,049	310	200	117	148	774	1.1%
7	79,227	68,699	234	281	103	158	776	1.1%
8	73,635	69,702	230	235	61	164	690	1.0%
9	68,773	62,140	367	98	47	98	610	1.0%
10	78,317	70,493	382	210	0	89	681	1.0%
11	72,318	62,841	176	290	119	164	749	1.2%
12	70,546	65,878	488	166	87	33	774	1.2%
13	65,568	59,849	360	218	88	2	667	1.1%
14	69,182	60,671	300	241	26	42	609	1.0%
15	75,591	68,862	464	254	0	61	779	1.1%
16	59,363	50,454	335	123	11	109	578	1.1%
17	87,500	74,777	473	168	76	199	916	1.2%
18	67,454	63,192	565	156	76	12	808	1.3%
19	78,387	71,918	328	344	121	138	931	1.3%
20	72,522	62,831	200	250	0	32	482	0.8%
21	70,137	66,445	314	280	193	124	910	1.4%
22	91,886	81,062	453	175	98	150	876	1.1%
23	90,342	75,653	738	209	89	2	1,038	1.4%
24	82,363	72,264	322	180	0	48	550	0.8%
25	95,773	88,648	341	298	174	216	1,029	1.2%
26	75,613	69,295	258	301	122	121	802	1.2%
27	94,250	82,444	459	183	126	125	893	1.1%
28	85,295	78,205	425	300	140	2	867	1.1%
29	88,545	77,878	460	200	118	21	798	1.0%
30	90,796	74,832	303	212	69	74	658	0.9%
31	89,387	80,391	400	153	108	45	707	0.9%
Total	**Total**	**2,165,781**	**10,830**	**6,894**	**2,837**	**3,187**	**23,748**	**1.10%**

Notes:

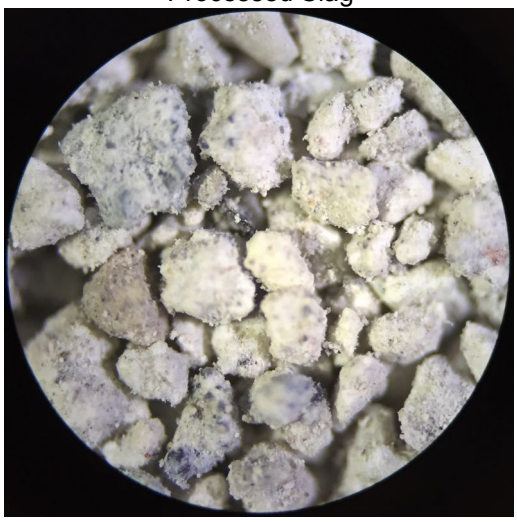
Conc – Concentrate due to incomplete liberation of metals

Appendix E - Microscopic Analysis

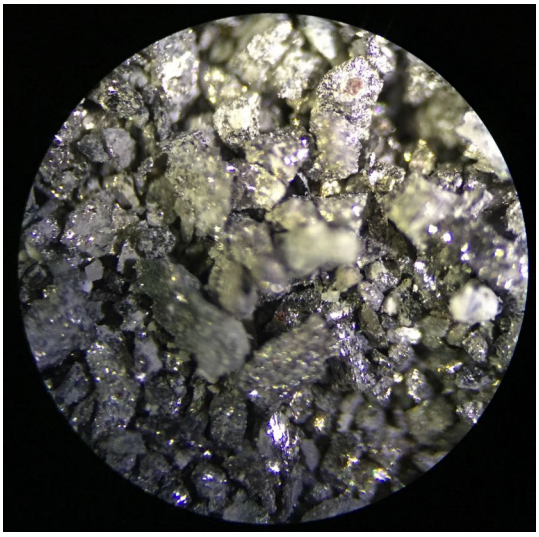
-1 mm Composite Samples

Analysis 1 (Samples 1-3)

Processed Slag

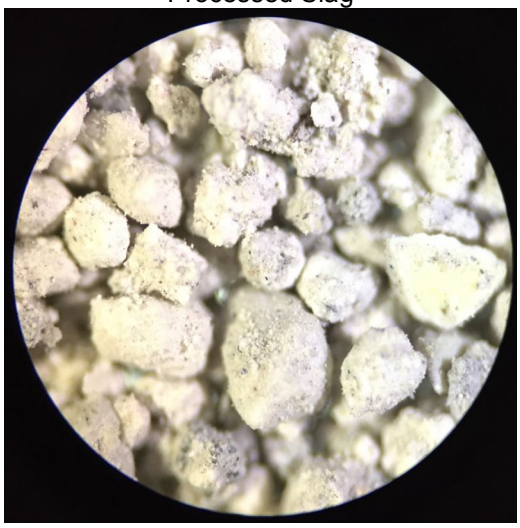


Recovered Metal

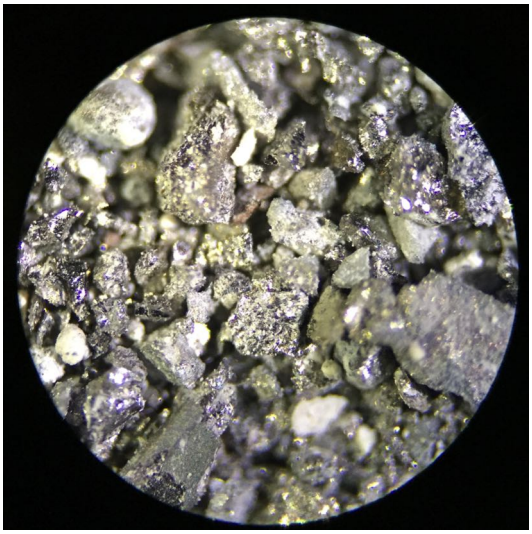


Analysis 2 (Samples 4-6)

Processed Slag



Recovered Metal

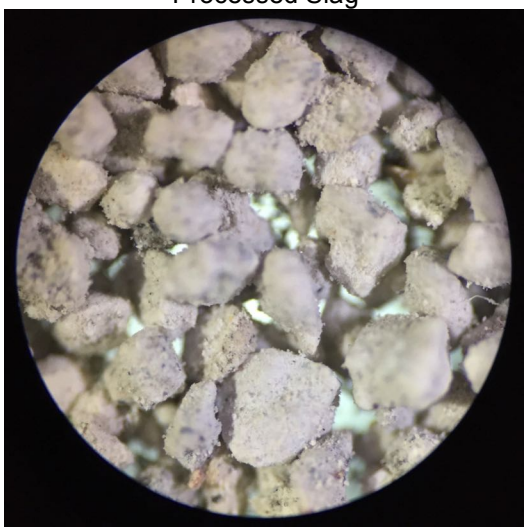


APPENDIX E - CONTINUED

-1 mm Composite Samples

Analysis 3 (Samples 7-9)

Processed Slag

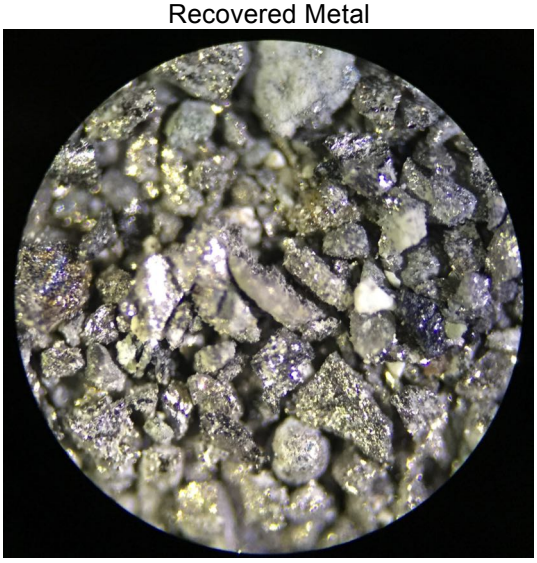


Recovered Metal

Analysis 4 (Samples 10-12)

Processed Slag

Recovered Metal

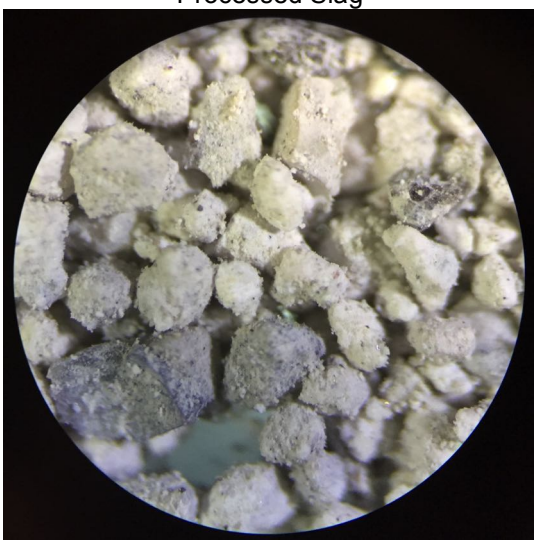


APPENDIX E - CONTINUED

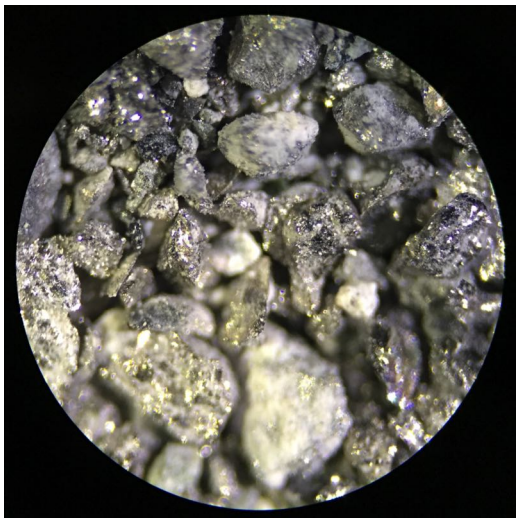
-1 mm Composite Samples

Analysis 5 (Samples 13-15)

Processed Slag



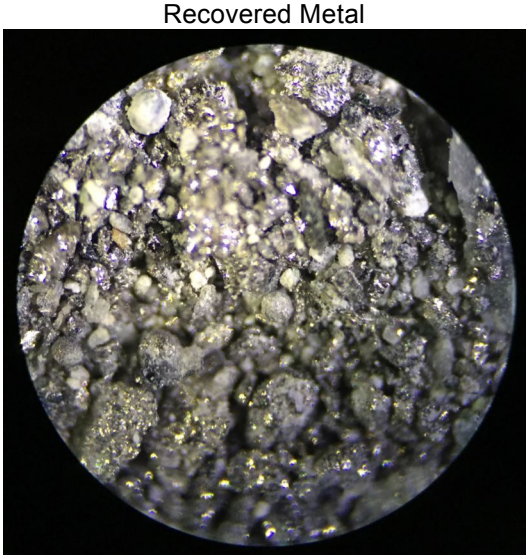
Recovered Metal



Analysis 6 (Samples 16-18)

Processed Slag

Recovered Metal



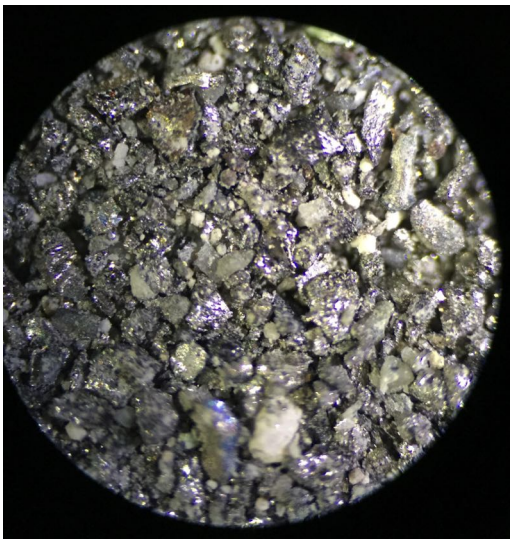
APPENDIX E - CONTINUED

-1 mm Composite Samples

Analysis 7 (Samples 19-21)

Processed Slag

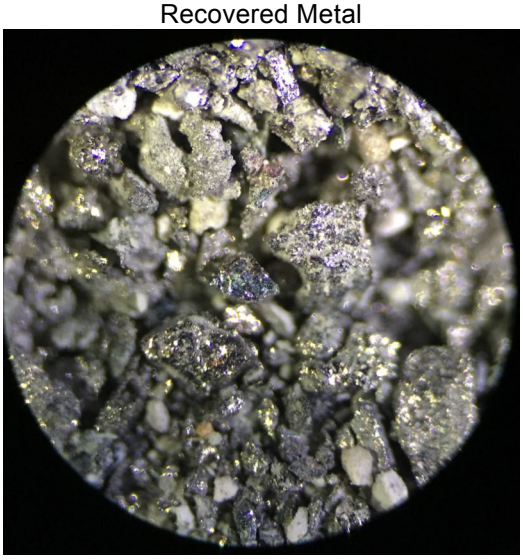
Recovered Metal



Analysis 8 (Samples 22-24)

Processed Slag

Recovered Metal

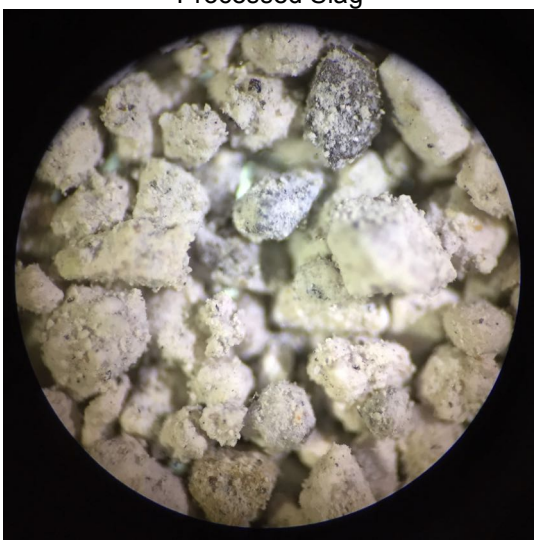


APPENDIX E - CONTINUED

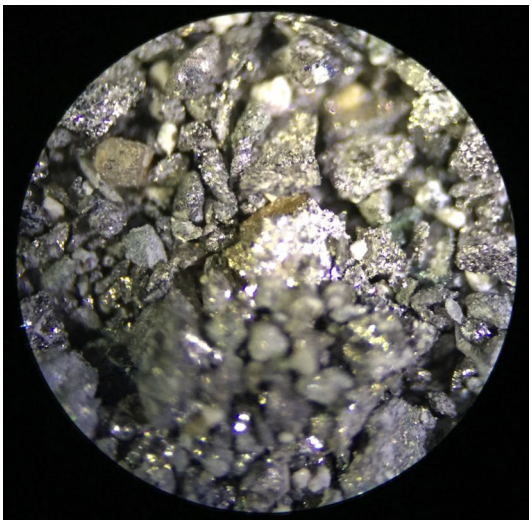
-1 mm Composite Samples

Analysis 9 (Samples 25-27)

Processed Slag

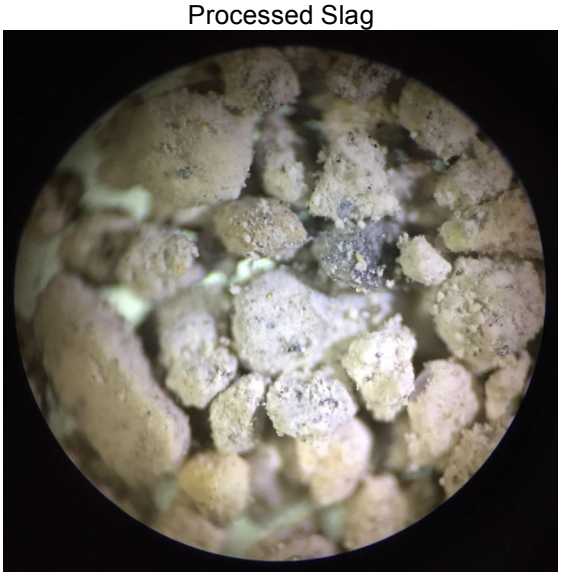


Recovered Metal

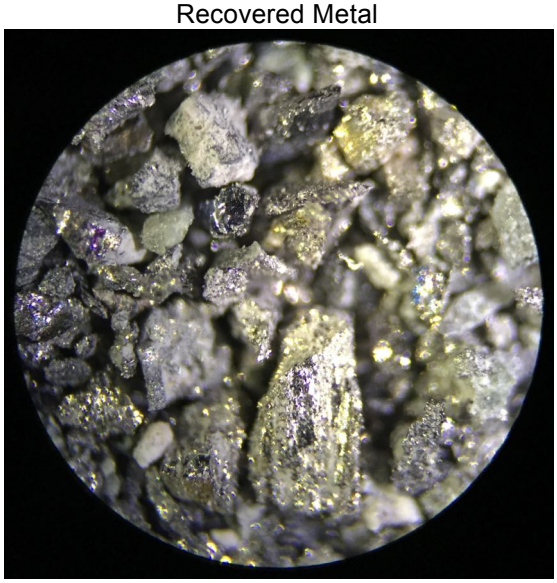


Analysis 10 (Samples 28-31)

Processed Slag



Recovered Metal



Appendix F – Metallurgical Analysis Recovered Metal

Composite Samples

I.D.	Samples	Fraction	Ni	Cr	Mo	Cu	P	Mn	C	Fe
1	1-3	-25 +8 mm	0.25	68.33	0.04	0.10	0.02	0.30	1.07	29.89
2	4-6	-25 +8 mm	0.21	68.72	0.01	0.01	0.02	0.15	0.38	30.51
3	7-9	-25 +8 mm	2.29	59.64	0.12	0.33	0.04	0.39	0.23	36.97
4	10-12	-25 +8 mm	0.55	61.04	0.05	0.27	0.03	0.40	0.61	37.05
5	13-15	-25 +8 mm	1.46	62.73	0.11	0.27	0.03	0.50	1.10	33.80
6	16-18	-25 +8 mm	0.45	63.22	0.05	0.18	0.04	0.42	1.31	34.33
7	19-21	-25 +8 mm	0.52	63.23	0.05	0.27	0.03	0.45	0.54	34.92
8	22-24	-25 +8 mm	0.41	62.50	0.05	0.18	0.03	0.54	0.41	35.89
9	25-27	-25 +8 mm	0.29	66.89	0.04	0.23	0.03	0.53	0.34	31.64
10	28-31	-25 +8 mm	0.27	63.93	0.04	0.24	0.02	0.44	0.90	34.15
11	1-31	-1 mm	1.04	63.53	0.10	0.95	0.11	2.23	1.80	30.24

Notes:

Results are shown as % of the constituent

Appendix G – TCLP/SPLP Processed Slag

-25 mm +8 mm Composite Samples (1-31)

PARAMETER Metals (TCLP)	S-1 (1-3)	S-2 (4-6)	S-3 (8-9)	S-4 (10-12)	S-5 (13-15)	S-6 (16-18)	S-7 (19-21)	S-8 (22-24)	S-9 (25-27)	S-10 (28-31)
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	0.12J	0.11J	0.45J	0.11J	0.069J	0.065J	0.063J	0.071J	0.081	0.078J
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	0.84	1	0.48J	0.72	0.67	0.55	0.88	0.37J	0.80	0.54
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	ND	ND	ND	ND	ND	0.041J	ND	ND	0.079J	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

PARAMETER Metals (SPLP)	S-1 (1-3)	S-2 (4-6)	S-3 (8-9)	S-4 (10-12)	S-5 (13-15)	S-6 (16-18)	S-7 (19-21)	S-8 (22-24)	S-9 (25-27)	S-10 (28-31)
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	0.023J	0.006J	0.015J	0.038J	ND	0.009J	0.0096J	0.011J	0.011J	0.012J
Cadmium	ND	ND	ND	0.00022J	ND	ND	ND	ND	ND	ND
Chromium	0.62	1	0.730	0.33	0.31	0.32	0.55	0.32	0.11	0.07
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	ND	0.0048J	ND	0.0057J	ND	ND	0.005J	0.0067J	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

Unit - mg/l

ND - Non detect

J - Result is less than reporting limit but greater than or equal to the method detection limit and the concentration is an approximate value.

TCLP - Toxicity Characteristic Leaching Procedure

TCLP* - Toxicity Characteristic Leaching Procedure limit

SPLP - Synthetic Precipitation Leaching Procedure

Appendix H – Mineralogy Processed Slag

-25 mm +8 mm Composite Samples (1–30)

PARAMETER	SM-1 (1-5)	SM-2 (6-10)	SM-3 (11-15)	SM-5 (16-20)	SM-5 (21-25)	SM-6 (26-30)
Al_2O_3	5.79	8.54	6.60	7.08	7.49	6.95
CaO	45.43	39.45	48.04	44.56	43.71	42.60
Co_3O_4	0.004	0.002	0.003	0.01	0.001	0.02
Cr_2O_3	5.11	3.04	2.98	3.24	2.54	8.95
Fe_2O_3	0.64	1.24	0.40	0.71	0.49	2.49
K_2O	0.009	0.16	0.031	0.093	0.04	0.03
MgO	14.43	14.74	13.41	14.02	14.51	12.09
MnO	0.085	0.072	0.051	0.068	0.049	0.08
Na_2O	0.021	0.085	0.080	0.034	0.030	0.02
Nb_2O_5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
NiO	<0.001	<0.001	<0.001	<0.001	<0.001	0.03
P_2O_5	0.008	0.011	0.001	0.008	0.006	0.02
SiO_2	28.25	32.45	28.19	29.94	30.87	26.45
TiO_2	0.20	0.19	0.19	0.22	0.24	0.25
V_2O_5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ZrO_2	0.001	0.001	0.001	<0.001	<0.001	<0.001
C	1.63	2.08	2.30	1.23	2.25	1.33
LOI	13.17	13.38	15.84	13.45	14.98	12.83
S	0.17	0.18	0.02	0.027	0.038	0.03
Moisture	25.06	27.27	28.28	28.4	29.23	29.50

Notes:

Unit – Weight (%)
SM – Slag Mineralogy

APPENDIX I – MINERALOGY SLURRY TOWER AREA SLAG

PARAMETER	SM-7 (32)	SM-8 (33)	SM-9 (34)	SM-10 (35)
Al_2O_3	6.92	6.37	6.16	6.56
CaO	46.29	47.56	51.8	50.26
Co_3O_4	0.003	0.010	<0.001	<0.001
Cr_2O_3	5.02	3.96	2.14	2.12
Fe_2O_3	0.15	0.03	<0.001	0.033
K_2O	<0.001	<0.001	<0.001	<0.001
MgO	14.37	14.7	13.01	13.52
MnO	0.10	0.079	0.058	0.058
Na_2O	0.013	0.009	0.011	0.014
Nb_2O_5	<0.001	<0.001	<0.001	<0.001
NiO	<0.001	<0.001	<0.001	<0.001
P_2O_5	<0.001	0.001	<0.001	<0.001
SiO_2	26.88	27.05	26.64	27.25
TiO_2	0.23	0.21	0.16	0.16
V_2O_5	<0.001	<0.001	<0.001	<0.001
ZrO_2	<0.001	<0.001	<0.001	<0.001
C	0.50	0.65	0.65	0.53
LOI	9.76	11.46	11.76	10.82
S	0.04	0.048	0.025	0.019
Moisture	25.96	28.38	30.84	31.79

Notes:
Unit – Weight (%)
SM – Slag Mineralogy

Appendix J – Total Metals Processed Slag

-25 +8 mm Composite Samples (1-15)

PARAMETER Metals	S-1 (1-3)	S-2 (4-6)	S-3 (7-9)	S-4 (10-12)	S-5 (13-15)
Aluminum	18,000	19,000	11,000	16,000	16,000
Antimony	ND	ND	ND	ND	ND
Arsenic	ND	**3.4**	ND	ND	ND
Barium	25J	23J	26	22J	29
Beryllium	ND	ND	ND	ND	ND
Cadmium	ND	0.29J	ND	ND	ND
Calcium	220,000	250,000	170,000	220,000	220,000
Chromium	1,800	2,400	2,200	1,200	550
Chromium +6	**280**	**44**	**2.6**	**220**	**62**
Cobalt	ND	ND	ND	ND	7.3
Copper	5	7.6	4.6	5.2	3.7
Iron	180	**2,300**	**1,600**	**500**	180
Lead	ND	ND	ND	ND	ND
Magnesium	38,000	49,000	28,000	43,000	39,000
Manganese	**160**	**460**	**150**	**160**	**87**
Mercury	ND	ND	ND	ND	ND
Nickel	2.8J	9.4J	5.3	ND	2.2J
Potassium	ND	270J	190J	ND	ND
Selenium	**5.9**	**4.1**	**2.5**	**2.1**	**2.9**
Silver	ND	ND	ND	ND	ND
Silica	270	280	250	210	230
Sodium	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND
Vanadium	46	56	37	42	28
Zinc	7.2	26	8	9.1	2.1J
Wet Chemistry	**S-1**	**S-2**	**S-3**	**S-4**	**S-5**
Percent Moisture (%)	35.3	39.7	15	37.6	38.5
Percent Solids (%)	64.7	60.3	85	62.4	61.5
pH (Standard Unit)	11.7	11.7	11.7	11.5	11.6
Total Alkalinity (mg/l)	950	480	550	820	240

Notes:

Unit - mg/kg

NA - Not available

ND - Non detect

J - Result is less than reporting limit but greater than or equal to method detection limit and is an approximate value

APPENDIX J - CONTINUED

-25 +8 mm Composite Samples (16-31)

PARAMETER Metals	S-6 (16-18)	S-7 (19-21)	S-8 (22-24)	S-9 (25-27)	S-10 (28-31)
Aluminum	16,000	17,000	18,000	18,000	22,000
Antimony	ND	ND	ND	ND	ND
Arsenic	0.97J	ND	ND	**1.7**	0.96J
Barium	32	22J	37	12J	11J
Beryllium	ND	ND	ND	ND	ND
Cadmium	0.16J	ND	ND	ND	ND
Calcium	230,000	250,000	250,000	190,000	180,000
Chromium	1,300	3,100	1,700	420	530
Chromium +6	**3.3**	**300**	**18**	**24**	**9.2**
Cobalt	ND	ND	ND	ND	ND
Copper	5.7	6.2	5.5	4.3	4.2
Iron	**960**	**1,300**	**780**	190	150
Lead	ND	ND	ND	ND	ND
Magnesium	38,000	46,000	41,000	43,000	47,000
Manganese	**160**	**190**	**120**	**54**	**36**
Mercury	ND	ND	ND	ND	ND
Nickel	6.4J	11	13J	1.8J	ND
Potassium	ND	ND	ND	ND	ND
Selenium	**2.7**	**3.8**	**3.2**	**2.7**	**1.8**
Silver	ND	ND	ND	ND	ND
Silica	210	310	400	5,300	410
Sodium	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND
Vanadium	35	57	35	17	9.1
Zinc	2.3	9.9	2.7J	5	2.6
Wet Chemistry	**S-6**	**S-7**	**S-8**	**S-9**	**S-10**
Percent Moisture (%)	32.6	40.5	38.6	33	33.2
Percent Solids (%)	67.4	59.5	61.4	67	66.8
pH (Standard)	11.7	11.7	11.7	11.7	12
Total Alkalinity (mg/l)	240	590	330	310	450

Notes:

Unit - mg/kg

NA - Not available

ND - Non detect

J - Result is less than reporting limit but greater than or equal to method detection limit and is an approximate value

Appendix K – Total Metals Process Water

-25 +8 mm Density Separation (1-15)

PARAMETER Metals	W-1 (1-3)	W-2 (4-6)	W-3 (7-9)	W-4 (10-12)	W-5 (13-15)
Aluminum	**0.28**	**0.36**	**21**	**0.55**	**0.99**
Antimony	ND	ND	ND	ND	ND
Arsenic	ND	ND	0.0057J	ND	ND
Barium	0.037J	0.013J	0.096J	0.025J	0.026J
Beryllium	ND	ND	0.00058J	ND	ND
Cadmium	ND	ND	0.00053J	ND	ND
Calcium	140	78	320	100	140
Chromium	**0.94**	**1.1**	**2.6**	**0.8**	**1.2**
Chromium +6	**0.97**	**1.1**	**1.8**	**0.87**	**1.2**
Cobalt	0.0010J	0.00065J	0.0030J	0.0011J	ND
Copper	0.022J	0.015J	0.05	0.016J	0.015J
Iron	0.095J	0.065J	**6.2**	0.087J	0.063J
Lead	ND	ND	**0.02**	ND	ND
Magnesium	0.16J	0.18J	42	0.046J	0.76J
Manganese	0.0036J	0.011J	0.64	0.0082J	0.0077J
Mercury	ND	ND	ND	ND	ND
Nickel	0.017J	0.013J	0.04	0.011J	0.014J
Potassium	9	16	14	11	8.4
Selenium	0.0051J	0.0044J	0.0074J	ND	ND
Silver	ND	ND	ND	ND	ND
Sodium	65	69	71	80	71
Thallium	ND	ND	ND	ND	ND
Vanadium	ND	ND	0.044J	ND	ND
Zinc	0.011J	0.0086J	0.11	ND	ND
Wet Chemistry					
pH (Standard)	11.6	11.6	11.8	11.6	11.7

Notes:

Unit - mg/l

NA - Not available

ND - Non detect

J - Less than reporting but greater or equal to method detection limit and is an approximate value

APPENDIX K - CONTINUED

-25 +8 mm Density Separation (16-31)

PARAMETER Metals	W-6 (16-18)	W-7 (19-21)	W-8 (22-24)	W-9 (25-27)	W-10 (28-31)
Aluminum	**0.71**	**1.2**	**3.6**	**1.8**	**1.6**
Antimony	ND	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND	ND
Barium	0.033J	0.023J	0.031J	0.0078J	0.014J
Beryllium	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND
Calcium	150	130	170	87	120
Chromium	**0.93**	**0.8**	**1.1**	**2.1**	**1.1**
Chromium +6	**0.93**	**0.85**	**0.1**	**2.1**	**1.1**
Cobalt	ND	0.00052J	0.00053J	ND	0.00059J
Copper	0.018J	0.014J	0.0071J	0.0063J	0.0092J
Iron	0.058J	ND	0.27	0.11	0.17
Lead	ND	ND	0.0042J	ND	ND
Magnesium	0.15J	ND	5.7	3.6J	3.4J
Manganese	0.0017J	ND	0.2	0.031	0.029
Mercury	ND	ND	ND	ND	ND
Nickel	0.024J	0.017J	0.0064J	0.0040J	0.0097J
Potassium	9.1	9.4	10	14	13
Selenium	0.0083J	ND	0.0057J	0.0047J	ND
Silver	ND	ND	ND	ND	ND
Sodium	76	76	86	95	90
Thallium	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND
Zinc	0.0077J	0.0086J	0.032	0.015J	0.018J
Wet Chemistry					
pH (Standard)	11.8	12	12	11.7	12

Notes:

Unit - mg/l

NA - Not available

ND - Non detect

J - Less than reporting but greater or equal to method detection limit and is an approximate value

Appendix L – Cr (VI) Process Water

Sample	Result	
	ppm	ppb
W1	0.97	970
W2	1.10	1100
W3	1.80	1800
W4	0.87	870
W5	1.20	1200
W6	0.93	930
W7	0.85	850
W8	0.10	100
W9	2.10	2100
W10	1.10	1100
S1	0.85	850
S2	11.00	11000
S3	0.20	200
S4	0.46	460
S5	0.18	180
S6	0.16	160
S7	0.18	180
S8	0.25	250
S9	0.46	460
S10	0.20	200

Notes:

W - -25 mm + 8 mm Density Separation (Batch Jig)

J - -8 mm + 1 mm Density Separation (Match Jig)

S - -1 mm Gravity Concentration Table (Shaking table)

ppm - parts per million

ppb - parts per billion

APPENDIX L - CONTINUED

Process Water Cr (VI)

Sample	Result	
	ppm	ppb
J1	1.30	1300
J2	2.20	2200
J3	2.20	2200
J4	1.00	1000
J5	2.30	2300
J6	3.70	3700
J7	0.77	770
J8	2.10	2100
J9	1.90	1900
J10	1.00	1000
J11	1.20	1200
J12	1.20	1200
J13	1.00	1000
J14	1.40	1400
J15	1.60	1600
J16	1.00	1000
J17	0.71	710
J18	2.00	2000
J19	1.20	1200
J20	0.67	670
J21	0.70	700
J22	0.92	920
J23	0.74	740
J24	1.50	1500
J25	1.80	1800
J26	2.40	2400
J27	3.30	3300
J28	0.64	640
J29	1.70	1700
J30	0.99	990
J31	1.80	1800

Notes:

W - -25 mm + 8 mm Density Separation (Batch Jig)

J - -8 mm + 1 mm Density Separation (Match Jig)

S - -1 mm Gravity Concentration Table (Shaking table)

ppm - parts per million

ppb - parts per billion

Appendix M – Air Quality Monitoring

Excavation - Personal Air Monitoring

Hexavalent Chromium

Sample ID	Total (ug)	Conc (ug/m3)	OSHA PEL (ug/m3)
CMP-FP-01E	<0.030	<0.031	5
CMP-FP-02S	<0.030	<0.031	5
CMP-FP-05E	<0.030	<0.031	5
CMP-FP-06S	<0.030	<0.031	5
CMP-FP-09S	<0.030	<0.031	5
CMP-FP-10E	<0.030	<0.031	5
CMP-FP-13S	<0.030	<0.031	5
CMP-FP-14E	<0.030	<0.031	5

Chromium

Sample ID	Total (ug)	Conc (ug/m3)	OSHA PEL (mg/m3)
CMP-FP-03S	<7.5	<0.0078	1
CMP-FP-04S	<7.5	<0.0078	1
CMP-FP-07E	<7.5	<0.0078	1
CMP-FP-08S	<7.5	<0.0078	1
CMP-FP-11S	<7.5	<0.0078	1
CMP-FP-12E	<7.5	<0.0078	1
CMP-FP-15S	<7.5	<0.0078	1
CMP-FP-16E	<7.5	<0.0078	1

Notes:

PM10 PEL based on respirable particles
ug - micrograms
mg - milligrams
m^3 - cubic meters
S - Spotter during excavation activities
E - Excavator that collected the samples
PEL - Permissible Exposure Limit
PM10 - particulate matter 10 micrometers or less in diameter
F - Samples collected by lab technician within in Pump House building
A - Samples collected by lab assistant within Pump House building
Conc - Concentration

APPENDIX M - CONTINUED

Processing - Personal Air Monitoring

Hexavalent Chromium

Sample ID	Total (ug)	Conc (ug/m3)	OSHA PEL (ug/m3)
CMP-F1	<0.030	<0.038	5
CMP-F2	<0.030	<0.033	5
CMP-F3	<0.030	<0.031	5
CMP-F4	<0.030	<0.031	5
CMP-A1	0.084	0.1	5
CMP-A2	0.054	0.059	5
CMP-A3	0.13	0.13	5
CMP-A4	<0.030	<0.038	5

Chromium

Sample ID	Total (ug)	Conc (ug/m3)	OSHA PEL (mg/m3)
CMP-F5	<7.5	<0.0094	1
CMP-F6	<7.5	<0.0082	1
CMP-F7	<7.5	<0.0077	1
CMP-F8	<7.5	<0.0078	1
CMP-A5	<7.5	<0.0094	1
CMP-A6	<7.5	<0.0082	1
CMP-A7	<7.5	<0.0077	1
CMP-A8	<7.5	<0.0078	1

Processing - PM10

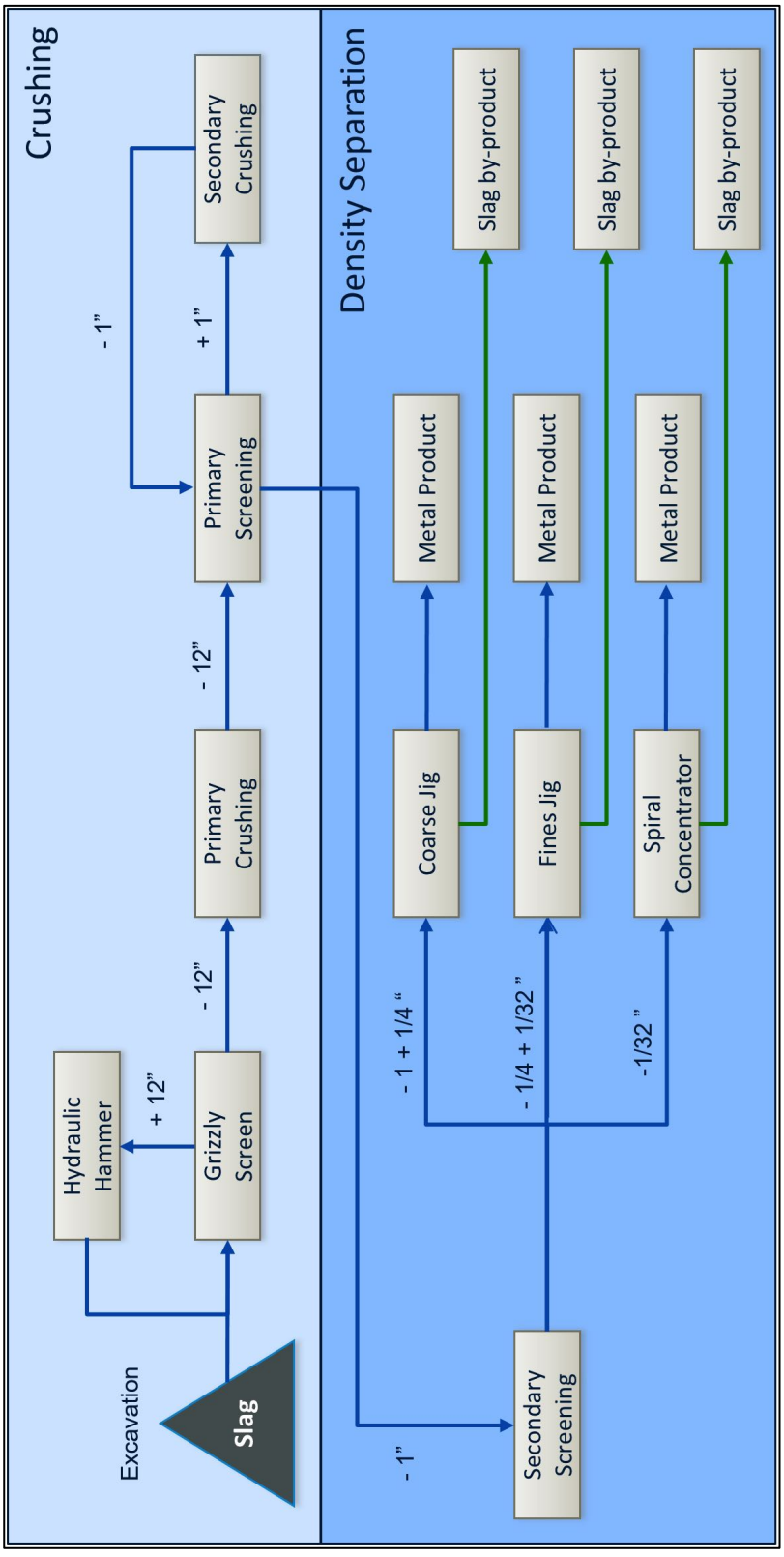
Particulate Matter

Sample ID	Total (ug)	Conc (ug/m3)	OSHA PEL (mg/m3)
1019474	7.8	9.8	5
1019472	22	26	5
1019475	2.3	2.6	5
1019473	0.16	0.17	5
1019471	0.49	0.53	5
1019476	<0.050	<0.057	5

Notes:

PM10 PEL based on respirable particles
ug - micrograms
mg - milligrams
m^3 - cubic meters
S - Spotter during excavation activities
E - Excavator that collected the samples
PEL - Permissible Exposure Limit
PM10 - particulate matter 10 micrometers or less in diameter
F - Samples collected by lab technician within in Pump House building
A - Samples collected by lab assistant within Pump House building
Conc - Concentration

Appendix N – Process Flow Minerals Processing



APPENDIX O – PROCESS FLOW WATER RECYCLING AND TREATMENT