CRONIMET Mining and Processing, LLC

Treatability Study of Ferrochrome Slag
Former Satralloy Site, Mingo Junction, OH

Version Control

Version	Date	Author	Change Description
1.0	September 1, 2016	Carlos Garcia Cabral	Original Document
2.0	September 30, 2016	Carlos Garcia Cabral	General Revision

Notes:

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1 Introduction

CRONIMET Mining (CRONIMET) supports its global customer-base in the mining and processing of mineral resources. The exploration of new and underdeveloped material deposits is the first step in the raw materials value chain.

CRONIMET has extensive experience in the recycling and repurposing of slag and other industrial by-products, including chromium smelter slag, in the United States, Europe, and Southern Africa.

In the preliminary exploration, the potential of the raw material sources is evaluated. CRONIMET applies technically and scientifically proven methods to systematically develop mining and minerals processing solutions in compliance with regulatory guidelines.

CRONIMET and Cyprus Amax Minerals Company (CAMC) have agreed to cooperate in the evaluation of various approaches to extract certain metals from the Ferrochrome (FeCr) Slag at the Former Satralloy Site (the "Site"). The purpose of this work-plan is to describe the approach and methods to be used in performing this treatability study (Study).

The objective of this Study is to assess the following:

- Environmental considerations such as:
  - Constituents of concern (COCs) in processed materials
  - Permitting and waste management
  - Leachability of processed materials
- Site conditions, such as:
  - Site specific health and safety hazards
  - Availability of utilities
  - Availability of logistic support services
- Characterization of the materials on the Site for future full-scale operation
- Operational considerations such as:
  - FeCr yield and recovery potential
- Suitability of recovered products for sale or reuse

The results of the treatability study will be used in the evaluation of remediation alternatives in the Feasibility Study (FS) for the Site.

2 Assessment of Site Conditions

CRONIMET will perform Site survey and review historical information in order to evaluate the availability and suitability of existing utilities and facilities. CRONIMET will perform a detailed site reconnaissance to identify potential obstacles and hazards.

CRONIMET will also investigate the availability of the typical logistic support services obligatory to sustain long-term operations.

3 Treatment Test Procedure

This treatment test procedure was developed to accurately characterize the Site and its material resource; and obtain the input data required to design and implement a treatment solution at the Site.

3.1 Required Equipment

The following equipment is proposed to be used for the Study:

- Excavating equipment
- Water truck
- Pick-up truck
- Riffle splitters
- Sieve shaker
- Laboratory crusher
- Holman-Wilfey fine particle separation table (laboratory)
- Dust suppression and control equipment
- Density separation plant (laboratory)
- Weigh scales
- General tools
- Power generator (if required)
- Lights
- Bulk sample containers
- Small sample containers
- Water sample containers
- PPE and two-way radios

3.2 Sampling Activities

The treatability study consists of the following sequential activities:

Sample Collection:

- Mark and delineate sampling locations
- Excavate target materials
- Crush target materials
- Manually sort and quantify (weigh) oversize material
- Prepare representative samples
- Weigh and bag samples
- Load and transport samples to on-site laboratory
- Offload and store samples in staging area

Laboratory Sample Processing:

- Crush
- Screen
- Particle size analysis
- Density separation (batch jig and shaking table)
- Sorting and physical analysis
- Prepare target materials for shipping
- Ship materials to the appropriate off-site laboratories
- Bag excess materials

Excess Material:

- Excess sample material will be returned to one of the Site slag piles.
- Treatment byproducts will be stored in the South Mill Building until TCLP results are available.
- The disturbed areas will be contoured to the approximate original condition with consideration for adequate storm water controls.

3.3 Sampling Procedure

A grid sampling method will be applied to obtain approximately 35 samples representative of the stockpile, as set out in Appendix A to this work plan. Excavating equipment will be used to remove sample material in a 3 m x 3 m square, to a depth of approximately 2 m. This procedure will be repeated at pre-determined locations across the slag piles. The proposed sampling locations as designated by CRONIMET, are shown in Appendices A through E.

The sample locations were spatially selected, based on a Site reconnaissance, to provide comprehensive data relating to the consistency or variability of the materials on the Site.

The excavated materials will be manually sorted to quantify the approximately distribution of oversize (+100 mm) feed material. The remaining material will be crushed to approximately -100 mm with a hydraulic hammer, and split using the cone-and-quartering method to obtain a representative sample of approximately 100 kg. Samples will be placed in appropriately labeled containers of 25 kg each and transported to the laboratory processing staging area located in the South Mill building. Subsequent processing of the samples will be done indoors.

Representative samples (i.e., 2 x 200 kg each) of the dust collected in the North and South Buildings will be processed and analyzed.

3.4 Sample Preparation

Samples will be crushed and screened to -25 mm using a laboratory crusher. The crushed material will be riffle split, one half stored and the other half (about 50 kg) will be screened at 25, 20, 15, 10, 6, 3 and 1 mm. Each size fraction will be weighed to obtain a particle size distribution. A fine particle size distribution will be performed on a sub-sample of the -1 mm size fraction by screening to 850, 750, 500, 350, 250, 180, 125, 90, and 50 µm. The screened material will be recombined to obtain -25+6 mm and -6+1 mm fractions, from which 40 kg batch jig test samples will be riffled out.

3.5 Batch Jig Test

Batch jig tests will be performed on the -25+6 mm and -6+1 mm fractions of each sample to determine recoverable FeCr yield when using an air-pulsed jigging process. Each batch (approximately 30 kg) will be processed in a batch jig for a sufficient period of time to allow for optimum stratification.

The material will then be removed in a series of layers of decreasing density. Each layer will be dried and weighed. A physical sorting of metal, middlings and slag will then be performed.

3.6 Shaking Table Test

Shaking table tests will be performed on the -1 mm fraction of each sample to determine recoverable ferrochrome yield and effectiveness of spiral concentrators to process the fine-particle materials.

3.7 Leaching Tests

SPLP and TCLP tests will be performed by an off-site accredited laboratory on 100 g subsamples of the bulk samples. The sub-samples will be representative of the overall particle size distribution.

The test procedure per bulk sample will include the following:

- Riffle 50 kg sub-sample
- Crush the sub-sample sample to -25 mm
- Riffle the sub-sample down to 20 kg
- Crush the 20 kg to -6 mm and riffle down to 1 kg
- Crush the 1 kg to -1 mm and riffle out 2 x 100 g samples
- The 2 x 100 g samples will be shipped to an off-site laboratory for leachate testing and analysis.

4 Analysis

Individual material streams will be sent to accredited laboratories to undergo chemical analysis as described in this section. The metals to be analyzed will be the RCRA metals plus key Site constituents of potential concern (COPCs), including: arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), selenium (Se), silver (Ag), and Vanadium (V). In addition, total metals analyses will include hexavalent chromium.

4.1 Treatment Products

Treatment products from the batch jig and shaking table processing will be analyzed for the following parameters:

- Total Metals
- SPLP Metals
- TCLP Metals
- SVOCs & VOCs
- PCBs
- pH
- Alkalinity

4.2 Recovered Metal

Samples of the recovered metal will be analyzed for the following parameters:

- Total Metals
- Oxides
- Carbon
- Sulfur
- Phosphorus
- Silica

4.3 Process Water

Samples of the process water will be analyzed for the following parameters:

- Total Metals
- pH
- Alkalinity

5 Schedule

The duration to complete the treatability study is estimated to take 3 to 4 months following OEPA approval of this work-plan. CRONIMET anticipates the following timeframes:

Task	***08/16***	***09/16***	***10/16***	***11/16***	***12/16***	***01/17***
Work-plan approval by OEPA						
Site Mobilization						
Sampling and Processing						
Analysis						
Site De-mobilization						
Preparation of Treatability Study Report						

Yes

6 Health and Safety Considerations

CRONIMET will prepare a Health and Safety Plan (HASP) for the treatability study. The HASP will comply with all requirements laid out in the Project Health and Safety Plan for the Satralloy Site, Jefferson County, Ohio that was prepared by Golder Associates, Inc. (Golder) and submitted to the Ohio Environmental Protection Agency (OEPA) on August 29, 2014.

Prior to commencing work on Site, CRONIMET will conduct a risk assessment (RA) and job hazard analysis (JHA) for all of the work activities that will be conducted at the Site. The RAs/JHAs will be submitted to CAMC for review prior to the commencement of field activities and will be revised, as necessary, once the fieldwork begins.

CRONIMET will implement a medical surveillance program as well as a written drug-testing program for this project as per the guidelines presented in the Satralloy Project HASP.

All employees involved in the project will be OSHA 40-hour HAZWOPER and OSHA 8-hour HAZWOPER refresher trained. At least one person on site at any one time will have first air/CPR training. In addition, any employee operating special equipment for the purpose of excavating and handling of slag material will be appropriately licensed/certified. Documentation of this training will be provided to CAMC for review prior to commencing activities on the Site.

All other health and safety requirements specified in the Satralloy Project HASP will be incorporated into the treatability study and included the CRONIMET Field HASP.

7 Environmental Considerations

CRONIMET will comply with all applicable environmental regulations and CAMC Site policies:

- Operations are not expected to produce large amounts of dust. Prevailing weather conditions and the moisture content of the material may require the temporary use of water or other environmentally acceptable dust suppressant materials.
- All processing activities will be conducted inside the South Mill Building. Dust control equipment, such as dust extractors, will be utilized to capture possible fugitive emissions.
- Air emissions will be "*de minimus"* as per OEPA regulation OAC 3745-15-05; therefore, no air permit will be required.
- CRONIMET will obtain an excavation permit as per the CAMC Project HASP prior to excavating the materials to be tested.
- All excess materials that pass TCLP will be returned to the Site.
- Materials the do not pass TCLP will be disposed of as hazardous waste.
- CRONIMET will diligently comply with all decontamination procedures as per the CAMC Project HASP.
- Excavation activities will be conducted under the Construction General Storm Water Permit and site-specific Storm Water Pollution Prevention Plan approved by the Ohio Environmental Protection Agency (OEPA) for interim action at the Site.
- Water used in the process will be recycled and there will be no discharge during processing. Any excess process water remaining on completion of processing will be placed on the decontamination pad as per pad as approved by OEPA in a letter from Erick Hagen dated September 26, 2013.

8 Data Evaluation and Report

The data from this treatability study will be used to develop the following:

- Technical solution for FeCr slag remediation
  - Conceptual treatment solution(s)
  - Process flow diagram
  - Conceptual plant design for full-scale operations
  - Conceptual processing plan
  - Technical risk assessment
- Permitting requirements
- Waste management and handling requirements
- Treatment economics
  - Material specifications
  - Suitability of materials for alternative uses
  - Capital Expenditure (CAPEX)
  - Operational Expenditure (OPEX)
  - Economic risk assessment

The results of the treatability study will be the basis for development and evaluation of treatment alternatives in the FS for the Site.

9 Appendices

- Appendix A: Sampling Locations Overview & Coordinates
- Appendix B: Area A Sample Locations
- Appendix C: Area B Sample Locations
- Appendix D: Area C Sample Locations
- Appendix E: Area D Sample Locations
- Appendix F: Laboratory scale set-up location (South Mill Building)

Appendix A – Sample Locations Overview & Coordinates


D
C
B
A

Area	Sample Location	Latitude	Longitude
A	1	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	40°18'23.20"N	80°40'28.98"W
B	8	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°18'36.20"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
C	28	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
D	32	40°18'54.37"N	80°40'7.04"W
	33	40°18'55.93"N	80°40'7.12"W
	34	40°18'56.94"N	80°40'8.65"W
	35	40°18'57.80"N	80°40'13.75"W

Appendix B – Area A Sample Locations


A
1
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7

Appendix C – Area B Sample Locations


26
27
23
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25
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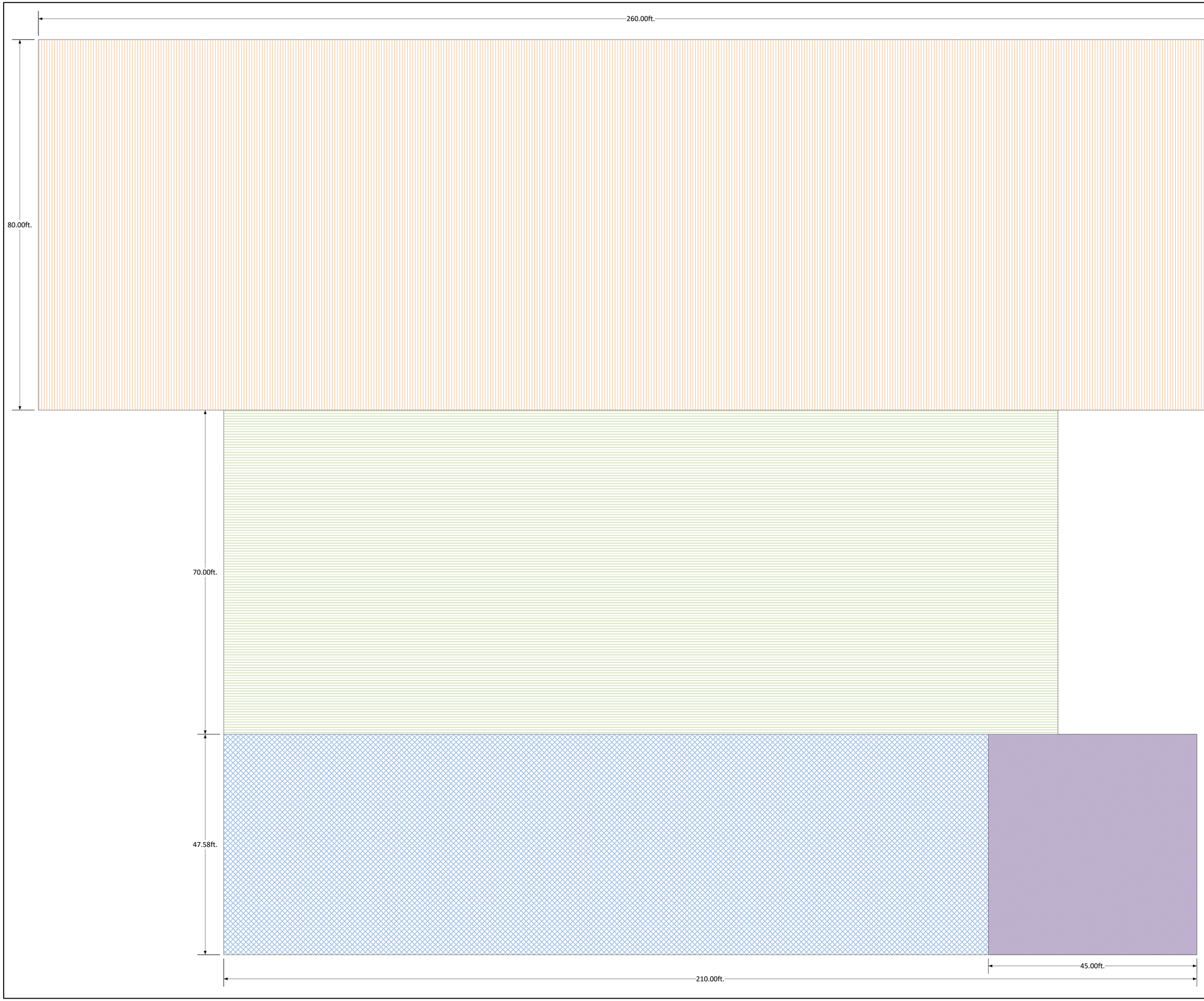
Appendix D – Area C Sample Locations


31
C
30
28
29

Appendix E – Area D Sample Locations


35
34
D
33
32

Appendix F – Location of Test Laboratory – South Mill Building



Legend

- Casting Bay (Historic)
- Storage Bay (Historic)
- Product Preparation Bay (Historic)
- Proposed Test Area (CRONIMET)

Notes:

- Diagram excludes the furnace processing area of the South Mill building.
- Dimensions taken from historical drawings.
- CRONIMET personnel will remain within the test area.
- The work area will be inspected by a certified PE prior to equipment mobilization.

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Client:	Freeport-McMoRan Inc.
Project:	Former Satralloy Site Slag Treatment
Title:	Location of Test Laboratory – South Mill Building
Date:	September 25, 2016
Drawing Nr:	CM-SA-001-CGC