Feasibility Study Work Plan

CFAC Facility
2000 Aluminum Drive
Columbia Falls, Montana

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Prepared for:
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Acronym List

Acronym	Definition
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirement
ARM	Administrative Rules of Montana
BERA	Baseline Ecological Risk Assessment
BHHRA	Baseline Human Health Risk Assessment
BTV	Background Threshold Value
CCC	Criterion Continuous Concentration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFAC	Columbia Falls Aluminum Company, LLC
CFR	Code of Federal Regulations
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
COPEC	Constituent of Potential Ecological Concern
CSM	Conceptual Site Model
CWA	Clean Water Act
CY	Cubic Yard
DEQ-7	MDEQ Circular DEQ-7
DU	Decision Unit
EC	Engineering Control
ELCR	Excess Lifetime Cancer Risk
EPC	Exposure Point Concentration
ERAGS	Ecological Risk Assessment Guidance for Superfund
ER/IP	Electrical Resistivity/Induced Polarization
FS	Feasibility Study
FT-BLS	Feet Below Land Surface
GRA	General Response Action
GW	Groundwater
HI	Hazard Index
HMW	High Molecular Weight
HQ	Hazard Quotient
IC	Institutional Control
ISM	Incremental Sample Methodology
ITRC	Interstate Technology & Regulatory Council
LOAEL	Lowest Observed Adverse Effect Level
LOEC	Lowest Observed Effect Concentration
LMW	Low Molecular Weight
MCA	Montana Code Annotated
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDL	Method Detection Limit
MDEQ	Montana Department of Environmental Quality
MG/KG	Milligrams Per Kilogram
MPDES	Montana Pollutant Discharge Elimination System
MNA	Monitored Natural Attenuation

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Acronym	Definition
NCP	National Contingency Plan
NOAEL	No Observed Adverse Effect Level
NOEC	No Observed Effect Concentration
NPDES	National Pollutant Discharge Elimination System
NRWQC	National Recommended Water Quality Criteria
O&M	Operations and Maintenance
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PRG	Preliminary Remediation Goal
RAGS	Risk Assessment Guidance for Superfund
RAL	Remedial Action Levels
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SC	Site Characterization
SDWA	Safe Drinking Water Act
SLERA	Screening Level Ecological Risk Assessment
SPL	Spent Potliner
SW	Surface Water
TBC	"To Be Considered" Criteria
UCL	Upper Confidence Limit
UG/L	Micrograms Per Liter
UIC	Underground Injection Control
USC	United States Code
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WP	Work Plan
95UCL	95 Percent UCL of the Mean

1. Introduction

On behalf of Columbia Falls Aluminum Company, LLC (CFAC), Roux Environmental Engineering and Geology, D.P.C. (Roux), has prepared this Feasibility Study Work Plan (FSWP) as part of the on-going Remedial Investigation/Feasibility Study (RI/FS) of the Superfund Site referred to as Anaconda Aluminum Co. Columbia Falls Reduction Plant, located two miles northeast of Columbia Falls in Flathead County, Montana (hereinafter, “the Site”). The RI/FS is being conducted pursuant to the Administrative Settlement Agreement and Order on Consent dated November 30, 2015, between CFAC and the United States Environmental Protection Agency (USEPA) (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Docket No. 08-2016-0002).

The purpose of this FSWP is to identify the tasks that will be completed as part of the Feasibility Study (FS) for the Site. The FSWP and FS will use the information collected during the Remedial Investigation (RI) to develop, screen, and evaluate potential remedial alternatives to reduce risks to acceptable levels within the Site. The data collected as part of the RI, including the Phase I Site Characterization (SC), Supplemental South Ponds Assessment, Phase II SC, and the results of the Baseline Human Health Risk Assessment (BHHRA) and Baseline Ecological Risk Assessment (BERA), will be utilized to complete the FS. The results of each phase of the RI were included in prior USEPA/ Montana Department of Environmental Quality (MDEQ) approved RI/FS reports, including: Phase I SC Data Summary Report (Roux, 2017a); Groundwater and Surface Water (GW/SW) Data Summary Report (Roux, 2018a); Phase II SC Data Summary Report (Roux, 2019); BHHRA (EHS Support, 2019d); BERA (EHS Support, 2019e); and RI Report (Roux, 2020).

The elements of the FS process addressed in this FSWP include:

- Development of Decision Units (DUs);
- Identification of Preliminary Applicable or Relevant and Appropriate Requirements (ARARs);
- Identification of Remedial Action Objectives (RAOs);
- Development of Preliminary Remediation Goals (PRGs); and
- Provision of Scope of Work for remainder of the FS process.

This FSWP was prepared in general accordance with the format outlined in the “Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA” (USEPA, 1988). The remaining sections of this report include the following information:

Section 2 – Site Background Information provides the reader with an understanding of the CFAC Site. It includes the Site description and history, a summary of RI activities and conclusions, and a summary of results for the baseline risk assessments.

Section 3 – Decision Units for FS Evaluations groups the exposure areas identified in the risk assessments as requiring additional evaluation into DUs for the purpose of establishing general response actions, identifying and screening candidate technologies, and evaluating remedial alternatives.

Section 4 – Development of Remedial Objectives presents the ARARs, RAOs, and PRGs identified to date for the CFAC Site.

Section 5 – FS Scope of Work provides an overview of the major steps remaining in the FS process, including the development and analysis of remedial alternatives. The results of the FS will provide the rationale for selecting the preferred remedial alternative for each DU within the CFAC Site.

Section 6 – References provides a list of references used in preparing this FSWP.

2. Site Background Information

2.1 Site Description and History

The Site is located at 2000 Aluminum Drive near Columbia Falls, Flathead County, Montana. The Site is approximately two miles northeast from the center of Columbia Falls and the Site is accessed by Aluminum Drive via North Fork Road (County Road 486). The boundaries of the Site were defined in the RI/FS Work Plan (Roux, 2015a) and are depicted on Figure 1. The Site consists of approximately 1,340 acres bounded by Cedar Creek Reservoir to the north, Teakettle Mountain to the east, Flathead River to the south, and Cedar Creek to the west.

The Site was operated as a primary aluminum reduction facility (commonly referred to as an aluminum smelter) from 1955 until 2009. A detailed description of the operational history at the Site was provided in Section 1.3.2 of the RI Report (Roux, 2020).

Buildings and industrial facilities remaining at the Site at the start of the RI/FS in 2016 included offices, warehouses, laboratories, mechanical shops, a paste plant, coal tar pitch tanks, pump houses, a casting garage, and the potline facility. Decommissioning of the industrial facilities was completed in the third quarter of 2019. Following decommissioning, the remaining structures include the administration building, the main warehouse, two ancillary warehouses, and the fabrication shop.

The Site also includes several closed landfills; one open landfill that hasn't been used since 2009; two closed leachate ponds; and several wastewater percolation ponds. A detailed description of each Site feature was provided in Section 1.3.4 of the RI Report (Roux, 2020). A rectifier yard and switchyard owned by Bonneville Power Administration and a right-of-way for the Burlington Northern Railroad are also within the Site boundaries. A map showing the locations of Site features is provided for reference on Figure 2.

There are no on-going manufacturing or commercial activities at the Site. A definitive future land use plan has not been developed for the Site. CFAC maintains a limited on-Site staff that is responsible for the maintenance of the remaining buildings and infrastructure at the Site, as well as maintenance associated with existing landfills.

2.2 Remedial Investigation Activities Summary

The following provides an overview of environmental investigations performed at the Site related to the RI/FS and the associated RI/FS reports documenting those investigations. A detailed description of the results of the investigations are provided in their respective reports and are summarized together in the Phase II SC Data Summary Report (Roux, 2019). The results of the BHHRA (EHS Support, 2019d) and BERA (EHS Support, 2019e) are also described in their respective reports. The overall scope of work and results of the Site characterization, BHHRA, and BERA are presented collectively within the RI Report (Roux, 2020).

Phase I SC Data Summary Report – 2017

CFAC and Roux completed a Phase I SC from April 2016 through July 2017, which included the collection and laboratory analysis of soil, sediment, groundwater, and surface water samples from within and around Site features. The Phase I SC activities were performed in accordance with the USEPA-approved Phase I

Sampling and Analysis Plan (SAP) and SAP Addendum (Roux, 2015b; 2016a). The results of these field activities are provided in the Phase I SC Data Summary Report.

Screening Level Ecological Risk Assessment (SLERA) – 2017

The SLERA, completed by Roux, provided an assessment of potential risks to ecological receptors that might be exposed to constituents from the Site. The SLERA evaluated the aspects of the Site that could influence potential exposures and risks to ecological receptors.

Based on the review of the historical processes and data collected during the SLERA, preliminary constituents of potential ecological concern (COPECs) were identified in surface water, sediment, and surface soil to which ecological receptors could potentially be exposed. Based on these results, it was determined the conclusions of the SLERA were insufficient to dismiss potential ecological risk, and further data gathering or data analyses was recommended to better understand the risk.

GW/SW Data Summary Report – 2018

The GW/SW Data Summary Report, completed by Roux, summarized the results of groundwater and surface water investigations that were completed from August 2016 through July 2017 to achieve the Phase I SC objectives listed in the RI/FS Work Plan (Roux, 2015a).

Phase II SC Data Summary Report – 2019

The Phase II SC program, completed by Roux, was designed to address any outstanding data gaps in order to conduct the risk assessment and complete the RI. CFAC and Roux completed a Phase II SC from June 2018 through October 2018, which included the collection and laboratory analysis of soil, sediment, groundwater, surface water, and porewater samples from within and around Site features. Within the same time period, a Background Investigation was conducted that included collection and laboratory analysis of soil, sediment, and surface water samples from reference areas outside of the Site boundaries. The Phase II SC activities were performed in accordance with the USEPA-approved Phase II SAP and the Background Investigation SAP (Roux, 2018c; 2018d). The results of the Phase II SC and Background Investigation field activities are provided in Sections 4 and 5 of the Phase II SC Data Summary Report, respectively.

The Phase II SC Data Summary Report also summarized the Supplemental South Pond Assessment sampling that was completed under the Expedited Risk Assessment SAP (Roux, 2017c).

BHHRA – 2019

The objective of the BHHRA, completed by EHS Support, was to characterize the potential risks to human receptors posed by exposure to affected environmental media at the Site in the absence of any remedial action. The BHHRA was conducted in accordance with the methodology and assumptions presented in the BHHRA WP (EHS Support, 2018a). The BHHRA provides the basis for determining whether remedial action is necessary to address potential risk to human health in the various exposure areas identified at the Site, as well as the extent of remedial action required. The BHHRA supports the FS in the evaluation of remedial alternatives to address any unacceptable current or future risk to human receptors from exposure to contaminants of concern (COCs).

BERA – 2019

The overall purpose of the BERA, completed by EHS Support, was to evaluate whether environmental conditions associated with historical operations at the Site pose an unacceptable risk to ecological receptors in the absence of any remedial action. The BERA was conducted in accordance with the methodology and assumptions presented in the BERA WP (EHS Support, 2018b). The BERA provides the basis for determining whether remedial action is necessary to address potential risk to ecological receptors in the various exposure areas identified at the Site, as well as the extent of remedial action required. The BERA supports the FS in the evaluation of remedial alternatives to address any unacceptable current or future risk to ecological receptors from exposure to COCs.

Remedial Investigation Report – 2020

The purpose of the RI Report was to present the results of the multiple phases of the RI (i.e., the Phase I SC, the Supplemental South Pond Assessment, and the Phase II SC completed at the Site from April 2016 through November 2018) and to summarize the scope and results of the BHHRA and BERA prepared for the Site. Collectively, the information presented in the RI Report provides the foundation to support the development and evaluation of remedial alternatives in the FS.

2.3 Baseline Risk Assessment Results Summary

The sections below summarize the results and key findings from the two Baseline Risk Assessments completed at the Site by EHS Support and Roux. The BHHRA scope and results are detailed in the BHHRA (EHS Support, 2019d), and the BERA scope and results are detailed in the BERA (EHS Support, 2019e).

2.3.1 Human Health Exposure Areas and Receptors

The objective of the BHHRA was to characterize the potential risks to human receptors posed by exposure to affected environmental media at the Site in the absence of any remedial action. The BHHRA provides the basis for determining whether remedial action is necessary to address potential risk to human health in the various exposure areas identified at the Site, as well as the extent of remedial action required.

The format for the BHHRA follows the USEPA Risk Assessment Guidance for Superfund (RAGS) Part D (USEPA, 2001a). The regulatory guidance for conducting the BHHRA includes RAGS Parts A through F (USEPA, 1989, 1991a, 1991b, 2001a, 2004b, and 2009), and other guidance documents and procedures that USEPA has issued in addition to the RAGS guidance. The additional guidance and procedures are referenced in the BHHRA WP (EHS Support, 2018a) as well as within the BHHRA (EHS Support, 2019d) where appropriate.

Included in the BHHRA is a review of the conceptual exposure models and discussion of exposure pathways for exposure areas. Exposure areas were defined considering both the current and reasonable anticipated future land use for the various areas of the Site. The boundaries of each exposure area were developed using professional judgement, and considered Site characteristics, current and potential future receptors, and the distribution of COPCs identified in the RI. Human health exposure areas are depicted on Figure 3. A summary of the exposure areas and anticipated future use for each area is described below.

- Main Plant Area – includes the area of historical manufacturing operations including the former Main Plant, associated buildings and infrastructure, and the former Rod Mill. The Main Plant Area is covered by impervious surfaces and there are no areas of significant vegetation other than weeds common to roadsides and disturbed areas. Based on the remote location from residential areas, flat land, and remaining post-decommissioning infrastructure, the foreseeable future use of this area is industrial or commercial.
- North Percolation Pond Area – is a water management area of historical wastewater discharge and consists of two ponds (North-East and North-West). Historical wastewater discharge flowed into the North-East pond from an influent ditch, and then to an approximately 1,440-foot-long unlined overflow ditch to the North-West Pond. Based on the depressed topography, the foreseeable future use of this area is industrial stormwater management.

- Central Landfills Area – consists of 12 distinct Site features (as shown on Figure 3) associated with waste management and disposal activities. Based on the existing Site features associated with waste management and disposal activities, the foreseeable future use of the Central Landfills Area is industrial (i.e., landfill management and maintenance activities).
- Incremental Sampling Methodology (ISM) Grid Area – comprises approximately 43 acres in the northern portion of the Main Plant Area and within the Central Landfills Area south of the landfills where aerial photographs indicate historical operations may have been conducted but no specific source area exists.
- Industrial Landfill Area – an inactive, uncapped landfill in the northern portion of the Site that received non-hazardous waste and debris. Based on the existing Site features associated with waste management and disposal activities, the foreseeable future use of this area is industrial (i.e., landfill management and maintenance).
- Eastern Undeveloped Area – undeveloped and vegetated with forest and shrubland, except for the area that includes the Borrow Pit Area. There were no operational activities conducted within this area. Based on limited accessibility (i.e., steep rugged terrain), proximity to landfills, Teakettle Mountain east of the area, the main rail line and Flathead River in the southern portion, and the Main Plant Area west of the area, the foreseeable future use of this area is industrial or undeveloped.
- North-Central Undeveloped Area – comprises undeveloped and vegetated shrubland in the northern portion of the Site, as well as roadways. There were no operational activities conducted within this area. Based on the proximity to landfills and the presence of the Northern Surface Water Feature, the foreseeable future use of this area is industrial or undeveloped.
- Western Undeveloped Area – includes roadways and mixed vegetation in the western third of the Site. Cedar Creek transects the area along the north-western border from north to south. The southwestern portion of this area is adjacent to the off-Site residential area referred to as Aluminum City. There were no operational activities conducted within this area. Based on the proximity to existing residential development, existing vegetative habitat, and main rail right-of-way immediately south of the area, the foreseeable future use of this area could be industrial, commercial, residential, or undeveloped for recreational use.
- South Percolation Pond Area – includes a series of three water management ponds and the surrounding vegetated area located on the south end of the Site adjacent to the Flathead River. Based on the existing operational ponds, riparian vegetation, and adjacent Flathead River, the foreseeable future use of this area is industrial water management or undeveloped.
- Flathead River Area – the portion of Flathead River which runs along the southern border of the Site. Based on the designated use of the Flathead River as well as local recreational uses, the current and future use of the Flathead River is recreational.
- Backwater Seep Sampling Area – a backwater area of the Flathead River west of the South Percolation Pond Area along the southern border of the Site that is documented as receiving groundwater discharge. Based on the presence of the steep relief and the backwater, it is foreseeable that the current and future use of this area will remain undeveloped; however, recreational users of the Flathead River may use the area for recreational purposes.
- Groundwater – groundwater was evaluated in the BHHRA utilizing three different exposure scenarios (Western Undeveloped Area Upper Hydrogeologic Unit, Plume Core Area[1] Upper Hydrogeologic Unit, and Site-wide Below Upper Hydrogeologic Unit).

Based on the current and reasonably foreseeable future use of the Site, and the potential for exposure to affected soil, groundwater, surface water, and sediment, the potential receptors within the overall Site boundary and associated Flathead River were identified for both current Site use and future use scenarios.

[1] The "Plume Core Area" for cyanide is identified as the area where monitoring wells had detected concentrations of total cyanide of greater than 300 µg/l in any of the six sampling rounds. The "Plume Core Area" for fluoride is identified as the area where monitoring wells had detected concentrations of fluoride of greater than 2,000 µg/l in any of the six sampling rounds.

Current potential receptors evaluated in the BHHRA are trespassers and recreationists. Potential future receptors evaluated include industrial or commercial workers, construction workers, residents, trespassers and recreationists (e.g., hunters and fishers). It is noted that the potential receptors vary by specific exposure area, as detailed within the BHHRA.

2.3.2 BHHRA Conclusions

The BHHRA evaluated potential human health risks to receptors at the Site. Data collected during the RI investigation activities within each exposure area were used to characterize potential risks. The receptors evaluated in the current and future scenarios, as appropriate, included industrial workers (industrial worker, landfill management worker, and stormwater management worker), construction workers, recreational trespassers (ATV rider and hunter), adolescent trespassers, adolescent and adult recreationists (boater, floater, and fisher), and residents (adult and child). The BHHRA included the evaluation of potential exposures to COPCs in soil, surface water, sediment, and groundwater, as well as the potential exposure to COPCs in fish (i.e., uptake of COPCs in surface water) by recreationists (fisher) and exposure to COPCs in venison (i.e., uptake of COPCs in soil) by recreational trespassers (hunter). Default and Site-specific exposure assumptions were developed for these receptors.

Table 9-1 through Table 9-35 and Appendix I and Appendix J of the BHHRA presented the calculated cumulative risks for each receptor by COPC in each potentially complete exposure scenario identified in the CEM. Table 27 of the RI Report (Table 9-36 of the BHHRA) presents a summary of the Excess Lifetime Cancer Risk (ELCR) and Hazard Index (HI) for each receptor.

Based on the evaluation of the BHHRA results, the following general conclusions can be drawn regarding human health risks at the Site.

Exposure Areas That Do Not Pose Risks Due to Site-Related Contamination

The conditions in the following exposure areas at the Site do not pose ELCR above *de minimis* levels or potential for non-cancer effects due to the presence of Site-related COPCs. These exposure areas include:

- Eastern Undeveloped Area;
- North-Central Undeveloped Area;
- Western Undeveloped Area;
- South Percolation Pond Area;
- Flathead River Area; and
- Backwater Seep Sampling Area.

As shown in Table 27 of the RI Report, it is noted that risk characterization results for the three undeveloped areas (i.e., Eastern, Western, and North-Central Undeveloped Areas) indicate a ELCR above 1E-06 or a non-cancer risk (HI >1) for exposure to surface soil. However, in each case, the risk was due to the presence of arsenic or manganese in soil, both of which were found in background soil samples at comparable concentrations. Therefore, these are not attributable to Site-related contamination, but rather to naturally occurring background conditions.

In addition, it is noted in the Western Undeveloped Area that one isolated detection of bis(2-ethylhexyl) phthalate in groundwater, at a concentration of 73 micrograms per liter (µg/L) at monitoring well CFMW-069 during the October 2018 sampling event, resulted in a calculated risk of 1E-05 for drinking water exposure under the hypothetical future residential scenario evaluated for this area. The prior sample collected at this location in June 2018 was non-detect, with a method detection limit (MDL) of 4.4 µg/L. Bis(2-ethylhexyl) phthalate is not a contaminant associated with historical operations at the Site, and it has not been identified at levels of concern anywhere on the Site. Given these factors and that bis(2-ethylhexyl) phthalate is recognized as a common field and lab contaminant (associated with plasticware), the calculated risk appears overestimated and unrelated to Site-related contamination. Therefore, bis(2-ethylhexyl) phthalate is not carried forward for evaluation of remedial alternatives.

Exposure Areas That Pose Risks Due to Site-Related Contamination

The conditions in the following exposure areas at the Site pose ELCR above *de minimis* levels or potential for non-cancer effects due to the presence of Site-related COCs:

- Main Plant Area (including the Main Plant ISM Grid Area);
- North Percolation Pond Area;
- Central Landfills Area (including the Central Landfills ISM Grid Area); and
- Industrial Landfill Area.

In addition, groundwater within the Plume Core Area poses risk based upon a hypothetical future residential drinking water scenario.

The key conclusions with respect to each of the above areas are presented below.

Main Plant Area: Risk in the Main Plant Area was calculated using both discrete and ISM soil sampling data. Discrete samples were collected across the entirety of the Main Plant Area (i.e., 290 acres). Using the discrete data, the calculated cumulative ELCRs range from 6E-07 for the trespasser scenario to 8E-06 for the industrial worker scenario. The ISM data was collected from a limited portion of the Site (i.e., a combined 43 acres between the Central Landfills Area and Main Plant Area). Using the ISM data for the Main Plant ISM Grid Area, the calculated cumulative ECLRs range from 2E-06 for the construction worker and trespasser scenarios to 2E-05 for the industrial worker scenario in that area. Polycyclic aromatic hydrocarbons[2] (PAHs) in soil are the primary risk driver for the ELCR within the Main Plant Area. As stated in the BHHRA, concentrations of arsenic in soil in the Main Plant Area are comparable to concentrations of background soil samples. Therefore, the presence of arsenic in this exposure area is not attributed to Site-related contamination. This area also exhibits some potential non-cancer effects with the HI of 4 (developmental, nervous, and thyroid target organ systems) for both the industrial and construction worker.

North Percolation Pond Area: The BHHRA results indicate a calculated cumulative ELCR of 1E-04 for a stormwater management worker scenario and 5E-05 for a trespasser scenario. In each case, the risk driver is exposure to PAHs within the pond. The BHHRA results indicate no potential for non-cancer risk effects due to COCs in the North Percolation Pond Area.

Central Landfills Area: Risk in the Central Landfills Area was calculated using both discrete and ISM soil sampling data. Discrete samples were collected across the entirety of the Central Landfills Area (i.e., 128 acres). Using the discrete data, the calculated cumulative ELCRs range from 6E-07 for the trespasser scenario to 1E-05 for the landfill management worker scenario. The ISM data was collected

[2] PAHs driving risk at the Site are benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene.

from a limited portion of the Site (i.e., a combined 43 acres between the Central Landfills Area and Main Plant Area). Using the ISM data for the Central Landfills ISM Grid Area, the calculated cumulative ECLRs range from 2E-06 for the trespasser scenario to 3E-05 for the landfill management worker in that area. PAHs in soil are the primary risk driver for the Central Landfills Area. As presented in Table 9-37 of the BHHRA, the potential contribution of risk from background for arsenic in the Central Landfills Area ranged from 57 to 63 percent. The BHHRA results indicate no potential for non-cancer risk effects due to COCs in the Central Landfills Area.

Industrial Landfill Area: The calculated cumulative ELCRs range from 2E-06 for the trespasser scenario to 1E-05 for the landfill management worker scenario. PAHs in soil are the primary risk driver for the Industrial Landfill Area. As presented in Table 9-37 of the BHHRA, the potential contribution of risk from background for arsenic in the Industrial Landfill Area is 50 percent. The BHHRA results indicate no potential for non-cancer risk effects due to COCs in the Industrial Landfill Area.

Groundwater Plume Core Area: As noted within the BHHRA, CFAC intends to prohibit the use of groundwater beneath the Site for potable use. However, as required by USEPA, the BHHRA evaluated risk associated with exposure to groundwater within the Plume Core Area under a residential exposure scenario[3] to provide a conservative evaluation of potential health risk in the absence of any controls.

The Plume Core Area was defined based upon evaluation of the cyanide and fluoride extents in groundwater within the upper hydrogeologic unit as described in Section 3.1 of the RI Report. Within this area, the calculated HIs for future adult exposure to total cyanide, free cyanide, and fluoride are 7E+01, 2E+00, and 5E+00, respectively; and cumulative HI is 8E+01. The calculated HIs for future child exposure to cyanide, free cyanide, and fluoride are 1E+02, 4E+00, and 9E+00, respectively, and cumulative HI is 1E+02. The results indicate potential for non-cancer effects if groundwater within the Plume Core Area is to be used as a source of drinking water.

In addition to the non-cancer effects, the results of the BHHRA indicate a calculated cumulative ELCR of 2E-04 for lifetime exposure (i.e., including exposure as a child, adolescent, and adult) to arsenic in groundwater under a future residential exposure scenario. Review of the data indicates the exposure point concentration (EPC) of 9.8 µg/L is primarily driven by elevated concentrations measured in two wells (CFMW-012 and CFMW-015, both adjacent to the West Landfill/Wet Scrubber Sludge Pond source area), where maximum concentrations were approximately 92 µg/L. The vast majority of wells within the Plume Core Area are non-detect for arsenic, with the typical MDL less than 1 µg/L.

2.3.3 Ecological Exposure Areas and Receptors

A BERA was conducted as part of the RI to evaluate whether environmental conditions associated with historical operations at the Site pose an unacceptable risk to ecological receptors based on the conceptual investigation framework presented in the BERA WP (EHS Support, 2018b) and two interim deliverables that are presented in Appendix A of the BERA. The BERA was conducted in accordance with USEPA guidance, primarily *Ecological Risk Assessment Guidance for Superfund* (ERAGS), and the BERA WP

[3] The BHHRA evaluated residential exposure in the Western Undeveloped Area including an assessment of the cumulative potential residential risks from exposure to soils and upper hydrogeologic groundwater (see BHHRA: Section 6.1.7 Western Undeveloped Area). In addition, the BHHRA assessed the cumulative potential residential risks from exposure to the plume core area groundwater as well as site-wide groundwater in the below upper hydrogeologic unit (see BHHRA: Section 6.1.13 Additional Groundwater Evaluation).

(EHS Support, 2018b) and interim work plan deliverables (EHS Support, 2019a, 2019b, 2019c). The complete BERA is provided in Appendix E of the RI Report.

The Site was divided into exposure areas for conducting the BERA as part of the RI. The ecological exposure areas defined for the BERA are similar to the BHHRA exposure areas; but slightly modified and further subdivided as appropriate to represent primary habitat types and receptor groups that may be exposed to COPCs. Five surface water features – Cedar Creek, Cedar Creek Reservoir Overflow Ditch, Flathead River Riparian Area, South Percolation Ponds, and Northern Surface Water Feature – are treated as separate exposure areas within the BERA based upon the types of habitats present. Ecological exposure areas are depicted on Figure 4. A brief description of these features is provided below:

- Cedar Creek – Cedar Creek originates north of the Site in the Whitefish mountains and flows approximately three miles southwest towards the City of Columbia Falls. The portion of Cedar Creek present at the Site flows along the western Site boundary. Cedar Creek is fairly shallow and, based on elevation of the groundwater table, groundwater from the Site does not recharge into Cedar Creek.
- Cedar Creek Reservoir Overflow Ditch – The Cedar Creek Reservoir Overflow Ditch runs from the Cedar Creek Reservoir to the Flathead River. The Cedar Creek Reservoir Overflow Ditch runs alongside the Sanitary Landfill, the Center Landfill, the southern Asbestos Landfill, and the East Landfill and associated leachate ponds before discharging into the Flathead River.
- Flathead River Riparian Area – The Riparian Area is vegetated with a riparian forest and is located north of the Flathead River between the South Percolation Ponds and the Backwater Seep Sampling Area. Groundwater seepage in this area drains via a small stream channel (the “Flathead River Riparian Area Channel,” less than a few feet wide) that discharges into the western end of the Backwater Seep Sampling Area.
- South Percolation Ponds – The South Percolation Ponds are a series of three ponds located on the south end of the Site, adjacent to the Flathead River. Groundwater levels in the area of the South Percolation Ponds range from approximately 8 feet to 14 feet below surrounding grade. The water level in the South Percolation Ponds has been observed to correlate closely with surface water elevations in the Flathead River; indicating a hydraulic connection between the two water bodies.
- Northern Surface Water Feature – The Northern Surface Water Feature is a seasonal ponding area located between Cedar Creek and the Cedar Creek Reservoir Overflow Ditch, just south of the Industrial Landfill. It is believed that during the spring, the snowmelt and increased seasonal precipitation creates a localized elevated or perched water table which feed the seeps. The substrate of the feature is predominantly grass covered with areas of channelization which help direct the groundwater from the seeps in the nearby cliff to the feature.

Ecological exposure areas were defined to represent the habitat types (aquatic, transitional, and terrestrial) and receptor groups that may be present and exposed to Site constituents. Ecological exposure areas were developed and grouped into three broad categories based on habitat types:

- Terrestrial Exposure Areas: Dry, upland areas that may support aboveground and/or belowground terrestrial flora and fauna.
    - Main Plant Area;
    - Central Landfills Area;
    - Industrial Landfill Area;
    - Eastern Undeveloped Area;
    - North-Central Undeveloped Area;
    - Western Undeveloped Area; and

- Flathead River Riparian Area[4].

- Transitional Exposure Areas: Characterized by intermittent or seasonal surface water inundation that may support aquatic or terrestrial receptors, depending on the time of year.
  - North Percolation Pond Area;
  - Cedar Creek Reservoir Overflow Ditch;
  - South Percolation Ponds; and
  - Northern Surface Water Feature.
- Aquatic Exposure Areas: Characterized by perennial or near-perennial inundation with water and physical habitats that can support aquatic receptor species.
  - Flathead River Riparian Area Channel[5];
  - Flathead River Area[6]; and
  - Cedar Creek.

The type(s) of impacted environmental media varies among the different ecological exposure areas and associated habitats, and could include surface water, sediment (including porewater), and soil.

2.3.4 BERA Conclusions

The findings of the BERA are summarized below to describe the potential risks identified and the uncertainties associated with the conclusions. The BERA findings are evaluated for each ecological exposure area to support area-specific recommendations to guide risk management decision-making for the Site.

Terrestrial Exposure Areas

The overall results of the BERA for the terrestrial exposure areas are presented in Table 28 of the RI Report (Table 8-1 of the BERA) and are summarized below.

Exposure Areas That Do Not Pose Risks Due to Site-Related Contamination

Current conditions in the following terrestrial exposure areas at the Site are not likely to result in adverse ecological effects resulting from exposure to Site-related COCs:

- Eastern Undeveloped Area;
- North-Central Undeveloped Area;
- Western Undeveloped Area; and
- Flathead River Riparian Area.

For the Eastern Undeveloped Area, North-Central Undeveloped Area, and Western Undeveloped Area, some sampling locations were identified with concentrations of barium or manganese that exceeded lowest observed effect concentration (LOEC) for terrestrial plants. However, these metals were present at concentrations consistent with background concentrations, and their presence was not attributed to

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4 The Flathead River Riparian Area is a terrestrial exposure area that includes the terrestrial environment south of the railroad and up to the Flathead River. This area does not include aquatic exposure areas (i.e., Flathead Riparian Area Channel, Backwater Seep Sampling Area) or transitional exposure areas (i.e., South Percolation Ponds) in the surrounding area.

5 The Flathead River Riparian Area Channel is an aquatic exposure area that is surrounded by the Flathead River Riparian Area. This feature is presented in BERA Figure 2-2 and is presented as the Riparian Sampling Area on Figure 2 of the RI Report.

6 The Flathead River Area is an aquatic exposure area that includes the main channel of the Flathead River.

Site-related pathways. Bis(2-ethylhexyl) phthalate in the Eastern Undeveloped Area exceeded a hazard quotient (HQ) based on no observed adverse effect level (NOAEL) (HQNOAEL) of 1 for the yellow-billed cuckoo, a special status species that is evaluated based only on NOAEL endpoints. However, as discussed in Section 7.1.7 of the BERA, bis(2-ethylhexyl) phthalate is not related to historical Site operations and is a common laboratory contaminant. Furthermore, it is not likely the yellow-billed cuckoo would be present at the Site due to its rarity in Montana and the absence of basic habitat requirements at the Site. Therefore, bis(2-ethylhexyl) phthalate is not carried forward for evaluation of remedial alternatives.

Exposure Areas That Pose Risks Due to Site-Related Contamination

Current conditions in the following terrestrial exposure areas at the Site have the potential to result in adverse effects to terrestrial receptors:

- Main Plant Area;
- Central Landfills Area;
- ISM Grid Area; and
- Industrial Landfill Area.

The key conclusions with respect to each of the above areas are presented below.

Main Plant Area: Risk estimates for the Main Plant Area, particularly in the north-central portion of this exposure area, indicate the potential for adverse effects associated with exposure to PAHs in soil within localized areas proximal to former operations. Direct contact exposure to PAHs in the Main Plant Area may result in adverse direct contact effects to terrestrial invertebrates in these localized areas. Exposure estimates for PAHs in soil resulted in wildlife ingestion lowest observed adverse effect level (LOAEL) HQ (HQLOAEL) values that exceeded 1 for two avian receptors (the American woodcock and the yellow-billed cuckoo), primarily due to the modeled ingestion of terrestrial invertebrates. In the northern portion of the Main Plant Area within the ISM Grid Area (i.e., Operational Area) footprint, there is potential for adverse effects for small mammals including the short-tailed shrew (exposure > HQLOAEL at 5 of 90 stations) and meadow vole (exposure > HQLOAEL at 9 of 90 stations).

Central Landfills Area: Risk estimates for the Central Landfills Area indicate the limited potential for adverse effects associated with exposure to PAHs and select metals, including copper, in soil within localized areas near the former Wet Scrubber Sludge Pond. The direct contact evaluation indicates that potential risk to soil invertebrates and terrestrial plants is low, although localized areas of PAHs and one elevated copper result at CFSB-002 (7,260 mg/kg) resulted in some NOEC and LOEC exceedances. Wildlife ingestion models indicate the potential for adverse effects to two avian receptors (the American woodcock and the yellow-billed cuckoo) and the short-tailed shrew associated with exposure to copper, PAHs, and Aroclor 1254 (a polychlorinated biphenyl, or PCB) assuming conservative exposure assumptions. However, wildlife exposure to copper was largely attributable to the anomalously high concentration at CFSB-002; EPCs for PAHs were also influenced by localized stations with elevated concentrations. Similar to the Main Plant Area, it is not likely the yellow-billed cuckoo would be exposed at estimated doses due to its rarity in Montana and the absence of basic habitat requirements in the Central Landfills Area. The modeled ingestion of terrestrial invertebrate prey items was the critical exposure pathway for wildlife receptors.

ISM Grid Area: Ecological risk estimates for the ISM Grid Area (i.e., Operational Area) were similar to risk estimates for overlapping areas within the Main Plant Area and Central Landfills Area. Direct contact exposure estimates indicate moderate risk to soil invertebrates and terrestrial plants based on soil exposure to PAHs and select metals, including copper, selenium (plants only), and zinc. Several of the decision units, particularly in the central third of the ISM Grid within the Central Landfills Area, contained concentrations of constituents that exceeded LOAEL-based benchmarks protective of small range receptors. Exceedances of LOAEL-based benchmarks in these DUs were primarily associated with LMW and HMW PAH exposure to the short-tailed shrew.

Industrial Landfill Area: Risk estimates for the Industrial Landfill Area indicate the limited potential for adverse effects associated with exposure to PAHs and select metals in soil. Risk estimates for the Industrial Landfill Area indicate limited potential for adverse effects associated with direct contact exposure to soil invertebrates and terrestrial plants. Wildlife ingestion models indicate estimated doses of nickel (the American woodcock and the short-tailed shrew) and HMW PAHs (the American woodcock and the yellow-billed cuckoo) resulting in HQ_{LOAEL} values from 1 to 5 in the Industrial Landfill Area, primarily due to the modeled ingestion of terrestrial invertebrate prey items. As a result, nickel and PAHs in soil at the Industrial Landfill Area represent a moderate risk to ecological receptors due to direct contact and indirect ingestion exposure pathways.

Based on these findings, the potential for adverse effects to ecological receptors exposed to soil in localized areas of the Main Plant Area, Central Landfills Area, ISM Grid Area, and Industrial Landfill Area cannot be entirely dismissed under current conditions. Concern regarding ecological exposure is limited to small bird and mammal populations that may use modified and disturbed habitats in developed areas of the Site. However, concerns regarding exposure to receptors representing other trophic groups is reduced due to the low-quality habitat available in these areas under current, developed conditions relative to the undeveloped portions of the Site.

Transitional Exposure Areas

Transitional exposure areas were evaluated assuming both dry (terrestrial) and inundated (semi-aquatic/aquatic) conditions. The overall results of the BERA for the transitional exposure areas are presented in Table 29 of the RI Report (Table 8-2 of the BERA; terrestrial scenario) and Table 30 of the RI Report (Table 8-3 of the BERA; aquatic scenario) and are summarized below.

Exposure Areas That Do Not Pose Risks Due to Site-Related Contamination

Current conditions in the following transitional exposure areas at the Site are not likely to result in adverse ecological effects resulting from the exposure to Site-related COCs:

- Cedar Creek Reservoir Overflow Ditch; and
- Northern Surface Water Feature.

Risk estimates for the Cedar Creek Reservoir Overflow Ditch indicate minimal risks to ecological receptors under dry and inundated scenarios. During periods of inundation, direct contact risk associated with surface water and sediment in the Cedar Creek Reservoir Overflow Ditch is expected to be minimal. Some exceedances of NOECs and LOECs in sediment and surface water were noted; however, consideration of Background Threshold Values (BTVs), concentration gradients, the low magnitude and frequency of exceedances, and other factors indicate that Site-related toxicity related to these constituents is unlikely. For times of the year when inundation does not occur, direct contact risk to terrestrial organisms is expected to be negligible relative to background risk. Wildlife risks associated with direct and indirect ingestion pathways to exposure media within the Cedar Creek Reservoir Overflow Ditch were negligible.

The small-range receptor evaluation indicated that a single sample in this exposure area had concentrations that exceeded only the NOAEL benchmark; however, no LOAEL-based benchmarks were exceeded. Therefore, no constituents in media associated with the Cedar Creek Reservoir Overflow Ditch are considered to be of concern for direct or indirect ingestion by wildlife receptors.

The potential for adverse effects associated with constituents in media at the Northern Surface Water Feature Area is considered minimal under both dry and inundated scenarios. During periods of inundation, direct contact exposure to COCs in surface water and sediment is expected to be limited to background exposure. During dry periods, risks to soil invertebrates and terrestrial plants are negligible. Wildlife ingestion modeling results indicated HQLOAEL values slightly exceeding 1 for barium and selenium exposure to the American dipper. However, this risk estimate is likely overestimated because inundation is seasonal and varies interannually, and likely does not support a permanent benthic invertebrate community to provide a forage base for the American dipper.

Exposure Areas That Pose Risks Due to Site-Related Contamination

Current conditions in the following transitional exposure areas at the Site have the potential to result in adverse effects to ecological receptors:

- North Percolation Pond Area; and
- South Percolation Ponds.

The key conclusions with respect to each of the above areas are presented below.

North Percolation Pond Area: Risk estimates for the North Percolation Pond Area indicate the potential for adverse effects based on exposure through direct contact and wildlife ingestion pathways. The greatest potential for adverse direct contact effects is associated with exposure to cyanide, fluoride, metals,[7] and PAHs during inundated conditions in the North-East Percolation Pond. Under dry scenarios, exposure to PAHs in soil exceeded NOEC values protective of soil invertebrates. Elevated risks associated with direct and indirect ingestion by wildlife receptors were also observed in the North Percolation Pond based on the results of the food chain modeling.

The North Percolation Ponds represent low quality habitat for terrestrial or aquatic receptors, based on their use as a former wastewater management structure. Based on the degraded habitat function and value of the North Percolation Ponds, exposure pathways may be more limited than the exposure assumptions used in direct contact and ingestion pathway evaluations. However, based on the risk estimates presented in the BERA, exposure to waste-related COCs in multiple media in the North Percolation Ponds has the potential to adversely affect ecological receptors. Further actions should be considered to reduce or further study the elevated ecological risk at this exposure area. Further risk assessment may not be beneficial, particularly in the North-East Percolation Pond until the future uses of the North Percolation Pond Area are determined.

South Percolation Ponds: The potential for adverse effects associated with constituents in media at the South Percolation Ponds is considered minimal under dry scenarios, but moderate under inundated scenarios due to potential adverse effects associated with direct contact with cyanide, metals, and PAHs in surface water. During periods of inundation, exposure to cyanide and select metals in surface water has the greatest potential for adverse effects to temporary aquatic communities via direct contact exposure

[7] Metals driving risk in the North Percolation Pond Area are barium, cadmium, lead, nickel, selenium, thallium, vanadium, and zinc.

pathways. Risk associated with direct and indirect ingestion by wildlife receptors in South Percolation Pond media is minimal based on the results of the food chain modeling.

Aquatic Exposure Areas

The overall results of the BERA for the aquatic exposure areas are presented in Table 31 of the RI Report (Table 8-4 of the BERA) and are summarized in this section.

Exposure Areas That Do Not Pose Risks Due to Site-Related Contamination

The conditions in one aquatic exposure area and a portion of another do not pose significant potential for adverse ecological effects resulting from the presence of Site-related COCs. These exposure areas include:

- Flathead River (excluding the Backwater Seep Sampling Area); and
- Cedar Creek.

For the portion of the Flathead River outside of the Backwater Seep Sampling Area, risk to ecological receptors is expected to be minimal. Outside of stations within the Backwater Seep Sampling Area, total and free cyanide concentrations were below NOEC benchmarks based on National Recommended Water Quality Criteria (NRWQC) criterion continuous concentration (CCC) and MDEQ chronic criteria, respectively. Filtered aluminum concentrations were below MDEQ chronic criteria. Barium concentrations in surface water outside of the Backwater Seep Sampling Area are consistent with regional conditions. Potential risks associated with direct and incidental wildlife ingestion pathways are considered to be minimal in the Flathead River main channel.

Potential risks associated with direct contact with surface water and sediment and wildlife ingestion pathways in Cedar Creek are considered to be negligible. Direct contact EPCs are generally below NOECs, with the exception of barium. However, barium concentrations in surface water and sediment porewater are consistent from upgradient to downgradient, indicating concentrations are representative of upgradient/ background conditions. Potential exposure to wildlife foraging in Cedar Creek is not considered to exceed background exposure.

Exposure Areas That Pose Risks Due to Site-Related Contamination

Exposure conditions in two aquatic exposure areas indicate the potential for adverse ecological effects due to direct contact pathways:

- Flathead River – Backwater Seep Sampling Area; and
- Flathead River Riparian Area Channel.

The key conclusions with respect to these areas are presented below.

<u>Flathead River – Backwater Seep Sampling Area</u>: The evaluation of Flathead River sediment, sediment porewater, and surface water data indicate that the greatest potential for ecological exposure to Site-related constituents is associated with direct contact exposure within the Backwater Seep Sampling Area, and areas where groundwater containing cyanide and fluoride discharges to surface water. Surface water exposure was greatest to cyanide (total and free), barium, and aluminum, with greater concentrations observed in the Backwater Seep Sampling Area. Attenuation of surface water concentrations occurs rapidly with increasing distance from the Backwater Seep Sampling Area, particularly during periods of elevated discharge within the Flathead River. Outside of the stations within the Backwater Seep Sampling

Area and stations along the shoreline immediately downstream of the Backwater Seep Sampling Area (CFSWP-026 through CFSWP-028), total and free cyanide concentrations were typically non-detect; and did not exceed chronic NRWQC- and DEQ-7-based benchmarks, respectively, in multiple rounds of surface water sampling events. This finding indicates the potential area of exposure to aquatic receptors at concentrations exceeding NOECs and LOECs based on MDEQ (total cyanide) and NRWQC (free cyanide) benchmarks is spatially-limited to a groundwater-surface water mixing zone along the shoreline within and immediately adjacent to the Backwater Seep Sampling Area. Potential risks associated with direct and incidental wildlife ingestion pathways are considered to be minimal in the Backwater Seep Sampling Area. The BERA discussed the possibility of further evaluation of chronic, direct contact exposure to cyanide in surface water and sediment porewater in the Backwater Seep Sampling Area/Flathead River Riparian Area through Tier III studies, as further discussed in Section 3.4.

Flathead River Riparian Area Channel: The evaluation of sediment and surface water data in the Flathead River Riparian Area Channel indicate the potential for adverse effects associated with direct contact exposure of aquatic receptors to cyanide (total and free), fluoride, and metals in surface water. Surface water data indicate potential exposure to COCs may be influenced by groundwater discharge similar to the Backwater Seep Sampling Area. A temporal analysis of COC concentrations in surface water indicate the greatest chronic exposure to cyanide in the Flathead River Riparian Area Channel likely occurs during periods of elevated discharge within the Flathead River.

2.3.5 Exposure Areas Requiring Additional Evaluation

As detailed above and in Sections 7 and 8.4 of the RI Report, and summarized in Section 8.5 of the RI Report, the following exposure areas are being carried forward for evaluation of remedial alternatives in the FS:

- Main Plant Area (including the Main Plant ISM Grid Area);
- North Percolation Pond Area;
- Central Landfills Area (including the Central Landfills ISM Grid Area);
- Industrial Landfill Area;
- South Percolation Ponds;
- Backwater Seep Sampling Area and Flathead River Riparian Area Channel; and
- Groundwater (Plume Core Area).

Based on the findings of the BHHRA and BERA and as discussed in the RI Report, exposure areas not listed above generally exhibit *de minimis* risk to human health and ecological receptors and, as such, are not proposed for further evaluation in the FS. These include:

- Eastern Undeveloped Area;
- North-Central Undeveloped Area;
- Western Undeveloped Area;
- Flathead River Area (excluding the Backwater Seep Sampling Area);
- Flathead River Riparian Area (excluding the Flathead River Riparian Area Channel);
- Cedar Creek;
- Cedar Creek Reservoir Overflow Ditch; and
- Northern Surface Water Feature.

The results of the risk assessments will only remain valid if future use of the Site matches the assumptions made in the risk assessments. Therefore, certain use restrictions consistent with the risk assessments must be applied (e.g., land use restrictions in the Eastern Undeveloped Area and North-Central Undeveloped Area to commercial or industrial use, only) and enforced at exposure areas not proposed for further evaluation in the FS. These restrictions, and the areas to which they apply, will be identified and addressed within the FS as common elements that are applicable to all remedial alternatives.

2.4 Remedial Investigation Conclusions

The RI consisted of a comprehensive study that set a foundation to inform risk management decisions and evaluate remedial alternatives for the Site. The dataset collected at the Site and from reference areas during the RI supports the development of a CSM that describes the following:

- The nature and extent of contamination in various environmental media at the Site;
- The degree to which these media are affected by on-going sources and by contaminant fate and transport processes that affect the spatial and temporal distribution of contamination; and
- The resultant risks to human health and ecological receptors from exposure to COCs.

The following sections summarize the findings of the RI.

2.4.1 COCs Contributing to Risk

Multiple phases of investigation were completed as part of the RI in order to generate a comprehensive dataset for the Site. A summary of the scope of work for each investigation phase of the RI including the Phase I SC, Supplemental South Pond Assessment, and Phase II SC is provided in Section 2 of the RI Report.

During the RI, samples of soil, groundwater, surface water, sediment, and sediment porewater were analyzed for a comprehensive list of potential contaminants, including approximately 268 separate target analytes. The results from this sampling were compared relative to conservative screening criteria for each media to identify COPCs according to procedures outlined in the RI/FS Work Plan, the BHHRA WP, and the BERA WP. Based on this evaluation, approximately 39 chemicals were retained as COPCs for evaluation in the BHHRA and approximately 40 chemicals were retained as COPECs for evaluation in the BERA. However, the results of the risk assessments indicated only a subset of COPCs contribute to risk estimates that exceed *de minimis* levels for potential human health risk (i.e., excess lifetime cancer risk of 1E-06 for carcinogens; or hazard quotient of 1 for non-carcinogens) or pose moderate or higher risk from the ecological perspective (i.e., HQ_{LOAEL} values greater than 1 for at least one receptor). Thus, these COPCs contributing to risk exceeding *de minimis* levels were the focus for in-depth evaluation within the nature and extent of contamination sections of the RI Report (Roux, 2020), and were presented by exposure area in Tables 9 and 10 of the RI Report. Details regarding the nature and extent of these COPCs driving risk are provided in Section 4 of the RI Report. In addition, although cyanide and fluoride are not risk drivers with respect to soil exposure pathways, both of these COPCs were retained for in-depth evaluation of their nature and extent in soil due to their prevalence in groundwater and surface water.

It is noted that manganese in soil is found in background soil samples at comparable concentrations; therefore, its presence is not attributable to Site-related contamination, but rather to naturally-occurring background conditions. As such, manganese is not carried forward for evaluation of remedial alternatives. Similarly, concentrations of arsenic in soil in the Main Plant Area are comparable to concentrations of background soil samples. Therefore, the presence of arsenic in this exposure area is not attributed to

Site-related contamination. Further, based upon mean background concentrations of arsenic, the potential contribution of risk from background for arsenic ranged from 52 to 63 percent in the Central Landfills Area and is 50 percent in the Industrial Landfill Area.

It is also noted that benzo(k)fluoranthene and Aroclor 1254 were included as potential risk contributors in Table 9a of the RI Report, but are omitted from Table 2-1 below. Benzo(k)fluoranthene (North Percolation Pond) and Aroclor 1254 (Central Landfills Area) were included in Table 9a of the RI Report because they contribute to a cumulative carcinogenic risk exceeding the 1E-06 target incremental ELCR threshold in these exposure areas as indicated in Table 9a. However, neither constituent individually exceeded the 1E-06 target incremental ELCR threshold, which was the threshold requirement for the identification of COCs. Further, based on the relative contribution of these constituents to the overall cumulative risk, both have a negligible risk contribution to the cumulative risk threshold of 1E-05.

The Site-related COPCs identified to drive risk at the Site for exposure areas requiring additional evaluation based on the results of the BHHRA and BERA, henceforth referred to as COCs, are summarized in Tables 2-1 and 2-2 below.

Table 2-1 COCs Contributing to Human Health Risk by Media and Exposure Area

COC	Soil					Sediment	Groundwater	
	Main Plant Area	North Percolation Pond Area	Central Landfills Area	Industrial Landfill Area	ISM Grid Area	North Percolation Pond Area	Upper Hydrogeologic Unit	Below Upper Hydrogeologic Unit
Metals								
Arsenic		X	X	X	X	X	X	X
PAHs								
Benzo(a)anthracene	X	X	X		X			
Benzo(a)pyrene	X	X	X	X	X	X		
Benzo(b)fluoranthene	X	X	X		X	X		
Dibenz(a,h)anthracene	X	X	X	X	X	X		
Indeno(1,2,3-c,d)pyrene	X	X	X		X	X		
Other Inorganics								
Cyanide, total							X	
Cyanide, free							X	
Fluoride							X	

X COC for human health risk exposure.

Certain COPCs identified within the BHHRA/RI Report as potentially contributing to human health risk have been further evaluated in this FSWP and are not retained for further evaluation in the FS. These COPCs are listed below along with where the rationale for not retaining these COPCs can be found within this FSWP.

Soil:

- Aroclor 1254 was identified as a risk contributor to cumulative carcinogenic risk exceeding the 1E-06 target incremental ELCR threshold in the Central Landfills Area, but does not individually exceed this threshold (see discussion in Section 2.4.1);

- Benzo(k)fluoranthene was identified as a risk contributor to cumulative carcinogenic risk exceeding the 1E-06 target incremental ELCR threshold in the North Percolation Pond Area, but does not individually exceed this threshold (see discussion in Section 2.4.1);
- Manganese was a COPC in Main Plant Area soil but is found in background soil samples at comparable concentrations (see discussion in Section 2.4.1).

Groundwater:

- Antimony was a COPC in below upper hydrogeologic unit (BUU) groundwater but is not a Site-related COC (see discussion in Section 2.4.3);
- Bis(2-ethylhexyl) phthalate was a COPC in upper hydrogeologic groundwater but is not a Site-related COC (see discussion in Sections 2.3.2 and 2.3.4).

Table 2-2a COCs Contributing to Ecological Risk by Media and Exposure Area – Soil and Sediment

COC	Soil						Sediment			
	Main Plant Area	North Percolation Pond Area	Central Landfills Area	Industrial Landfill Area	ISM Grid Area	South Percolation Ponds	North Percolation Pond Area	South Percolation Ponds	Flathead River – Backwater Seep Sampling Area	Flathead River Riparian Area Channel
Metals										
Barium		X				X	X	X		X
Cadmium							X			
Copper			X		X			*		
Lead							X			
Nickel		X	X	X			X			
Selenium		X			X		X			
Thallium		X								
Vanadium		X		X			X			
Zinc					X		X			
Other Inorganics										
Cyanide, total							X	X		X
Cyanide, free									X	X
PAHs										
LMW PAHs[1]	X	X	X		X		X			
HMW PAHs[2]	X	X	X	X	X		X			
PCBs										
Aroclor 1254			X		X					

[1] LMW PAHs – Low Molecular Weight Polyaromatic Hydrocarbons
[2] HMW PAHs – High Molecular Weight Polyaromatic Hydrocarbons
X COC for ecological risk exposure.
* Copper is a divalent metal that is likely not bioavailable in sediment, according to the results of the acid volatile sulfide-simultaneously extractable metals and porewater evaluation (BERA; EHS Support, 2019e).

Table 2-2b COCs Contributing to Ecological Risk by Media and Exposure Area – Surface Water and Porewater

COC	Surface Water				Porewater		
	North Percolation Pond	South Percolation Pond	Flathead River – Backwater Seep Sampling Area	Flathead River Riparian Area Channel	South Percolation Ponds	Flathead River – Backwater Seep Sampling Area	Flathead River Riparian Area Channel
Metals							
Aluminum	X	X	X	X			
Barium	X	X		X	X		X
Cadmium	X						
Copper	X	X					
Iron		X					
Zinc	X						
Other Inorganics							
Cyanide, total		X	X	X	X	X	X
Cyanide, free		X	X	X		X	X
Fluoride	X						
PAHs							
Multiple PAH Compounds[1]	X						

[1] Multiple PAH Compounds comprised of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, and indeno(1,2,3-c,d)pyrene, as defined in the BERA.

X COC for ecological risk exposure.

Note: Copper was identified in Table 10d of the RI Report as a Sediment Porewater BERA COPC in the South Percolation Ponds exposure area; however, as indicated in Table 8-3 of the BERA, the EPC for copper in porewater was less than the LOEC, and therefore should not be retained as a COC.

The findings from the RI indicate that PAHs, cyanide, and fluoride are the COCs which are the primary risk drivers at the Site. These COCs are the most widespread across the Site, and generally overlap spatially with the other COCs (identified in the tables above), which contribute to risk in localized areas of the Site. In addition, other COCs (i.e., metals) were identified in soil, sediment, or surface water samples within a few specific exposure areas (e.g., South Percolation Ponds) and drive ecological risk in those areas.

2.4.2 Sources of COCs in Site Media

The RI Report (Roux, 2020) identified the following Site features as potential source areas:

- Main Plant Area;
- West Landfill, Wet Scrubber Sludge Pond, and Center Landfill;
- Percolation Ponds; and
- Former Drum Storage Area.

A summary of each potential source area is provided below.

Main Plant Area

The findings from the RI indicate that concentrations of PAHs, cyanide, and fluoride are the primary COCs present in soil throughout the Main Plant Area based upon the frequency and magnitude of exceedances of screening levels. However, these concentrations in soil do not appear to be a significant source of PAHs, cyanide, or fluoride in groundwater. Despite the widespread occurrence of PAHs in soil across the area and the exceedances of various screening criteria, PAHs are not typically mobile and are generally non-detect in groundwater in all sampling rounds. The concentrations of cyanide and fluoride in groundwater within and downgradient (south) of the Main Plant Area are less than those measured in wells upgradient (north) of the Main Plant Area near the landfills, suggesting the Main Plant Area soils are not a significant source of the cyanide and fluoride concentrations observed in groundwater (i.e., if the soils were a significant source, an increase in cyanide and fluoride concentrations would be expected).

West Landfill, Wet Scrubber Sludge Pond, and Center Landfill

The RI results indicate the West Landfill and Wet Scrubber Sludge Pond are the primary sources of cyanide and fluoride in groundwater at the Site. The iso-concentration maps presented in the RI Report (Roux, 2020) indicate the highest cyanide and fluoride concentrations in groundwater appear to originate at the Wet Scrubber Sludge Pond and the West Landfill consistently during all six rounds of sampling. Cyanide and fluoride emanate from this source area and migrate in south/south-westerly direction from the aforementioned landfills toward the Flathead River. Total cyanide and fluoride concentrations in groundwater within the upper hydrogeologic unit (the coarse-grained glacial outwash and alluvium deposits that are found above the glacial till) decrease with increasing distance away from the landfills.

The Center Landfill is likely a secondary source area for the observed elevated cyanide and fluoride concentrations in groundwater, based on the elevated concentrations in groundwater adjacent to the landfill.

The results of the RI indicated the East Landfill, the Industrial Landfill, the Sanitary Landfill, and the Asbestos Landfills are not significant contributing sources to the cyanide and fluoride in groundwater.

Percolation Ponds

The results of the RI indicated the North-East Percolation Pond and its influent ditch typically contained among the highest concentrations of cyanide and PAHs in soil and sediment, followed by the effluent ditch, and the North-West Percolation Pond. However, concentrations of cyanide and fluoride in groundwater downgradient (south) of the North Percolation Ponds are less than those measured in wells upgradient of the ponds. This continued decrease in concentrations as groundwater flows beneath the ponds suggests that the ponds are not a significant source of the cyanide and fluoride concentrations observed in groundwater (i.e., if the ponds were a significant source, an increase in cyanide and fluoride concentrations would be expected). Additionally, although PAHs were detected frequently in North Percolation Pond soil, they were not detected in any groundwater monitoring wells immediately downgradient from the North Percolation Ponds, indicating the PAHs in soil and sediment within the ponds are not a source to groundwater. However, it’s likely the soils/ sediments within the North Percolation Pond are the source of the COCs in the surface water from the pond.

The results of the RI indicate the soil/ sediment within the South Percolation Ponds are not a source of contamination at the Site, and that contaminants in the ponds are not impacting areas outside or downgradient of the ponds.

Former Drum Storage Area

In the Former Drum Storage Area, cyanide and fluoride were detected at elevated concentrations (maximum concentrations of 13 mg/kg and 796 mg/kg, respectively) in surface and shallow soil samples but decreased by an order of magnitude with increasing depth. Based on this finding, this feature may be a contributing source to the elevated cyanide and fluoride concentrations in groundwater that appear to originate beneath this area and the West Landfill and Wet Scrubber Sludge Pond. However, the decrease in concentrations with depth and the absence of any observed waste materials suggest any contributions from this area to groundwater contamination are much less than the contributions from the adjacent aforementioned areas.

2.4.3 Contaminant Fate and Transport

An evaluation of the fate and transport of COCs at the Site was conducted based upon knowledge of the Site physical characteristics, the concentrations and extent of COCs in various media, and source area characteristics. The evaluation considered the physicochemical characteristics of the COCs and various physical, chemical, and biological processes that influence contaminant fate and transport. The fate and transport analysis focused on contaminants that were identified as primary COCs through the risk assessment process, including PAHs, cyanide, and fluoride. A summary of the fate and transport evaluation is provided below.

Migration of COCs from Source Areas

The results of the RI indicate groundwater is the primary migration pathway for the potential transport of COCs from the various source areas (i.e., West Landfill, Wet Scrubber Sludge Pond, Center Landfill). In addition, results indicate that cyanide and fluoride are the primary COCs from a contaminant migration/fate and transport perspective. All other COCs identified in soil, sediment, or surface water samples within the source areas appear to be stable and not migrating at levels of concern based upon risk assessment results (as discussed in Section 2.3).

A consistent pattern was observed during all six rounds of groundwater sampling; cyanide and fluoride migrates in a south/south-westerly direction from the aforementioned source areas toward the Flathead River. Total cyanide and fluoride concentrations in groundwater within the upper hydrogeologic unit decrease with increasing distance away from the West Landfill, Wet Scrubber Sludge Pond, and Center Landfill. Cyanide and fluoride concentrations measured in monitoring wells outside of the contours shown on Plates 18 and 19 of the RI Report are less than one-half of the USEPA Maximum Contaminant Limit (MCL) in all six rounds of sampling. Cyanide concentrations are typically non-detect in the north, west, and south-west portions of the Site (e.g., near Aluminum City) during all rounds of sampling. These data, as well as the six rounds of groundwater flow data, indicate that migration of the cyanide and fluoride is not in the direction towards Aluminum City, but rather follows the southerly groundwater flow patterns towards the Flathead River.

During all six rounds of sampling, the total cyanide and fluoride concentrations in groundwater decrease with depth within the upper hydrogeologic unit, and concentrations were generally non-detect in monitoring wells screened below the upper hydrogeologic unit. These findings indicate there is limited vertical migration and that the cyanide and fluoride are primarily migrating horizontally within the upper hydrogeologic unit. These findings are consistent with observed hydrogeologic conditions described in Section 6.1 of the RI Report (Roux, 2020), which indicate there is only limited, if any, hydraulic connectivity between the upper hydrogeologic unit and the water bearing zones screened in the underlying glacial till.

Due to this lack of connectivity between the upper hydrogeologic unit and the BUU, COCs observed in the BUU are likely not Site-related. This is corroborated by the presence and distribution of antimony in the BUU; antimony is not a contaminant attributed to the Site's historical operations, and the distribution of elevated concentrations of antimony do not correspond with Site source areas. In addition, antimony does not exceed MDEQ numeric water quality standards in all but one of the 464 groundwater samples collected from the upper hydrogeologic unit. Further, concentrations of cyanide and fluoride (the primary COCs in groundwater, which have been shown to be highly mobile) did not exceed MDEQ numeric water quality standards in the BUU; if a source were contributing to groundwater contamination in the BUU, elevated concentrations of cyanide and fluoride above MDEQ numeric water quality standards would be expected in groundwater samples collected from the BUU. Rather, the antimony detections in the BUU are likely related to naturally occurring metals concentrations in groundwater. The occurrence of antimony in groundwater has been observed at similar concentrations since the 1980s and was determined to represent only background concentrations, as documented in the Hydrogeological Evaluation report prepared by Hydrometrics dated September 9, 1985 (Hydrometrics, 1985). As such, it is reasonable to conclude that the COCs observed in the BUU are not Site-related and are therefore not retained for further evaluation in the FS.

The hydrogeologic studies (i.e., groundwater elevation data and surface water elevation data) indicate that groundwater discharges to the Flathead River. The Backwater Seep Sampling Area, the Riparian Area, and the South Percolation Pond Area are all located within the extent of the "Seep Area" that was historically a permitted discharge under the former Site Montana Pollutant Discharge Elimination System (MPDES) Permit (#MT00300066). The "Seep Area" was defined in the permit as the area which has potential to receive groundwater expressed from the upper hydrogeologic unit to the Flathead River. Historically, groundwater in the Backwater Seep Sampling Area has consistently been observed to discharge from the banks and has been sampled as part of the requirements for the former Site MPDES Permit (#MT00300066). The Site MPDES Permit was terminated effective April 17, 2019 due to the permanent plant closure and the elimination of discharges controlled by the permit.

Elevated concentrations of cyanide in sediment and sediment porewater are present in the Backwater Seep Sampling Area and Riparian Area. Elevated concentrations of fluoride in sediment porewater are present in the Backwater Seep Sampling Area, Riparian Area, and South Percolation Ponds, though fluoride was not detected at elevated concentrations in sediment in these features. These concentrations, along with the documented migration of these constituents in groundwater, indicate the groundwater is the primary source of the cyanide and fluoride concentrations in surface water, sediment, and sediment porewater measured in these areas. Concentrations of cyanide in surface water, sediment, and sediment porewater up-river in the Flathead River were typically non-detect, further supporting that groundwater discharge is the primary source of the cyanide in the sediment and surface water of the Backwater Seep Sampling Area and Riparian Area. In addition, direct discharges into the South Percolation Ponds could have contributed to surface water and sediment impacts in this area.

All surface water, sediment, and sediment porewater samples collected within the main stem of the Flathead River downgradient of the Backwater Seep Sampling Area, Riparian Area, and South Percolation Ponds during all six rounds of sampling were generally non-detect for total cyanide. Fluoride was generally detected in surface water and sediment samples collected within the main stem of the Flathead River downgradient of these areas, but at concentrations below screening levels and similar to concentrations in samples collected upstream; fluoride was typically not detected in sediment porewater samples. These findings confirmed the elevated levels of cyanide and fluoride found in groundwater and in the Backwater

Seep Sampling Area, Riparian Area, and the South Percolation Pond are not measurably impacting surface water, sediment, or sediment porewater quality within the main channel of the Flathead River.

Cyanide and Fluoride Flux

Results of the hydrogeologic investigations and analytical laboratory testing were utilized to estimate the mass flux of cyanide and fluoride in the upper hydrogeologic unit groundwater. The purpose of the assessment was to evaluate the general areas of the Site contributing most of the groundwater COCs and to assess how those contributions may change along the general groundwater flow path towards the Flathead River.

The evaluations were conducted for areas directly downgradient of the source areas (i.e., West Landfill, Wet Scrubber Sludge Pond, and Center Landfill) and in areas south of the source areas along the groundwater flow path toward the Flathead River. Plates 20 and 21 of the RI Report (Roux, 2020) present the locations of groundwater flow transects and sub-transects that were evaluated for cyanide and fluoride, respectively. In general, the transects cover the extent of the cyanide and fluoride plumes in groundwater and, in some cases, extend beyond these areas. Groundwater velocity, contaminant velocity, and mass flux estimates were developed based on a number of interpretations and assumptions; therefore, the quantities presented should be considered approximate, order of magnitude estimates.

The results of the cyanide and fluoride mass flux are provided in Section 6.4 of the RI Report. Data inputs and assumptions for calculations to generate these estimates, including Darcy velocity/specific discharge, groundwater effective velocity, and contaminant velocity are also provided in Section 6.4 of the RI Report.

The evaluation indicated mass flux of cyanide and fluoride are highest immediately downgradient of the landfills, which is consistent with the understanding that the West Landfill, Wet Scrubber Sludge Pond, and Center Landfill are the sources of cyanide and fluoride in groundwater. Contaminant flux decreases with increasing distance from the landfills. With respect to cyanide, the decrease in flux with increasing distance from the landfills is likely due to various attenuation process such as biodegradation and sorption.

Fluoride flux decreases by an order of magnitude downgradient of the landfills and north of the Main Plant Area. A potential explanation for this decrease in concentration is the precipitation of fluoride out of groundwater immediately outside and downgradient of the source area as described in Section 6.3.4 of the RI Report.

The cyanide and fluoride flux calculated for the transect immediately upgradient of the Flathead River was used to estimate the maximum hypothetical concentration that should be expected to occur within the main stem of the Flathead River. As a conservative measure, this estimate was performed considering the minimum Flathead River discharge for the three-year period of the RI. The results indicate the maximum concentrations within the Flathead River would be more than an order of magnitude below the limits of detection for cyanide and fluoride. These findings are consistent with the observations noted above; namely, that both constituents are typically non-detect within the main stem of the Flathead River. The data inputs and assumptions for the flux calculations and estimate of hypothetical maximum concentrations were provided in Section 6.4.3 of the RI Report.

3. Decision Units for FS Evaluations

Based on the size and complexity of the Site, decision units (DUs) with common elements or conditions were established to evaluate and address COCs specific to an environmental media and/or area of the Site. DUs have been developed for the Site to be used in both the preliminary screening and in the more detailed FS alternatives analysis. Ultimately, a set of remedial alternatives will be established and evaluated for each identified DU.

A total of six (6) DUs were defined to encompass the exposure areas identified in Section 2.3.5 as requiring additional evaluation:

- Landfills DU1;
- Landfills DU2;
- Soil DU;
- North Percolation Pond DU;
- River Area DU; and
- Groundwater DU.

The physical description of each DU including location and media are detailed in the subsections below, and a map showing the areal extent of each DU is provided as Figure 5.

3.1 Landfills DU1

The Landfills DU1 is defined as the West Landfill, the Wet Scrubber Sludge Pond, the Center Landfill, and the surficial and shallow soil (0-0.5 and 0.5-2 feet below land surface [ft-bls], respectively), if any, within their footprints. Each of these waste management units has been identified in the RI Report (Roux, 2020) as a source of groundwater contamination at the Site to varying degrees, as discussed further below.

The waste management units are described in the following subsections and in detail in the RI Report (Roux, 2020). The COCs for the Landfills DU1 are summarized in Table 3-1 below.

Table 3-1 Summary of COCs in the Landfills DU1

COC	Human Health	Ecological
	Soil	Soil
Metals		
Arsenic	X	
Copper		X
Nickel		X
PAHs		
Benzo(a)anthracene	X	
Benzo(a)pyrene	X	
Benzo(b)fluoranthene	X	
Dibenz(a,h)anthracene	X	

COC	Human Health	Ecological
	Soil	Soil
Indeno(1,2,3-c,d)pyrene	X	
LMW PAHs		X
HMW PAHs		X
PCBs		
Aroclor 1254		X

In addition, although cyanide and fluoride are not risk drivers with respect to human health or ecological exposure pathways within the Landfills DU, it is important to recognize that these three waste management units are the sources of cyanide and fluoride in groundwater downgradient of these features.

West Landfill

The West Landfill comprises approximately 7.8 acres, with areal dimensions of approximately 615 feet by 600 feet. The landfill reportedly is unlined, extends approximately 30 to 35 feet below surrounding grade (as-built drawings provided in Appendix G1 of the RI Report; CFAC, 2013), and rises approximately 13 feet above grade on the eastern side of the landfill and over 30 feet above grade from the western side. Groundwater levels in the area of the West Landfill range from approximately 36 ft-bls during high-water season to 87 ft-bls during low-water season. Landfill gas vents are present within the West Landfill.

As noted in the RI/FS Work Plan, historical aerial photographs indicate that the West Landfill appears undeveloped until between 1963 and 1974, later than the 1955 date described in several prior reports (CFAC, 2013; Weston, 2014; RMT, 1997). Minimal disturbance, and only along the southern boundary of the West Landfill, was observed in the 1956 and 1963 aerial photographs; while the majority of the West Landfill appeared to be in use by the time of the 1974 aerial photograph (Appendix F of the RI Report). Therefore, based on the historical aerial photographs, use of the West Landfill for SPL disposal commenced between 1963 and 1974. The West Landfill was used to dispose of SPL and other wastes through 1980, though SPL disposal into the West Landfill reportedly ended in 1970. The landfill was closed in 1981 and capped with a synthetic (hypalon) cap in 1994 (CFAC, 2013). The as-built drawings for the West Landfill cap completed in 1994 (Appendix G1 of the RI Report), indicate an average thickness of the waste within the landfill is 30 feet, which is consistent with the reported waste thickness of 35 feet (CFAC, 2013).

Wet Scrubber Sludge Pond

The Wet Scrubber Sludge Pond is approximately 10.8 acres in size with areal dimensions of approximately 750 feet by 580 feet. The observed height of the berm surrounding the Wet Scrubber Sludge Pond is approximately 15 feet above surrounding grade. Based on the historical documents reviewed, the total depth of waste material including the above-grade portion is estimated to be approximately 30 feet. Groundwater levels measured in adjacent monitoring wells indicate that during high-water season, groundwater is observed to be approximately 60 ft-bls; though groundwater levels in CFMW-007 adjacent to the West Landfill were 35.5 ft-bls. During low-water season, groundwater is observed to be approximately 105 ft-bls.

The Wet Scrubber Sludge Pond reportedly received waste material from the wet scrubbers at the aluminum reduction plant from 1955 until 1980, at which time the wet scrubbers for the aluminum reduction plant were replaced with dry scrubbers that produce much less waste (RMT, 1997). The pond was subsequently capped with an unlined earthen cap in 1981 and vegetated.

Center Landfill

The Center Landfill is approximately 1.8 acres in area, in a circular shape, with an aerial diameter of approximately 330 feet. The Center Landfill was also historically referred to as the carbon mound. Based on the historical documents reviewed, the landfill was constructed above grade and is approximately 15 feet above surrounding grade. Depth to groundwater in the area of the Center Landfill ranges from approximately 57 feet to 139 feet below surrounding grade.

The Center Landfill was reportedly unlined. The landfill was closed in 1980 and, based on historical drawings, capped with a 6-inch clay cap and 18-inches of till (Marquardt Billmayer, 1981). The Center Landfill appears to be a potentially contributing source to groundwater contamination, but to a lesser degree than the West Landfill and Wet Scrubber Sludge Pond.

3.2 Landfills DU2

The Landfills DU2 is defined as the remaining waste management units in the Central Landfills Area and Industrial Landfill Area exposure areas and the surficial and shallow soil (0-0.5 and 0.5-2 feet below land surface [ft-bls], respectively), if any, within their footprints. This includes the East Landfill, the Industrial Landfill, the Sanitary Landfill, and the Asbestos Landfills. As discussed in the RI Report (Roux, 2020), these landfills are not sources of groundwater contamination at the Site.

Each of these waste management units are described in the following subsections and in detail in the RI Report (Roux, 2020). The COCs for the Landfills DU2 are summarized in Table 3-2 below.

Table 3-2 Summary of COCs in the Landfills DU2

COC	Human Health	Ecological
	Soil	Soil
Metals		
Arsenic	X	
Copper		X
Nickel		X
Vanadium		X
PAHs		
Benzo(a)anthracene	X	
Benzo(a)pyrene	X	
Benzo(b)fluoranthene	X	
Dibenz(a,h)anthracene	X	
Indeno(1,2,3-c,d)pyrene	X	
LMW PAHs		X
HMW PAHs		X
PCBs		
Aroclor 1254		X

East Landfill

The East Landfill encompasses an area of approximately 2.4 acres. The aerial dimensions are approximately 330 feet by 730 feet. Based on the historical documents reviewed, the East Landfill was constructed above ground level (CFAC, 2013), and is approximately 30 feet above the surrounding grade. Groundwater levels in the area of the East Landfill range from approximately 109 feet to 130 feet below surrounding grade.

The East Landfill was reportedly built with a clay liner and capped with a 6-inch thick clay layer, a synthetic cap, and an 18-inch vegetated till cover (Appendix G2 of the RI Report). The landfill was also built with two lined leachate collection ponds. The landfill was operated from 1980 to 1990 for disposal of SPL and was closed in 1990.

The North Leachate Pond was located directly north of the East Landfill and was approximately 0.6 acres in size, with aerial dimensions of approximately 250 feet by 115 feet. The North Leachate Pond was lined with a Hypalon liner. The leachate pond received stormwater runoff and leachate from the East Landfill and was hydraulically connected to the Wet Scrubber Sludge Pond by a drainage pipe. The pond was also aerated to reduce concentrations of cyanide. The pond was closed in 1994.

The South Leachate Pond was located directly south of the East Landfill and was approximately 0.9 acres in size. The South Leachate Pond received stormwater runoff and leachate from the East Landfill. The South Leachate Pond was lined with Hypalon liner. Similar to the North Leachate Pond, the South Leachate Pond was aerated to reduce concentrations of cyanide (CFAC, 1994; CFAC, 2003). The pond was emptied in 1990 and was dried, capped, and closed in 1993.

Industrial Landfill

The Industrial Landfill is an inactive, uncovered landfill in the northern portion of the Site, encompassing approximately 12.4 acres. The aerial dimensions of the landfill are approximately 720 feet by 800 feet, though the shape is irregular. The height of the Industrial Landfill varies and ranges from approximately 10 to 20 feet above surrounding grade. Groundwater levels in the area of the Industrial Landfill range from approximately 19 feet to 31 feet below surrounding grade.

The Industrial Landfill began operations in the 1980s based on aerial photography. The Industrial Landfill received non-hazardous waste and debris (CFAC, 2013) until landfilling operations ceased in October 2009. Details regarding the depth of landfilled material or presence of a liner are unknown.

Sanitary Landfill

The Sanitary Landfill is approximately 3.8 acres in size, approximately 330 feet wide by 540 feet long. Based on the historical documents reviewed, the depth of landfilled material is unknown. Groundwater levels in the area of the Sanitary Landfill range from approximately 23 feet to 94 feet below surrounding grade.

Based on aerial photography review, the Sanitary Landfill operated in the early 1980s. The landfill was reportedly clay lined, and was used for plant garbage (RMT, 1997). According to the 2014 Site Reassessment Report, the landfill was covered with clean fill and vegetated.

Asbestos Landfills

As described in the RI/FS Work Plan (Roux, 2015a), two areas were identified as being former asbestos disposal areas based on historical information. These areas are referred to as the North Asbestos Landfills and the South Asbestos Landfills. The North Asbestos Landfills are located north of the West Landfill and consist of two separate areas (i.e., North-West and North-East Asbestos Landfills); the South Asbestos Landfills are located south of the East Landfill, near the eastern boundary of the Site, and consist of two separate areas (i.e., South-West and South-East Asbestos Landfills). The four disposal areas are referred to collectively as the Asbestos Landfills.

The Asbestos Landfills were constructed as early as the late 1970s or early 1980s and were in use from 1993 to 2009. Details regarding disposal area construction are unknown; however, based on observations made during the Phase I SC field reconnaissance and test pitting activities, a natural soil cover overlies the asbestos materials within the disposal areas. The deepest asbestos bag observed was 4.5 ft-bls. There is no evidence of an engineered cap or liner.

3.3 Soil DU

The Soil DU is defined as the soil within the Main Plant Area, the ISM Grid Area, and the areas surrounding the waste management units in the Central Landfills Area exposure area (including the Former Drum Storage Area). Details regarding these areas are provided in the following subsections. Based upon the results of the BHHRA and BERA, the COCs for the Soil DU are summarized in Table 3-3 below.

Table 3-3 Summary of COCs in the Soil DU

COC	Human Health	Ecological
	Soil	Soil
Metals		
Arsenic	X	
Copper		X
Nickel		X
Selenium		X
Zinc		X
PAHs		
Benzo(a)anthracene	X	
Benzo(a)pyrene	X	
Benzo(b)fluoranthene	X	
Dibenz(a,h)anthracene	X	
Indeno(1,2,3-c,d)pyrene	X	
LMW PAHs		X
HMW PAHs		X
PCBs		
Aroclor 1254		X

As documented in the BHHRA and BERA, the above COCs were determined based upon evaluation of potential exposure to soil at various depth intervals (ranging from 0 to 12 ft-bls) for human health exposure scenarios and from 0 to 2 ft-bls for ecological exposure scenarios.

It is noted that in some areas COCs are present in soil at greater depths than quantitatively evaluated in the risk assessments. However, there is no potential for receptors to be exposed to the COCs at these greater depths under current or reasonable future use scenarios; therefore, the remedial alternatives will focus on soil where there is potential for exposure. Access restrictions (i.e., institutional controls) to ensure the exposure assumptions with respect to deeper soils remain valid will also be included within the remedial alternatives as needed.

In addition, although cyanide and fluoride are not risk drivers with respect to human health or ecological exposure pathways for soil, the presence of these COCs in soil was evaluated during the RI relative to their potential contributions to groundwater impacts. With the exception of soils in the Former Drum Storage Area, the findings indicate that cyanide and fluoride in general Site soils are not the source of the observed cyanide and fluoride groundwater plumes that have been delineated at the Site. Rather, the wastes and associated contaminated soil within and beneath the West Landfill, Wet Scrubber Sludge Pond, and Center Landfill (i.e., Landfills DU1) are the primary sources of cyanide and fluoride in groundwater at the Site. This is supported by the decreasing concentrations of cyanide and fluoride in groundwater with increasing distance from these areas. This continued decrease in concentrations as groundwater flows away from these areas indicates that downgradient soil is not a significant source of the cyanide and fluoride concentrations observed in groundwater (i.e., if the downgradient soils were a significant source, an increase in cyanide and fluoride concentrations would be expected downgradient).

As described above, soil within the Former Drum Storage Area is considered a potential source of cyanide and fluoride in groundwater. However, the decrease in concentrations with depth and the absence of any observed waste materials suggest that any contributions from this area to groundwater contamination are much less than the contributions from the adjacent waste management units.

The Main Plant Area Soils

The Main Plant Area is the portion of the Site historically used for production of aluminum. Decommissioning and demolition of the industrial facilities within the Main Plant Area was completed in the third quarter of 2019. The Main Plant Area includes the following former buildings and features:

- The Potline Buildings where the aluminum smelting occurred;
- The casting house, mechanical shops, Paste Plant, Rod Mill, and warehouses adjacent to the potlines; and
- The Rectifier Yards.

Details regarding these former buildings and Site features are provided below.

Potline Buildings

The Main Plant Area is where the production of aluminum occurred. The facility was approximately 47 acres and spanned approximately 1,760 feet by 1,170 feet.

In 1955, the plant began operation with four pot rooms. The plant expanded to ten pot rooms in the 1960s. The potline buildings had courtyards and various support buildings in between the pot rooms. The courtyards contained air ventilation structures including the dry scrubbers. Support buildings include the casting house, offices, garages, and a briquette storage area (Anaconda Aluminum, 1981).

The dry scrubbers in the plant were installed to replace a wet scrubber sludge system, which operated until final installation of the dry scrubbers between 1976 and 1978.

Many raw materials were required for aluminum production and were stored on-Site. Raw materials were delivered to the Site at several transfer stations, located just north of the Main Plant, and adjacent to the railroad. Raw material transfer stations include the Petroleum Coke Building, the Alumina Unloading Stations, and the Lime Unloader station (Roux, 2015a).

Rod Mill

The Rod Mill is approximately 1.2 acres and is located on the south-western portion of the Main Plant Area. This area was used as a Rod Mill during the first decade of plant operation. Afterwards, the Rod Mill was used for storage. During the 1990s, the Rod Mill was used for storage of hazardous waste, including SPL and PCBs (RMT, 1997).

Paste Plant

The Paste Plant manufactured anode briquettes from petroleum coke and coal tar pitch. Once made, the briquettes were sent to the Main Plant Area for use in the pots. Several other buildings were part of the briquette making process, including the petroleum coke unloading building, a petroleum coke silo, a paste plant wet scrubber (replaced by a dry scrubber in 1999), coal tar pitch tanks, and a coal tar pitch unloading shed (RMT, 1997; E&E, 1988; CFAC, 2003).

Rectifier Yards

The Rectifier Yards are located in the south portion of the Main Plant Area and are approximately 18 acres in size. The Rectifier Yards were essential to powering the Site operations; the western Rectifier Yard has since been decommissioned. A portion of the eastern Rectifier Yards are still active and are owned by Bonneville Power Administration.

Transformers and capacitors in the Rectifier Yards historically used transformer oil containing PCBs. Transformer oil containing PCBs were removed in the 1990s (RMT, 1997).

ISM Grid Area Soils

The ISM Grid Area comprises approximately 43 acres north of the Main Plant Area and within the Central Landfills Area south of the landfills where aerial photographs indicate historical operations may have been conducted but no known source area exists. While the entire site was investigated via the collection of grab samples at soil boring locations, the ISM Grid Area was also investigated using ISM soil sampling methods to characterize average conditions across 43 individual grid cells, each approximately one acre in size. This area also encompasses the Former Drum Storage Area

Central Landfills Area Soils

The Central Landfills Area exposure area is depicted in Figures 3 and 4. Individual waste management units within this exposure area are detailed in Sections 3.1 and 3.2, and are evaluated as part of Landfills DU1 and Landfills DU2. The portion of this exposure area that is outside the footprints of the waste management units is included as part of the Soil DU for evaluation.

3.4 North Percolation Pond DU

The North Percolation Pond DU consists of the North-East Percolation Pond and its influent ditch, the North-West Percolation Pond, and the approximately 1,440-foot-long overflow ditch. Details regarding the North Percolation Ponds are provided in the following subsections. The COCs for the North Percolation Pond DU are summarized in Table 3-4 below.

Table 3-4 Summary of COCs in the North Percolation Pond DU

COC	Human Health		Ecological		
	Soil	Sediment	Soil	Sediment	Surface Water
Metals					
Arsenic	X	X			
Aluminum					X
Barium			X	X	X
Cadmium				X	X
Copper					X
Lead				X	
Nickel			X	X	
Selenium			X	X	
Thallium			X		
Vanadium			X	X	
Zinc				X	X
Other Inorganics					
Fluoride					X
PAHs					
Benzo(a)anthracene	X				
Benzo(a)pyrene	X	X			
Benzo(b)fluoranthene	X	X			
Dibenz(a,h)anthracene	X	X			
Indeno(1,2,3-c,d)pyrene	X	X			
LMW PAHs			X	X	
HMW PAHs			X	X	
Multiple PAH Compounds[1]					X

[1] Multiple PAH Compounds comprised of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, and indeno(1,2,3-c,d)pyrene, as defined in the BERA.

Surface water in the North Percolation Pond DU is seasonal in nature and is a direct result of depressions created as part of the Site's historical operations and management of process water. Since the accumulation of standing water can be prevented by altering the topography of the area, surface water for the North Percolation Pond DU is not carried forward through the technology screening. Instead, the potential risk attributed to surface water in the North Percolation Pond DU will be mitigated by appropriately decommissioning the associated anthropogenic, engineered features and addressing the potential risk attributed to soil and sediment in the DU.

North-East Percolation Pond

The North-East Percolation Pond is approximately 2 acres in size, and the topography is depressed below the surrounding area with a maximum depth of approximately 14 ft-bls. The thickness of the waste material in the percolation pond ranges from approximately 0.5 to 2 feet based on visual observations made during drilling (i.e., vertical extent of highly viscous to solid black carbonaceous material). The North-East Percolation Pond was constructed in 1955, and based on the aerial photography review, the exact size and shape of the North-East Percolation Pond changed slightly over time. This percolation pond received discharges from various operations within the Main Plant Area until manufacturing ceased in 2009. The North-East Percolation Pond is currently operational as a discharge point for stormwater drainage. Groundwater levels in the area of the North-East Percolation Pond range from approximately 30 feet to 73 feet below surrounding grade.

North-West Percolation Pond

The North-West Percolation Pond is approximately 8 acres in size, and the topography is depressed below the surrounding area with a maximum depth of approximately 22 ft-bls. The thickness of the waste material in the percolation pond ranges from approximately 0.5 to 2 feet based on visual observations made during drilling. The North-West Percolation Pond was constructed to receive overflow water from the North-East Percolation Pond. The two ponds were connected by an approximately 1,440-foot-long unlined ditch. Based on the review of aerial photography, the North-West Percolation Pond appears to be in the process of being constructed in 1972. Groundwater levels in the area of the North-West Percolation Pond range from approximately 24 feet to 44 feet below surrounding grade.

3.5 River Area DU

The River Area DU is defined as the soil, sediment, and surface water in the South Percolation Ponds, Backwater Seep Sampling Area, and Riparian Area Channel. As discussed below, CFAC is considering the potential for early action in the South Percolation Ponds pursuant to USEPA's January 9, 2017 guidance regarding remediating contaminated sediment sites and their August 23, 2019 guidance regarding early action at Superfund National Priority List sites. If CFAC were to pursue such early action, the ponds would likely be evaluated and addressed as a separate OU, subject to separate USEPA review and approval. Details regarding these features are provided below. The COCs for the River Area DU are summarized in Table 3-5 below.

Table 3-5 Summary of COCs in the River Area DU

COC		Ecological		
	Soil	Surface Water	Sediment	Sediment Porewater
Metals				
Aluminum		X		
Barium	X	X	X	X
Copper		X		
Iron		X		
Other Inorganics				
Cyanide, total		X	X	X
Cyanide, free		X	X	X

South Percolation Ponds

The South Percolation Ponds are a series of three ponds located on the south end of the Site, adjacent to the Flathead River. Based on review of historical aerials, the South Percolation Ponds were constructed in the early 1960s in conjunction with the construction of the dam on the upriver (east side) of the South Percolation Ponds. The dam diverted water from a side channel of the Flathead River and allowed for construction of the ponds in the dewatered area. The ponds are 2.4, 1.2, and 6.6 acres in size (from west to east) forming a total of 10.2 acres and are connected in series. Wastewater and stormwater entered the South Percolation Pond system from a concrete pipe located on the west end of the pond system. From the pipe, water flows via an unlined ditch into the west pond. Groundwater levels in the area of the South Percolation Ponds range from approximately 8 feet to 14 feet below surrounding grade. The water level in the South Percolation Ponds has been observed to correlate closely with surface water elevations in the Flathead River; indicating a hydraulic connection between the two water bodies.

The South Percolation Ponds received water from the sewage treatment plant, the aluminum casting contact chilling water, non-contact cooling water from the rectifier and other equipment, process wastewater from the casting mold cleaning and steam cleaning, non-process wastewater from the fabrication shop steam cleaning, and stormwater (2014 Draft MPDES Permit Fact Sheet). With facility demolition completed, the South Percolation Ponds only receive stormwater discharge through the influent pipe at the west end of the ponds system. CFAC intends to decommission the influent pipe to eliminate the direct discharge of stormwater into the Ponds.

As described in Section 2.4.3, the Backwater Seep Sampling Area, the Riparian Area Channel, and the South Percolation Pond Area are all located within the extent of the "Seep Area" that was defined in the former MPDES Permit (#MT00300066) as the area which has potential to receive groundwater expressed from the upper hydrogeologic unit to the Flathead River. The Site MPDES Permit was terminated effective April 17, 2019 due to the permanent plant closure and the elimination of discharges controlled by the permit.

Based on the above, the South Percolation Ponds are no longer needed for water management at the Site. In addition, maintaining the ponds has required an on-going effort by CFAC to periodically reinforce and/or rebuild the dam in the Flathead River at the eastern (i.e., upstream) end of the ponds system. As subsequently discussed in Section 4.4, the South Percolation Ponds are the only feature within the River Area DU that contain sediments with COCs at concentrations exceeding Preliminary Remedial Goals (PRGs). Therefore, it is CFAC's intention to decommission the South Percolation Ponds, remove sediments if needed to satisfy ecological PRGs, and remove the dam to allow the river to reclaim the channel that occupied this area prior to construction of the dam. CFAC believes it may be appropriate to evaluate this as a potential early action to reduce risk associated with the contaminated sediments and the dam; subject to review and approval by USEPA.

Backwater Seep Sampling Area

The Backwater Seep Sampling Area represents the western portion of the "Seep Area" as defined in the former MPDES Permit (#MT00300066). The Backwater Seep Sampling Area is a documented groundwater discharge point to the Flathead River that was historically sampled as part of the permit and was sampled throughout the RI. Some of the Site groundwater discharges at the base of steep river bank into a backwater channel of the Flathead River.

As noted in the BERA, further evaluation of chronic, direct contact exposure to cyanide in surface water and sediment porewater in the Backwater Seep Sampling Area/Flathead River Riparian Area may be warranted to refine risk estimates. Potential re-evaluation/refinement of the Backwater Seep Sampling Area risk would also be warranted if the dam at east end of the South Percolation Ponds is removed as part of an early action because of the significant impact that such action would have on the hydrogeology in the Backwater Seep Sampling Area.

Riparian Area

The Riparian Area is vegetated with a riparian forest and is located north of the Flathead River between the South Percolation Pond Area and the Backwater Seep Sampling Area. The Riparian Area is within the central portion of the "Seep Area" as defined in the former MPDES Permit (#MT00300066). Groundwater seepage in this area drains via a small stream channel (less than a few feet wide) that discharges into the eastern end of the Backwater Seep Sampling Area. Similar to the Backwater Seep Sampling Area, potential re-evaluation/refinement of the Riparian Area risk may be appropriate if early action is taken at the South Percolation Ponds.

3.6 Groundwater DU

The Groundwater DU is defined as the groundwater within the extent of the upper hydrogeologic unit underlying the Site described in Section 3.2.1 of the RI Report. As described in the RI Report and Section 2.4.3, Site-related groundwater impacts appear limited to groundwater within the upper hydrogeologic unit. Groundwater is retained for further evaluation in the FS because of the potential human health risks associated with the hypothetical drinking water scenario, as well as discharge to the River Area DU resulting in ARAR exceedances, as outlined in Section 2.3.2. The COCs for groundwater within the upper hydrogeologic unit are summarized in Table 3-6 below.

Table 3-6 Summary of COCs in the Groundwater DU

COC	Human Health
	Upper Hydrogeologic Unit
Metals	
Arsenic	X
Other Inorganics	
Cyanide, total	X
Cyanide, free	X
Fluoride	X

It is noted that isolated detections of arsenic and antimony are present in the BUU. Based upon the evaluation in Section 2.4.3, the presence of these constituents in the BUU do not appear to be Site-related. Therefore, these constituents in the BUU are not retained for further evaluation in the FS. In addition, there is no potential for receptors to be exposed to COCs in the BUU under current or reasonable future use scenarios, and institutional controls to prevent the human consumption of groundwater from beneath the Site will also be included within the remedial alternatives.

Iso-concentrations maps of total cyanide concentrations and fluoride concentrations in groundwater during all six rounds are shown on Plates 13 and 15 of the Phase II SC Data Summary Report (Roux, 2019), respectively.

4. Development of Remedial Objectives

The process of identifying and screening technologies begins with the creation of the remedial objectives. This section presents the remedial objectives of the FS process, which includes the applicable or relevant and appropriate requirements (ARARs), Remedial Action Objectives (RAOs), and Preliminary Remediation Goals (PRGs).

4.1 Preliminary Applicable or Relevant and Appropriate Requirements

This section identifies preliminary ARARs and other guidance and criteria “to be considered” (TBC) for the Site. An ARAR is defined as a legally applicable or relevant and appropriate standard, requirement, criterion, or limitation under federal environmental law, or promulgated under state environmental or facility siting law that is more stringent than the federal law. CERCLA Section 121(d) requires that remedial actions either comply with, or have been granted a waiver from, an ARAR. TBCs are agency advisories, criteria, or guidance to be considered where ARARs do not exist. By definitions, TBCs are neither promulgated nor enforceable, and as such as not required as cleanup standards.

ARARs are divided into three categories: chemical-specific, action-specific, and location-specific standards as described below.

- **Chemical-Specific ARARs** are typically health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, are expressed as numerical values. The values represent cleanup standards (i.e., the acceptable concentration of a chemical at the site).
- **Action-Specific ARARs** are generally technology- or activity-based requirements or limitations on actions or conditions taken with respect to hazardous substances on the site. Action-specific ARARs do not typically determine the remedial alternative; however, the ARARs indicate how a selected alternative must be implemented or achieved.
- **Location-Specific ARARs** are restrictions on the concentrations of hazardous substances or the conduct of activities in special locations.

A preliminary set of potential ARARs and TBCs for the Site was presented in the RI/FS Work Plan (Roux, 2015a). Potential chemical-specific and location-specific ARARs were identified based on review of Site data. Potential action-specific ARARs and TBCs will be based on the remedial action alternatives to be developed in the FS. Currently, no TBCs are identified for the Site.

The identification of ARARs and TBCs will continue throughout the FS process as more information is developed. Further review and analysis will be conducted during the FS to expand or refine, as appropriate, the preliminary ARARs. Input from the USEPA and MDEQ will be utilized in the refinement process. Final determination of ARARs will be documented in the FS report and presented in a table detailing:

- The chemical / location / action subject to requirement;
- The requirement(s);
- The prerequisite (i.e., why the requirement is important); and
- The citation(s).

For the recommended remedy, a comment explaining how the requirement(s) would be met will also be provided.

In addition to the ARARs described below, the work described in this FS Work Plan will be completed in general accordance with the National Contingency Plan (40 Code of Federal Regulations (CFR) Part 300).

4.1.1 Chemical-Specific ARARs

Chemical-specific ARARs are typically health- or risk-based numerical values that represent a cleanup standard. The following chemical-specific ARARs may be used to evaluate data for the Site:

1. The Federal Safe Drinking Water Act (SDWA), 42 United States Code (USC) 300(g-1), 40 CFR 141.161. The SDWA sets Maximum Contaminant Level Goals (MCLGs) and MCLs for public drinking water supplies.
2. The Federal Clean Water Act (CWA), 33 U.S.C 1311-1387 establishes the water quality criteria for surface water. The water quality criteria are designed to protect aquatic life (marine and freshwater) and human health. These criteria are expressed on the basis of acute and chronic toxicity levels. The selected remedy must comply with these criteria.
3. The MDEQ Circular DEQ-7 (DEQ-7) contains numeric water quality standards for Montana's surface water and groundwater in accordance with the Administrative Rules of Montana (ARM) 17.30.620 through 17.30.670. The standards were developed in compliance with Section 75-5-301, Montana Code Annotated (MCA) of the Montana Water Quality Act, Section 80-15-201, MCA (Montana Agricultural Chemical Groundwater Protection Act), and Section 303(c) of the CWA.
4. ARM 17.30.1005 and 17.30.1006 provide that groundwater is classified I through IV based on its beneficial uses and set the standards for the different classes of groundwater. All beneficial uses of groundwater must be protected. In addition to the Circular DEQ-7 Numeric Water Quality Standards listed above, concentrations of other dissolved or suspended substances must not exceed levels that render the waters harmful, detrimental, or injurious to beneficial uses.
5. ARM 17.30.1011 provides that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality in accordance with MCA 75-5-303.
6. ARM 17.30.608 provides that the waters of the Flathead River and Cedar Creek are classified as B-1 for water use, and the waters of Cedar Creek Overflow Ditch are classified as D-1. The B-1 classification standards are contained in ARM 17.30.623 (applicable) of the Montana water quality regulations. The D-1 classification standards are contained in ARM 17.30.650 (applicable) of the Montana water quality regulations. This section provides the water quality standards that must be met and beneficial uses for the water use classifications, which must be protected. ARM 17.30.637 and 17.30.705 contain general prohibitions regarding state surface waters and provisions to prevent further degradation.
7. The National Ambient Air Quality Standards (40 CFR part 50) established by EPA under the Clean Air Act set primary and secondary standards for pollutants considered harmful to public health and the environment: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, fine particulate matter, and sulfur dioxide. Additional state air quality standards are documented in the Montana Ambient Air Quality Standards (MCA 17-8-201 et seq.). These standards are applicable during remedial action construction.

4.1.2 Action-Specific ARARs

Action-specific ARARs are technology- or activity-specific requirements or limitations. The action-specific ARARs will be used to screen remedial alternatives.

The following action-specific ARARs are applicable to the development of alternatives at Superfund sites. Additional ARARs will be generated as necessary during the FS process.

1. The Resource Conservation and Recovery Act (RCRA) Subtitle C regarding managing hazardous waste. Subtitle C contains regulations for generation, transportation, treatment, and storage and

disposal of hazardous wastes. RCRA Subtitle C also includes air emissions from hazardous waste treatment. Storage and disposal facilities are regulated under 40 CFR §261.

2. CWA 40 CFR 402, 405-471; 40 CFR 125; AAC Section 18-9-A901 establishes the National Pollutant Discharge Elimination System (NPDES) permit program. The NPDES permit program and state equivalent programs regulate discharges into "waters of the United States" by establishing numeric limits and monitoring requirements for such discharges.
3. Clean Air Act Section 111(b) describes emission guidelines for non-methane gasses generated from landfills (typically Municipal Solid Waste Landfills).
4. MPDES program (ARM 17.30.13), ARM 17.24.633, and ARM 17.30.6 contain provisions to control sediment and stormwater such that water quality in state surface water is protected.
5. MCA 75-5-605 and MCA 75-5-303 (including ARM 17.30.705 and ARM 17.30.1011) contain prohibited activities regarding state waters and provisions to prevent further degradation.
6. The SDWA Section 1422 describes the underground injection control (UIC) program for subsurface injection into groundwater. The UIC Program is responsible for regulating the construction, operation, permitting, and closure of injection wells that place fluids underground for storage or disposal, and therefore UIC Program regulations would be a potential ARAR for any such activities.
7. ARM 17.8.304, 17.8.308, 17.8.220, and 17.8.223 include requirements to address emission of particulate matter and dust control that must be complied with during remedial actions.
8. ARM 17.8.604 lists certain wastes that may not be disposed of by open burning.
9. Montana Solid Waste Management Act and regulations, MCA 75-10-201 et seq., ARM 17.50.101 et seq. Regulations promulgated under the Solid Waste Management Act, MCA 75-10-201 et seq., and pursuant to the federal Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act, 42 U.S.C. §§ 6901 et seq. (RCRA Subtitle D) specify requirements that apply to the to the transportation of solid wastes and the operation, closure, and post-closure care of solid waste facilities.
10. ARM 17.74.369 specifies requirements for the management, transportation, and disposal of asbestos.

4.1.3 Location-Specific ARARs

Potential location-specific ARARs address: cultural resources, wetlands protection, floodplain management, hydrological resources, biological resources, other natural resources, and geological characteristics.

The following location-specific ARARs are applicable to the development of alternatives at the Site. Additional ARARs will be generated as necessary during the FS process.

1. The Endangered Species Act (16 USC §§ 1531-1544; 50 CFR Part 200 and 50 CFR Part 402) protects critical habitats upon which endangered species or threatened species depend. These regulations require action to conserve endangered species or threatened species, including consultation with the Department of Interior and the Fish and Wildlife Service. Similar regulations exist for non-endangered species such as the Bald and Golden Eagle Protection Act (20 CFR Part 22) and the Migratory Bird Treaty Act (16 U.S.C. 703-712; 50 CFR Part 10).
2. The Fish and Wildlife Coordination Act, as amended (16 USC §§ 661-667e), prevents loss of and damage to wildlife resources. Amendments also expanded the instances in which diversions or modifications to water bodies would require consultation with the Fish and Wildlife Service.
3. National Historical Preservation Act of 1996, as amended (16 USC §§ 470-470x-6, 36 CFR pt. 800, 40 CFR§ 6.301[b]), the Archaeological and Historical Preservation Act (16 USC § 469-469c-1, 40 CFR § 6.301[c]), the Historic Sites Act, as amended (16 USC §§ 461-467), and the Antiquities Act of 1906 (54 USC §§ 320301-320303).
4. The American Indian Religious Freedom Act (42 USC §§ 1996) and the Native American Graves and Repatriation Act (25 USC §§ 3001-3013).

5. Floodplain Management 40 CFR 6.302(b) Executive Order 11988 requires that federal agencies proposing actions to be located in a floodplain must first evaluate the potential adverse effects those actions might have on the natural and beneficial values served by the floodplain.
6. Regulations promulgated under the Montana Natural Streambed and Land Preservation Act, MCA 75-7-101 et seq., specify requirements to protect the environmental life support system from degradation and provide adequate remedies to prevent unreasonable depletion and degradation of natural resources.
7. Protection of Wetlands 40 CFR 6.302(a) Executive Order 11900 directs federal agencies to avoid construction located in wetlands.
8. Montana Controlled Groundwater Areas pursuant to MCA 85-2-501 et seq. to designate a controlled groundwater area to prevent new appropriations or limit certain types of water appropriations due to water availability or water quality problems for the protection of existing water rights.
9. Regulations promulgated under the Solid Waste Management Act, MCA 75-10-201 et seq., specify requirements that apply to the location of any solid waste management facility.
10. The Floodplain and Floodway Management Act, MCA 76-5-101 et seq., and associated regulations specify requirements for activities in the floodplain or floodway.

4.1.4 ARAR Waivers

Section 121(d)(4) of CERCLA identifies six circumstances under which ARARs may be waived:

- The remedial action selected is only a part of a total remedial action (interim remedy) and the final remedy will attain the ARAR upon its completion.
- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options.
- Compliance with the ARAR is technically impracticable from an engineering perspective.
- An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach.
- The ARAR is a State requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.
- For §104 Superfund-financed remedial actions, compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

4.2 Remedial Action Objectives

RAOs are qualitative statements that describe what a remedial action is intended to accomplish at a Site. RAOs can be specific to certain COCs, environmental media, and the exposure pathways and receptors to be protected. RAOs can take into consideration both current and future land use, as well as groundwater and surface water beneficial use designations.

Based upon the results of the BHHRA and BERA, preliminary RAOs were identified in collaboration with USEPA and MDEQ and are presented below. Final determination of RAOs will be documented in the FS pending legal review by the USEPA and MDEQ. These RAOs are based upon reasonable anticipated future use of each exposure area as outlined in the BHHRA and BERA. The approach for developing and applying the PRGs referenced below is discussed in the next section.

Solid Media

- Prevent ingestion, direct contact, and inhalation of contaminated soils and sediments that would result in unacceptable risk [cancer risk of 1E-05 or a target hazard quotient (HQ) of 1 or greater] from PAHs[1] assuming reasonably anticipated future land uses.
  [1] Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene
- Reduce migration of arsenic, cyanide, and fluoride from contaminated soils and wastes that results in exceedances of Montana DEQ-7 standards in groundwater.
- Reduce migration of metals[2], cyanide, and PAHs[3] from contaminated soils, sediments, and wastes that results in exceedances of Montana DEQ-7 aquatic life criteria in surface water and porewater.
  [2] Aluminum, barium, cadmium, copper, iron, and zinc
  [3] Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, and indeno(1,2,3-C,D)pyrene
- Reduce ingestion of and direct contact with metals[4] and LMW/HMW PAHs from contaminated surficial and shallow soils that would result in LOEC- or LOAEL-based HQs greater than 1 for terrestrial and transitional ecological receptors.
  [4] Barium, copper, nickel, selenium, thallium, vanadium, and zinc
- Reduce ingestion of and direct contact with metals[5], cyanide, and LMW/HMW PAHs from contaminated surficial and shallow soils and sediments that would result in LOEC- or LOAEL-based HQs greater than 1 for aquatic and semi-aquatic ecological receptors.
  [5] Barium, cadmium, lead, nickel, selenium, vanadium, and zinc

Groundwater

- Reduce cyanide, fluoride, and arsenic concentrations in groundwater within the upper hydrogeologic unit to levels below Montana DEQ-7 standards, prevent further degradation of groundwater that exceeds Montana DEQ-7 standards (i.e., ensure no actions are taken that could increase concentrations of COCs within the contaminant plume), and prevent expansion of the contaminant plume into groundwater that meets Montana DEQ-7 standards.
- Prevent ingestion of or direct contact with groundwater contaminated with arsenic, cyanide, and fluoride in excess of Montana DEQ-7 standards.
- Reduce migration of cyanide in groundwater that results in exceedances of Montana DEQ-7 aquatic life criteria in surface water and porewater.

Surface Water

- Restore metals[6] and cyanide concentrations in River Area DU surface water to the aquatic life criteria identified in Montana DEQ-7 as applied to State of Montana B-1 class waters.
  [6] Aluminum, barium, copper, and iron

4.3 Preliminary Remediation Goals

PRGs are target concentrations to be used in the development, evaluation, and selection of remedial alternatives. Ideally, a remedy that achieves PRGs will both comply with ARARs and reduce risk to levels that satisfy the National Contingency Plan (NCP) requirements for protection of public health and the environment (USEPA, 1991a). Using the exposure assumptions from the BHHRA and BERA, PRGs were developed by EHS Support to be protective of the most sensitive receptor in a given exposure area based on the current and likely future use of that exposure area as documented in the technical memorandums for PRG Development (Appendices A and B) and summarized in Tables 4-1 through 4-4 below. In addition, chemical-specific ARARs are also identified as PRGs where appropriate (i.e., groundwater, surface water, and porewater).

4.3.1 Human Health PRGs

The soil and sediment PRGs for Human Health Risk Drivers (Human Health PRGs) are risk-based calculations that develop target levels using carcinogenic and non-carcinogenic toxicity values for specific exposure scenarios. Two sets of PRGs were calculated using different target incremental ELCR values of 1E-06 and 1E-05. As discussed in the BHHRA, cancer risks less than 1E-06 are generally considered *de minimis* and excess cancer risks that range between 1E-04 and 1E-06 are generally not considered large enough to warrant action under Superfund. Additionally, the MDEQ allowable cancer risk level is 1E-05. The target non-carcinogenic risk for each set of PRGs was based on an HQ of 1. In accordance with the guidance (USEPA, 1991a), the lower of the carcinogenic and non-carcinogenic risk-based PRGs will be used as the risk-based PRG for the chemicals.

Human Health PRGs were calculated for potentially complete exposure pathways for various receptors applicable to each exposure area requiring additional evaluation, including trespassers, stormwater management workers, industrial workers, landfill management workers, and construction workers. For each exposure area, the most conservative, applicable PRG was selected, , resulting in Human Health PRGs based on the construction worker scenario for benzo(a)pyrene and the industrial worker scenario for the remaining COCs in the Main Plant Area exposure area, the stormwater management worker scenario for the North Percolation Pond exposure area, and the landfill management worker scenario for the Central Landfills Area and Industrial Landfill Area exposure areas.

The methodology for calculating the Human Health PRGs is detailed in Appendix A. Tables 4-1 and 4-2 below summarize the results of these calculations.

Table 4-1 Human Health PRGs for Soil

Parameters	Main Plant Area		North Percolation Pond Area		Central Landfills Area		Industrial Landfill Area	
	1E-06	1E-05	1E-06	1E-05	1E-06	1E-05	1E-06	1E-05
Metals								
Arsenic	NA	NA	20	200	4.0	40	4.0	40
PAHs								
Benzo(a)anthracene	28	280	140	1,400	28	280	NA	NA
Benzo(a)pyrene	2.8	20	14	140	2.8	28	2.8	28
Benzo(b)fluoranthene	28	280	140	1,400	28	280	NA	NA
Dibenz(a,h)anthracene	2.8	28	14	140	2.8	28	2.8	28
Indeno(1,2,3-c,d)pyrene	28	280	140	1,400	28	280	NA	NA

All concentrations are in milligrams per kilogram (mg/kg)
Main Plant Area receptors: Construction Worker, Industrial Worker, and Trespasser.
North Percolation Pond receptors: Stormwater Management Worker and Trespasser.
Central Landfills Area receptors: Landfill Management Worker and Trespasser.
Industrial Landfill Area receptors: Landfill Management Worker and Trespasser.

Table 4-2 Human Health PRGs for Sediment

Parameters	North Percolation Pond Area	
	1E-06	1E-05
Metals		
Arsenic	20	200
PAHs		
Benzo(a)pyrene	14	140
Benzo(b)fluoranthene	140	1,400
Dibenz(a,h)anthracene	14	140
Indeno(1,2,3-c,d)pyrene	140	1,400

All concentrations are in milligrams per kilogram (mg/kg)
North Percolation Pond receptors: Stormwater Management Worker and Trespasser.

Maps depicting the relative concentrations of the above COCs in soil and sediment with respect to the Human Health PRGs are provided in Appendices C and D. These maps are thematic maps (i.e., color coded dot maps) that facilitate the identification of locations where the analyte was detected and where the analyte concentrations exceed the Human Health PRGs. In addition, a singular map consolidating the exceedances of any of the above Human Health PRGs is provided for soil samples as well as for sediment samples as the first figure in Appendix C and Appendix D, respectively.

The promulgated MDEQ Circular DEQ-7, Montana Numeric Water Quality Standards (June 2019) for COCs in the upper hydrogeologic unit are provided in Table 4-3 below for use as the groundwater Human Health PRGs. As described in the RI Report and Section 2.4.3, Site-related groundwater impacts appear limited to groundwater within the upper hydrogeologic unit; COCs observed in the BUU are therefore not retained for further evaluation in the FS.

Table 4-3 Human Health PRGs for Groundwater

COC	DEQ-7 Groundwater Human Health Standards
Metals	
Arsenic	10
Other Inorganics	
Cyanide, total	200
Cyanide, free	200
Fluoride	4,000

All concentrations are in micrograms per liter (µg/L)

Maps depicting the arsenic, cyanide (total), and fluoride plume areas exceeding DEQ-7 standards within the upper hydrogeologic unit are provided in Appendix E. For each, the plume extent is identified as the area where monitoring wells had detected concentrations greater than the DEQ-7 standards in any of the six sampling rounds throughout the RI. As presented in these figures, the extent of the arsenic and fluoride plumes are generally confined within the boundary of the cyanide plume extent.

4.3.2 Ecological PRGs

The soil and sediment PRGs for Ecological Risk Drivers (Ecological PRGs) are risk-based calculations based on low-effect endpoints. Low-effect endpoints represent the LOEC for direct contact exposure pathways or the LOAELs for ingestion exposure pathways as identified in literature studies. Identification of LOECs and LOAELs are further detailed in the BERA (EHS Support, 2019e).

Candidate soil and sediment PRGs developed for the potential receptors identified in the BERA consisted of Direct Contact PRGs, Wildlife PRGs (LOAEL-based), and BTVs. BTVs were calculated as part of the Phase II SC, and the documentation for these analyses are further detailed in Appendix UU of the Phase II SC Data Summary Report (Roux, 2019). For each COC, the lowest risk-based PRG (i.e., Direct Contact or Wildlife) was selected as the final Ecological PRG for soil and sediment, unless that value was below the BTV, in which case the BTV was selected as the Ecological PRG.

As described in the BERA WP (EHS Support, 2018b), soil and sediment in the four transitional areas (i.e., the North Percolation Pond Area, South Percolation Pond Area, Cedar Creek Overflow Ditch, and Northern Surface Water Feature) were combined and evaluated as both soil and sediment in order to be protective of ecological receptors that may utilize the areas during dry and wet conditions, respectively. For the soil evaluation in these areas, the surficial and shallow soil samples (0-0.5 and 0.5-2 ft-bls, respectively) and sediment samples were combined to form the soil dataset used to evaluate terrestrial exposure scenarios. For the sediment evaluation in these areas, surficial soil samples (0-0.5 ft-bls) and sediment samples were combined to form the sediment dataset used to evaluate aquatic or semi-aquatic exposure scenarios that may occur when the areas are inundated.

The detailed methodology for development of the Ecological PRGs is detailed in Appendix B. Tables 4-4 through 4-6 below summarize the derived Ecological PRGs.

Table 4-4 Ecological PRGs for Soil

Parameters	Soil PRGs – All Exposure Areas		Applicable Exposure Areas					
	PRG	Basis	Main Plant Area	North Percolation Pond Area	Central Landfills Area	Industrial Landfill Area	ISM Grid Area	South Percolation Ponds
Metals								
Barium	1,000	Terrestrial plants		X				X
Copper	490	Terrestrial plants			X		X	
Nickel	140	Short-tailed shrew		X	X	X		

Selenium	3.4	Terrestrial plants		X			X	
Thallium	0.5	Terrestrial plants		X				
Vanadium	80	Terrestrial plants		X		X		
Zinc	810	Terrestrial plants					X	
PAHs								
LMW PAHs	175	Soil Invertebrates	X	X	X		X	
HMW PAHs	69	American Woodcock	X	X	X	X	X	
PCBs								
Aroclor 1254*	1.2	Short-tailed shrew			X			

All concentrations are in milligrams per kilogram (mg/kg)
* Aroclor 1254 will not be carried forward through the technology screening process; see discussion below.

Table 4-5 Ecological PRGs for Sediment

Parameters	Sediment PRGs – All Exposure Areas		Applicable Exposure Areas		
	PRG	Basis	North Percolation Pond Area	Flathead River Riparian Area Channel	South Percolation Ponds
Metals					
Barium	300	BTV	X	X	X
Cadmium	4.9	Benthic invertebrates	X		
Lead	120	Benthic invertebrates	X		
Nickel	48	Benthic invertebrates	X		
Selenium	1.38	BTV	X		
Vanadium	38	American Dipper	X		
Zinc	450	Benthic invertebrates	X		
PAHs					
LMW PAHs	196	American Dipper	X		
HMW PAHs	28.2	American Dipper	X		

All concentrations are in milligrams per kilogram (mg/kg)

As discussed in the technical memorandum for PRG Development for Ecological Risk Drivers (Appendix B), a PRG was not developed for cyanide in sediment, which was identified in the BERA as a COC in sediment in both its total and dissolved (free) fractions, because cyanide does not persist in the sediment matrix. Instead, the potential risk attributed to cyanide in sediment will be mitigated by addressing groundwater inputs to benthic habitats and demonstrating reductions overtime to porewater concentrations in those areas.

In addition, the PRG developed for Aroclor 1254 is greater than the maximum concentration measured in the Central Landfills Area that was identified as a COPEC based on the BERA exposure model as the result of a recommended adjustment to the parameters and assumptions used in the wildlife ingestion models. This adjustment is detailed in the technical memorandum for PRG Development for Ecological Risk Drivers (Appendix B). Therefore, Aroclor 1254 will not be carried forward through the technology screening process.

Thematic maps depicting the relative concentrations of the above COCs in soil and sediment with respect to the Ecological PRGs are provided in Appendices F and G. In addition, a singular map consolidating the exceedances of any of the above Ecological PRGs is provided for soil samples as well as for sediment samples as the first figure in Appendix F and Appendix G, respectively.

The promulgated MDEQ Circular DEQ-7, Montana Numeric Water Quality Standards (June 2019) are provided for use as the surface water Ecological PRGs in Table 4-6 below. For COCs without available DEQ-7 Aquatic Life Standards, the development of acute and chronic criteria is documented in Appendix B.

Table 4-6 Ecological PRGs for Surface Water

COC	DEQ-7 Chronic Aquatic Life Standards (or alternate if not available)	DEQ-7 Acute Aquatic Life Standards (or alternate if not available)	Applicable Exposure Areas			
			North Percolation Pond	South Percolation Pond	Flathead River – Backwater Seep Sampling Area	Flathead River Riparian Area Channel
Metals[1]						
Aluminum	87	750	X	X	X	X
Barium[2]	220	2,000	X	X		X
Cadmium*	0.45	0.96	X			
Copper*	5.16	7.29	X			
Copper*	15.27	24.10		X		
Iron	1,000	NA		X		
Zinc*	66.6	66.6	X			
Other Inorganics						
Cyanide, total	5.2	22		X	X	X
Cyanide, free	5.2	22		X	X	X
Fluoride	NA	NA	X			

PAHs[3]						
Benzo(a)anthracene	2.23	9.25	X			
Benzo(a)pyrene	0.96	3.98	X			
Benzo(b)fluoranthene	0.68	2.81	X			
Benzo(g,h,i)perylene	0.44	1.82	X			
Chrysene	2.04	8.49	X			
Fluoranthene	7.11	29.5	X			
Indeno(1,2,3-c,d)pyrene	0.28	1.14	X			

All concentrations are in micrograms per liter (µg/L)

1 Except aluminum, standards for metals in surface water are based upon the analysis of samples following a "total recoverable" digestion procedure.

2 DEQ-7 Aquatic Life Standards are not available for barium; chronic and acute criterion for barium derived by the Ohio Environmental Protection Agency, as discussed in Appendix B.

3 Listed as Multiple PAH Compounds in previous tables. DEQ-7 Aquatic Life Standards are not available for these PAHs; final chronic values and final acute values for these PAHs provided by USEPA, as discussed in Appendix B.

NA – No DEQ-7 Aquatic Life Standards provided.

* The DEQ-7 Aquatic Life Standards for these metals are hardness-specific; values representative of Site-specific data as listed in the above table will be used as PRGs. Hardness ranges and respective calculated standards are provided in Table 4-7 and discussed below.

The DEQ-7 Aquatic Life Standards for cadmium, copper, and zinc are dependent on hardness. In the North Percolation Ponds, two surface water samples were collected with hardness as calcium carbonate ranging from 50,000 to 224,000 µg/L. This hardness range results in the following range of standards for each respective COC:

- DEQ-7 Chronic Aquatic Life Standards for cadmium ranging from 0.45 to 1.50;
- DEQ-7 Acute Aquatic Life Standards for cadmium ranging from 0.96 to 4.18;
- DEQ-7 Chronic Aquatic Life Standards for copper ranging from 5.16 to 18.58;
- DEQ-7 Acute Aquatic Life Standards for copper ranging from 7.29 to 29.93; and
- DEQ-7 Chronic and Acute Aquatic Life Standards for zinc ranging from 66.6 to 237.3.

In Table 4-6 above, the minimum calculated standard was used for cadmium, copper, and zinc in the North Percolation Ponds.

In the South Percolation Ponds, 26 surface water samples were collected with hardness as calcium carbonate ranging from 144,000 to 1,740,000 µg/L, with first, second, and third quartiles of 160,000, 178,000, and 214,000, respectively. This hardness range results in the following range of standards for each respective COC:

- DEQ-7 Chronic Aquatic Life Standards for copper ranging from 12.74 to 30.50, with first, second, and third quartiles of 13.94, 15.27, and 17.87, respectively; and
- DEQ-7 Acute Aquatic Life Standards for copper ranging from 19.74 to 51.68, with first, second, and third quartiles of 21.80, 24.10, and 28.67, respectively.

In Table 4-6 above, the median calculated standard was used for copper in the South Percolation Ponds. Given the distribution (e.g., interquartile range) of the data, the median is representative of the hardness concentrations typically observed in the South Percolation Ponds exposure area and is robust against the few high concentrations that are potential statistical outliers.

Thematic maps depicting the relative concentrations of the above COCs in surface water are provided in Appendix H.

The DEQ-7 Aquatic Life Standards for surface water are provided for use as the porewater Ecological PRGs in Table 4-8 below.

Table 4-8 Ecological PRGs for Porewater

COC	DEQ-7 Chronic Aquatic Life Standards (or alternate if not available)	DEQ-7 Acute Aquatic Life Standards (or alternate if not available)	Applicable Exposure Areas		
			South Percolation Ponds	Flathead River – Backwater Seep Sampling Area	Flathead River Riparian Area Channel
Metals[1]					
Barium[2]	220	2,000	X		X
Other Inorganics					
Cyanide, free	5.2	22		X	X

All concentrations are in micrograms per liter (µg/L)

1 Except aluminum, standards for metals in surface water are based upon the analysis of samples following a "total recoverable" digestion procedure.

2 DEQ-7 Aquatic Life Standards are not available for barium; chronic and acute criterion for barium derived by the Ohio Environmental Protection Agency, as discussed in Appendix B.

Thematic maps depicting the relative concentrations of the above COCs in porewater are provided in Appendix I.

4.3.3 PRG Application

For the application of human health PRGs, consideration of potential receptors and exposure scenarios will be based on current and planned future use (e.g., industrial, commercial, residential) and activities (e.g., intermittent inspections versus full time commercial/industrial work) within human health exposure areas. For the application of ecological PRGs, consideration of potential receptor groups will be based on the availability of ecological habitats under current and planned future land use. The application of ecological PRGs within exposure areas will also consider the size of the home (foraging) range of the most sensitive wildlife receptor used as the basis for an ecological PRG, including small range receptors. Ecological PRGs for small home range receptors will be applied on a point-by-point basis to understand the frequency and distribution of exceedances to evaluate the need for remedial action. Thematic maps displaying COC concentrations exceeding human health and ecological PRGs are provided in Appendices C through I and will support the development of the remedial approach.

As discussed in the technical memorandums for PRG Development (Appendices A and B), the calculated, Site-specific, risk-based PRGs should not be regarded as not-to-exceed values. Rather, based on the conservative assumptions and endpoints used in calculations, the calculated, Site-specific PRGs represent a conservative estimate of the average concentration that receptors could be exposed to that would be expected to result in minimal risk. Attainment of human health and ecological PRGs will generally be based on achieving EPCs calculated as the 95 percent upper confidence limit of the mean concentration (95UCL) that are equal to or less than human health or ecological PRGs within the respective exposure areas. This scenario may result (and often does) in constituents remaining in place within some limited areas at concentrations that exceed the calculated PRG. However, ARARs-based standards would be considered "not-to-exceed" PRG values, excluding statutorily allowable exceedances. In addition, PRGs based on BTVs and PRGs for small home range receptors will be applied on a point-by-point basis to understand the frequency and distribution of exceedances to evaluate the need for remedial action and will not be compared to 95UCL EPCs.

As will be described in Section 5.4, remedial action limits (RALs) will be developed based on PRGs that are protective of representative human health and ecological receptors using statistical approaches in accordance with EPA's draft Guidance on Surface Soil Cleanup at Hazardous Waste Sites: Implementing Cleanup Levels dated May 2004.

4.4 Areas and Volumes of Impacted Media

The estimated areas and volumes of impacted media for each DU are tabulated below, focusing on locations contributing to risk and/or areas of known disposed wastes.

Soil DU

For the Soil DU, exceedances of Human Health PRGs and/or Ecological PRGs are observed in both surficial and shallow soil (0-0.5 and 0.5-2 ft-bls, respectively) in the southern portion of the Central Landfills Area encompassed within the ISM Grid Area (i.e., Operational Area) and the northern portion of the Main Plant Area.

The estimated areas for surficial and shallow soil were determined by grouping the samples that exceed the PRGs and creating an area with buffer between the closest samples that are below the PRGs. The buffer is the lesser of 20 feet from the sample location or halfway between the closest samples that are below the PRGs. Since the risk-based soil PRGs are a conservative estimate of the average concentration that receptors could be exposed to that would be expected to result in minimal risk, and should not be regarded as not-to-exceed values as discussed in Section 4.3.3 and the technical memorandums for PRG Development (Appendices A and B), it is expected that the estimated area and volume for the Soil DU are sufficiently conservative and represent the upper bound of what is expected to be assessed for remediation in the FS while recognizing that additional refinement may be performed during the remedial design phase.

Exceedances of PRGs in surficial soil are more numerous and occupy a larger area than those in shallow soil. The footprint of impacted shallow soil generally falls within the extent of the surficial soil impacts. In surficial soil, the reasonable upper estimate for the area of soil exceeding Human Health PRGs and/or Ecological PRGs is approximately 18 acres. At a thickness of 0.5 feet (0-0.5 ft-bls), this equates to a reasonable upper estimate on volume of approximately 14,500 cubic yards (CY). In shallow soil, the reasonable upper estimate for the area of soil exceeding Human Health PRGs and/or Ecological PRGs is approximately 9 acres. At a thickness of 1.5 feet (0.5-2 ft-bls), this equates to a reasonable upper estimate on volume of approximately 22,000 CY.

The Former Drum Storage Area, which is 1.1 acres adjacent to the West Landfill and the Wet Scrubber Sludge Pond, did not exceed any PRGs except for the Human Health PRG for arsenic calculated using the target incremental ELCR value of 1E-06. However, the top 2 feet of the area have elevated concentrations of cyanide that are adjacent to the plume, and as such will be further evaluated for remedial action.

Landfills DU1

The approximate areas and estimated depths for each of the waste management units within Landfills DU1 are shown below. The respective volumes for the estimated depths are calculated accordingly and presented in CY.

Table 4-14 Estimated Areas and Volumes for Waste Management Units in Landfills DU1

Waste Management Unit	Area (acres)	Depth of Waste (*estimated*, ft)	Volume of Waste (estimated, CY)
Center Landfill	1.8	Approximately 15	Approximately 44,000
West Landfill	7.8	Approximately 30 to 48	Approximately 378,000 to 604,000
Wet Scrubber Sludge Pond	10.8	Approximately 30; Top of feature is 15 ft above grade	Approximately 522,000

Landfills DU2

The approximate areas and estimated depths for each of the waste management units within the Landfills DU are shown below.

Table 4-15 Estimated Areas and Depths for Waste Management Units in Landfills DU2

Waste Management Unit	Area (acres)	Depth of Waste (*estimated*, ft)
Asbestos Landfills	3.4	Approximately 5
East Landfill	2.4	Approximately 30
Industrial Landfill	12.4	Approximately 10 to 20
Sanitary Landfill	3.8	Unknown

North Percolation Pond DU

The approximate areas and depths of impacted material for each of the pond structures within the North Percolation Pond DU are shown below. Reasonable lower and upper estimates of the average depth of the surficial layer of highly viscous to solid black carbonaceous material that exists across the majority of the North-East Percolation Pond, and intermittently across the ditches and North-West Percolation Pond. Based upon soil borings, the maximum thickness of this carbonaceous material ranges from 0.5 to 2 feet. It is estimated that on average 6 to 12 inches of soil beneath this carbonaceous material is impacted at levels that contribute to potential human health and ecological risk. The respective volumes for the estimated range of depths are calculated accordingly and presented in CY.

Table 4-16 Estimated Areas and Range of Volumes for North Percolation Pond Structures

Pond Structure	Area (acres)	Reasonable Lower Estimate		Reasonable Upper Estimate	
		Avg Depth (ft-bls)	Volume (CY)	Avg Depth (ft-bls)	Volume (CY)
North-East Percolation Pond	2.0	1.5	4,850	4	12,900
North-West Percolation Pond	8.0[1]	0.5	4,850	2	19,400
Influent Ditch	0.2	0.5	160	3	960
Overflow Ditch	0.2	0.5	160	3	960

[1] To calculate the estimated volume for the North-West Percolation Pond, an area of 6.0 acres was used to reflect the observed intermittent nature of the carbonaceous material.

River Area DU

The approximate areas and depths for each of the structures within the River Area DU are shown below. A reasonable lower estimate and a reasonable upper estimate of the average depth of each structure are provided based on the information available. The respective volumes for the estimated range of depths are calculated accordingly and presented in CY.

Table 4-17 Estimated Areas and Range of Volumes for River Area DU Structures

Structure	Area (acres)	Reasonable Lower Estimate		Reasonable Upper Estimate	
		Avg Depth (ft-bls)	Volume (CY)	Avg Depth (ft-bls)	Volume (CY)
South Percolation Ponds	10.2	0.5	8,200	2	33,000
Backwater Seep Sampling Area	No exceedances of sediment/soil PRGs in this area				
Riparian Area Channel	No exceedances of sediment/soil PRGs in this area				

Groundwater DU

The approximate area of the plume area (upper hydrogeologic unit) exceeding MCLs/DEQ-7 standards is 300 acres. The saturated thickness of the upper hydrogeologic unit varies across the Site depending upon the depth to underlying glacial till and the proximity to Teakettle Mountain. Saturated thickness was observed to be less near Teakettle Mountain when compared to areas beneath the Central Landfills Area and to the west of this area. Water level elevation data indicated that groundwater elevations fluctuate seasonally at varying magnitudes depending on the area of the Site; as such, the saturated thickness fluctuates seasonally. During high-water season, the saturated thickness of the upper hydrogeologic unit varies from approximately 19 feet to 92 feet. During low-water season, the saturated thickness of the upper hydrogeologic unit varies from approximately 1 foot to 77 feet.

As discussed in the RI Report, concentrations of cyanide and fluoride in upper hydrogeologic unit groundwater decrease with increasing depth. Therefore, it appears the upper portion of the upper hydrogeologic unit is conveying the majority of the contaminant mass.

5. FS Scope of Work

This section describes the scope of work for the remainder of the FS process. An FS Report will be prepared to document the entire FS process, in accordance with the NCP (40 CFR 300) as well as consistent with the most recent USEPA guidance. In addition to an introduction and Site background information, the FS report will generally include the information described in subsections 5.2 through 5.6 below.

To adhere to the schedule set forth in the Administrative Settlement Agreement and Order on Consent, the draft FS report will be submitted to the USEPA and MDEQ on or before October 12, 2020. As detailed in the RI/FS Work Plan (Roux, 2015a), the project team responsible for the execution of this work is depicted in the organization chart provided in Figure 6.

5.1 Screening of Remedial Technologies

A Technology Screening Memo will be prepared to identify and screen general response actions (GRAs), remedial technologies, and process options that are potentially capable of achieving the RAOs identified in Section 4. GRAs are initial broad response actions, such as "removal" or "containment," considered during technology screening to address the RAOs for the contaminated media identified at the Site. Candidate technologies to implement these actions are then subsequently identified. The Technology Screening Memo will also assemble a range of remedial action alternatives to be evaluated for each DU.

A broad range of technologies and process options will be identified for the technology screening, with an emphasis on treatment technologies that are technically implementable, effective in mitigating potential risks posed by materials remaining at the Site, and capable of achieving the RAOs. Additionally, the availability of onsite or nearby borrow sources will be evaluated in support of remedial cap/cover alternatives. At the request of the USEPA and MDEQ, the Technology Screening Memo will also evaluate an alternative that includes excavation of the waste materials in Landfills DU1 and placement within a newly constructed onsite repository. The need for treatment of these excavated wastes prior to disposal will also be assessed as part of this alternative.

Factors to be considered in the evaluation include the state of technology development, Site conditions, characteristics and distribution of impacted media, and specific COCs that could limit the effectiveness or implementability of a technology. These technologies will be screened against the CERCLA evaluation criteria of effectiveness, implementability, and cost.

The retained technologies and process options will be assembled into remedial alternatives. Alternatives may be targeted for an individual DU, or a combined alternative for multiple DUs may be appropriate. For example, an alternative may address both the Landfills DU1 and the Groundwater DU by implementing a containment response action for the West Landfill, the Wet Scrubber Sludge Pond, and the Center Landfill which are sources of cyanide and fluoride in groundwater. The assembled remedial alternatives will be briefly described within the Technology Screening Memo to provide opportunity for USEPA/MDEQ review and concurrence of the remedial alternatives prior to detailed development and evaluation in the FS.

5.2 Finalization of ARARs and RAOs

This FSWP identified preliminary ARARs and RAOs for the Site. Further review and analysis will be conducted during the FS to expand or refine, as appropriate, the preliminary ARARs and RAOs. Input from the USEPA and MDEQ will be utilized in the refinement process. Final determination of ARARs and RAOs will be documented in the FS report.

5.3 Identification of Areas of Concern

Remedial action levels (RALs) will be developed to identify the Areas of Concern (AOCs) for further evaluation within the Soil DU and the River Area DU in accordance with EPA's draft Guidance on Surface Soil Cleanup at Hazardous Waste Sites: Implementing Cleanup Levels dated May 2004 (EPA 2004a). As defined in the draft guidance, the RAL is the maximum concentration that may be left in place within an exposure area such that the 95UCL within the exposure area is at or below the cleanup level (i.e., the PRG for the exposure area). The RAL will be determined iteratively for each exposure area by removing and replacing the highest concentrations in the dataset until the 95UCL is equal to or less than the PRG. The replacement concentrations will be assumed to be at background levels. Upon determination of the RALs for each exposure area, the extents for AOCs will be plotted by grouping the samples that exceed the RALs and the lesser of 20 feet from the sample location or halfway between the closest samples that are below the RALs.

RALs will be first calculated for the primary risk driver for each DU. Using the Soil DU as an example, PAHs are the primary risk driver and, as such, RALs for PAHs will be calculated first. After removing the samples with PAH concentrations exceeding the RALs, the 95UCL concentrations will be re-calculated for the other COCs for the exposure areas within the Soil DU. If residual concentrations are below PRGs for the other COCs, remedial actions addressing PAHs in the Soil DU will also result in acceptable risks from the other COCs and no further evaluation is necessary. Otherwise, additional evaluation would be required and a similar exercise calculating RALs and identifying AOCs for one or more other COCs will be conducted.

Ecological PRGs for small home range receptors and BTV-based PRGs will be applied on a point-by-point basis to understand the frequency and distribution of exceedances. These points will be overlaid with the identified AOCs exceeding RALs to evaluate if any additional AOCs should be included in the remedial action. The extent or volume of contaminated materials will be determined after AOCs are established. These AOCs, in addition to the Landfills DU1, Landfills DU2, the North Percolation Pond DU, and the Groundwater DU, will be the focus of the FS.

5.4 Development of Remedial Alternatives

The next step of the FS process will be detailed development and evaluation of the remedial alternatives assembled in the Technology Screening Memo. Alternatives will be sufficiently defined such that differences between alternatives can be identified. Using different RALs and types of remedial technologies, the remedial alternatives developed will range in the spatial extent of active remediation (i.e., reduction of toxicity, mobility, or volume of impacted materials), time frames to achieve cleanup objectives, and costs. These ranges of characteristics will allow a comparison of the remedial alternatives in the FS. All alternatives will be assessed with common elements such as ICs and ECs.

A remedial action alternative may be comprised of either an individual technology or remedial approach, or a combination of multiple technologies or remedial approaches. For example, alternatives for remediating soil contamination will depend on the type and distribution of contaminants and may include removal of soil from some portions of the site and capping of others. To avoid considering all possible combinations of technologies, only those combinations that could be effective in terms of meeting the RAOs will be considered in addition to the CERCLA-required No Action alternative.

The detailed development of remedial action alternatives will depend on multiple factors such as:

- Nature and extent of COCs – Some technologies (or remedial approaches) may be effective for select COCs but not for others. If multiple COCs are identified, then more than one type of remedial technology (or approach) may be required.
- Targeted media – The technologies (or remedial approaches) to control migration of COCs may vary depending whether the COCs are observed in soil, sediment, or groundwater.
- Performance and regulatory standards – Depending on the COCs, one or multiple technologies (or remedial approaches) may be required spatially and/or temporally to meet the performance and regulatory standards (e.g., ARARs, RAOs, PRGs).

Site and COC characteristics affect areas and depths of installation, material volumes, methods and sequence of construction, flow and reaction rates, sampling and analysis, effort to optimize, energy use, waste management, and other relevant issues that require consideration for a detailed evaluation of alternatives.

5.5 Detailed Evaluation of Remedial Alternatives

A detailed evaluation of each remedial alternative retained for each DU will be presented in the FS report. The detailed evaluations shall apply the first seven of the nine evaluation criteria described in the NCP (40 CFR 300) to the assembled remedial alternatives. The nine evaluation criteria include: (1) overall protection of human health and the environment; (2) compliance with ARARs; (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility, or volume; (5) short-term effectiveness; (6) implementability; (7) cost; (8) state (or support agency) acceptance; and (9) community acceptance. The last two evaluation criteria will be evaluated after the FS, during execution of the Record of Decision (ROD) as discussed further in Section 5.6.

At this stage, preliminary cost estimates will be provided for each retained remedial alternative with the intention of achieving the CERCLA FS cost-estimating goal for accuracy of -30 to +50 percent. Costs, including capital costs, O&M costs, and the present value of these costs, will be calculated in accordance with the USEPA RI/FS Guidance. The preliminary cost estimate provides a basis for evaluating the cost criterion for each retained remedial alternative.

5.6 Comparative Analysis of Remedial Alternatives

The purpose of the comparative analysis is to identify the relative advantages and disadvantages of each remedial alternative relative to one another, focusing on the relative performance of each alternative against the first seven evaluation criteria set forth by the NCP (40 CFR 300) and listed above in Section 5.5. The resulting strengths and weaknesses of each alternative will then be weighed to identify the alternative providing the best balance among the criteria.

The relative performance of each alternative will be evaluated with respect to each of the CERCLA evaluation criteria using the scoring system presented in Table 5-1 below. The scores have no independent value; they are only meaningful when compared among the different alternatives.

Table 5-1 Evaluation Criteria Rating System

Evaluation Criteria		Condition	Value
1	Overall protection of human health and the environment	Is fully protective	Yes
		Is not protective	No
2	Compliance with ARARs	Complies with all ARARs	Yes
		Does not comply with all ARARs	No
3	Long-term effectiveness and permanence	Effective and permanent	5
		Effectiveness may diminish over time	3
		Not effective over the long-term	0
4	Reduction of toxicity, mobility, or volume	Eliminates toxicity, mobility, volume	5
		Reduces toxicity, mobility, volume	3
		No reduction or treatment	0
5	Short-term effectiveness	Low risk and/or high protection	5
		Limited risk and/or limited protection	3
		High risk and/or low protection	0
6	Implementability	High technical, administrative, and logistical feasibility	5
		Limited technical, administrative, or logistical feasibility	3
		Technically unproven, permitting uncertain, or resources unavailable	0
7	Cost	Actual predicted present value will be normalized to a 0 to 5 scale, with the Highest Cost Alternative earning a 0, and the no action alternative earning a 5.	0 to 5

As shown, the rating for threshold criteria (Criteria 1 and 2) can be one of two values; the criterion is either fully met or not met. Therefore, no numerical values are assigned to the threshold criteria. For balancing criteria (Criteria 3 through 7), the rating can range from zero to five; a five is scored if the criterion factors are fully met, and a zero is scored if the criterion factors are not met. The numerical comparative analysis focuses on the balancing criteria. Determination of scoring values for each alternative is based on comparisons between the alternatives.

Based on the comparative analysis, the FS report will identify a recommended remedial alternative for each DU that will achieve the RAOs and provide the best balance of the above evaluation criteria. A preferred remedy will be identified at the conclusion of the FS report. Based on the FS, USEPA will issue a proposed remedial action plan for formal public comment. Based on the public comments, the ROD will evaluate the modifying criteria CERCLA criteria: (8) state (or support agency) acceptance; and (9) community acceptance. Final selection of the remedy will be made by USEPA and the selected remedy will be identified in the ROD.

Respectfully submitted,

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TABLES

Italics denote table is embedded within report text

Notes Utilized Throughout Tables, Figures, and Appendices

BERA	Baseline Ecological Risk Assessment
BHHRA	Baseline Human Health Risk Assessment
BSSA	Backwater Seep Sampling Area
CFAC	Columbia Falls Aluminum Company, LLC
CFMW	Columbia Falls Monitoring Well
CFSB	Columbia Falls Soil Boring
CFSDP	Columbia Falls Sediment Point
CFSWP	Columbia Falls Surface Water Point
CN	Cyanide
COC	Contaminant of Concern
DEQ-7	Montana Department Of Environmental Quality - DEQ Circular 7
DU	Decision Unit
EA	Exposure Area (see below for list of EAs)
ECO	Ecological
Ecological PRG	PRG for Ecological Risk Drivers
ELCR	Excess Lifetime Cancer Risk
EPC	Exposure Point Concentration
F	Fluoride
FS	Feasibility Study
FT	Feet
HH	Human Health
HI	Hazard Index
HMW	High Molecular Weight
Human Health PRG	PRG for Human Health Risk Drivers
ISM	Incremental Sampling Methodology
ISS	Incremental Soil Sampling
J	Estimated Value
J-	Estimated Low Bias
J+	Estimated High Bias
LMW	Low Molecular Weight
MDEQ	Montana Department Of Environmental Quality
mg/kg	Milligrams Per Kilogram

Notes Utilized Throughout Tables, Figures, and Appendices

ND	Non Detect
NS	Not Sampled
P1	Phase I Site Characterization
P2	Phase II Site Characterization
PAH	Polycyclic Aromatic Hydrocarbon
PRG	Preliminary Remediation Goal
R1	Round 1
R2	Round 2
R3	Round 3
R4	Round 4
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
SL	Screening Level
SSPA	Supplemental South Pond Assessment
SW	Surface Water
T	Total
TBD	To Be Determined
TR	Target Risk
U	Indicates That Analyte Was Not Detected At The Limit Reported
UCL	Upper Confidence Limit
µg/L (ug/l)	Micrograms Per Liter
USEPA	United States Environmental Protection Agency

Notes Utilized Throughout Tables, Figures, and Appendices

Human Health Exposure Areas	
EA 1	Main Plant Area
EA 2	North Percolation Pond Area
EA 3	Central Landfills Area
EA 4	Industrial Landfill Area
EA 5	Eastern Undeveloped Area
EA 6	North-Central Undeveloped Area
EA 7	Western Undeveloped Area
EA 8	South Percolation Pond Area
EA 9	Flathead River Area
EA 9A	Backwater Seep Sampling Area
Ecological Exposure Areas	
EA 1	Main Plant Area
EA 2	North Percolation Pond Area
EA 3	Central Landfills Area
EA 4	Industrial Landfill Area
EA 5	Eastern Undeveloped Area
EA 6	North-Central Undeveloped Area
EA 7	Western Undeveloped Area
EA 8	Flathead River Riparian Area
EA 9	Flathead River Area
EA 10	Cedar Creek
EA 11	Cedar Creek Reservoir Overflow Ditch
EA 12	South Percolation Ponds
EA 13	Northern Surface Water Feature

Notes Utilized Throughout Tables, Figures, and Appendices

General Notes - Tables

--	In Tables 4-9 through 4-13, sample results not exceeding a PRG are indicated as "--".

General Notes - Appendices

Transitional Areas

The North Percolation Pond Area, South Percolation Ponds, Cedar Creek Reservoir Overflow Ditch, and Northern Surface Water Feature exposure areas are transitional areas that were evaluated as both soil and sediment in order to be protective of ecological receptors that may utilize the areas during dry and wet conditions, respectively.

Appendix F	**Ecological PRG Comparisons in Soil** Surficial and shallow soil samples (0-0.5 and 0.5-2 ft-bls, respectively) and sediment samples were combined to form the soil dataset used to evaluate terrestrial exposure scenarios.
Appendix G	**Ecological PRG Comparisons in Sediment** Surface soil samples (0-0.5 ft-bls) and sediment samples were combined to form the sediment dataset used to evaluate aquatic or semi-aquatic exposure scenarios that may occur when the areas are inundated.

Sampling Rounds

Groundwater, sediment, surface water, and porewater sample locations were often sampled in various sampling rounds.

Appendix E	**Human Health PRG Comparisons in Groundwater** The maximum concentration of all sampling rounds was used for each monitoring well to determine the approximate extent of detected concentrations greater than DEQ-7 Groundwater Human Health Standards.
Appendices G, H, and I	**Ecological PRG Comparisons in Sediment, Surface Water, and Porewater** The maximum concentration of all sampling rounds was used for each sample location.

Exposure Areas

Select site features within the River Area DU were assessed as additional ecological exposure areas, as discussed in Section 2.3.3 and in the BERA (EHS Support, 2019e).

Appendices H and I	**Ecological PRG Comparisons in Surface Water and Porewater** Ecological exposure areas EA8 (Flathead Riparian Area) and EA9 (Flathead River Area) were determined to be exposure areas that do not pose risks due to Site-related contamination. However, the Flathead Riparian Area Channel and the Backwater Seep Sampling Area (BSSA) were determined to be exposure areas that pose risks due to Site-related contamination. As such, in these appendices, EA8 refers to the Flathead Riparian Area Channel, only, and EA9 refers to the BSSA, only.

Table 4-7a. Site-Specific Data Supporting Ecological Surface Water PRGs for Hardness Dependent Metals in EA2
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Sample Location	Sample Date	Sampling Round	Sample Fraction	Unit	Hardness as Calcium Carbonate	MDEQ-7 Chronic Aquatic Life Standards			MDEQ-7 Acute Aquatic Life Standards		
						Cadmium	Copper	Zinc	Cadmium	Copper	Zinc
CFSWP-023	04/03/2017	P1 R3	T	µg/L	224,000	1.50	18.58	237.3	4.18	29.93	237.3
CFSWP-024	06/15/2017	P1 R4	T	µg/L	50,000	0.45	5.16	66.6	0.96	7.29	66.6

Statistic	Hardness as Calcium Carbonate	MDEQ-7 Chronic Aquatic Life Standards			MDEQ-7 Acute Aquatic Life Standards		
		Cadmium	Copper	Zinc	Cadmium	Copper	Zinc
Min	50,000	0.45	5.16	66.6	0.96	7.29	66.6
Median	137,000	0.98	11.87	151.9	2.57	18.61	151.9
Max	224,000	1.50	18.58	237.3	4.18	29.93	237.3

Table 4-7b. Site-Specific Data Supporting Ecological Surface Water PRGs for Hardness Dependent Metals in EA12
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Sample Location	Sample Date	Sampling Round	Sample Fraction	Unit	Hardness as Calcium Carbonate	MDEQ-7 Chronic Aquatic Life Standards	MDEQ-7 Acute Aquatic Life Standards
						Copper	Copper
CFSWP-018	04/03/2017	P1 R3	T	µg/L	184,000	15.71	24.87
CFSWP-018	06/06/2016	P1 R1	T	µg/L	180,000	15.42	24.36
CFSWP-018	06/15/2017	P1 R4	T	µg/L	216,000	18.01	28.92
CFSWP-018	06/21/2018	P2 R1	T	µg/L	218,000	18.16	29.17
CFSWP-018	10/17/2018	P2 R2	T	µg/L	176,000	15.12	23.85
CFSWP-018	12/01/2016	P1 R2	T	µg/L	260,000	21.11	34.44
CFSWP-019	04/03/2017	P1 R3	T	µg/L	180,000	15.42	24.36
CFSWP-019	06/06/2016	P1 R1	T	µg/L	180,000	15.42	24.36
CFSWP-019	06/15/2017	P1 R4	T	µg/L	168,000	14.53	22.82
CFSWP-019	06/21/2018	P2 R1	T	µg/L	171,000	14.75	23.21
CFSWP-019	10/16/2018	P2 R2	T	µg/L	168,000	14.53	22.82
CFSWP-019	11/07/2017	SSPA	T	µg/L	535,000	30.50	51.68
CFSWP-019	12/01/2016	P1 R2	T	µg/L	208,000	17.44	27.91
CFSWP-020	03/16/2017	P1 R3	T	µg/L	160,000	13.94	21.80
CFSWP-020	06/06/2016	P1 R1	T	µg/L	176,000	15.12	23.85
CFSWP-020	06/15/2017	P1 R4	T	µg/L	160,000	13.94	21.80
CFSWP-020	06/21/2018	P2 R1	T	µg/L	155,000	13.57	21.16
CFSWP-020	10/11/2018	P2 R2	T	µg/L	144,000	12.74	19.74
CFSWP-020	11/07/2017	SSPA	T	µg/L	1,740,000	30.50	51.68
CFSWP-020	12/01/2016	P1 R2	T	µg/L	256,000	20.83	33.94
CFSWP-058	06/21/2018	P2 R1	T	µg/L	159,000	13.87	21.67
CFSWP-058	10/11/2018	P2 R2	T	µg/L	224,000	18.58	29.93
CFSWP-059	06/22/2018	P2 R1	T	µg/L	159,000	13.87	21.67
CFSWP-059	10/11/2018	P2 R2	T	µg/L	188,000	16.00	25.38
CFSWP-060	06/22/2018	P2 R1	T	µg/L	159,000	13.87	21.67
CFSWP-060	10/16/2018	P2 R2	T	µg/L	152,000	13.34	20.77

Statistic	Hardness as Calcium Carbonate	MDEQ-7 Chronic Aquatic Life Standards	MDEQ-7 Acute Aquatic Life Standards
		Copper	Copper
Min	144,000	12.74	19.74
Q1	160,000	13.94	21.80
Median	178,000	15.27	24.10
Q3	214,000	17.87	28.67
Max	1,740,000	30.50	51.68

Table 4-9a. Exceedances of PRGs in Soil Samples in EA1
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFISS-033	CFISS-034	CFISS-037	CFISS-038	CFISS-039	CFISS-040	CFISS-043	CFMW-028a	CFMW-035
			Sample Depth	0-0.5	0-0.5	0-0.5	0-0.5	0.5-2	0-0.5	0-0.5	4.5-6	0-0.5
	Analyte	PRG	Unit									
HH	Benzo(a)anthracene	280	mg/kg	--	--	--	--	--	--	--	**400**	--
	Benzo[a]pyrene	20	mg/kg	**44**	**110**	--	--	--	--	--	**450**	--
	Benzo[b]fluoranthene	280	mg/kg	--	--	--	--	--	--	--	**570**	--
	Indeno(1,2,3-C,D)Pyrene	280	mg/kg	--	--	--	--	--	--	--	**360**	--
ECO	Copper	490	mg/kg	--	--	--	**887**	--	--	--	--	--
	Zinc	810	mg/kg	--	--	**888 J**	**1720 J**	--	--	--	--	--
	LMW PAHs	175	mg/kg	--	--	--	--	--	--	--	**16404**	--
	HMW PAHs	69	mg/kg	--	--	--	--	**72.2**	**201.6**	**71.7**	**3510**	**114.5**

Table 4-9a. Exceedances of PRGs in Soil Samples in EA1
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFMW-037	CFMW-070	CFSB-040	CFSB-040	CFSB-040	CFSB-042	CFSB-042	CFSB-044	CFSB-044
			Sample Depth	0-0.5	0-0.5	0-0.5	0.5-2	10-12	0-0.5	0.5-2	0-0.5	0.5-2
	Analyte	PRG	Unit									
HH	Benzo(a)anthracene	280	mg/kg	--	--	--	--	--	--	--	--	--
HH	Benzo[a]pyrene	20	mg/kg	--	**22**	**130**	**24**	**23**	**24**	--	**42**	**34**
HH	Benzo[b]fluoranthene	280	mg/kg	--	--	--	--	--	--	--	--	--
HH	Indeno(1,2,3-C,D)Pyrene	280	mg/kg	--	--	--	--	--	--	--	--	--
ECO	Copper	490	mg/kg	--	--	--	--	--	--	--	--	--
ECO	Zinc	810	mg/kg	--	--	--	--	--	--	--	--	--
ECO	LMW PAHs	175	mg/kg	--	--	**341.63**	--	--	--	--	--	--
ECO	HMW PAHs	69	mg/kg	**175.1**	**188.6**	**1035**	**197**	--	**220.4**	**76.5**	**394.3**	**301**

Table 4-9a. Exceedances of PRGs in Soil Samples in EA1
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFSB-045	CFSB-045	CFSB-048	CFSB-055	CFSB-066	CFSB-274	CFSB-275	CFSB-276	CFSB-278
			Sample Depth	0-0.5	0.5-2	0-0.5	0-0.5	0-0.5	0-0.5	0-0.5	0-0.5	0-0.5
	Analyte	PRG	Unit									
HH	Benzo(a)anthracene	280	mg/kg	--	--	--	--	--	--	--	--	--
	Benzo[a]pyrene	20	mg/kg	--	--	**37**	--	--	**31**	--	--	--
	Benzo[b]fluoranthene	280	mg/kg	--	--	--	--	--	--	--	--	--
	Indeno(1,2,3-C,D)Pyrene	280	mg/kg	--	--	--	--	--	--	--	--	--
ECO	Copper	490	mg/kg	--	--	--	--	--	--	--	--	--
	Zinc	810	mg/kg	--	--	--	--	--	--	--	--	--
	LMW PAHs	175	mg/kg	--	--	--	--	--	--	--	--	--
	HMW PAHs	69	mg/kg	**98.3**	**95.3**	**287.6**	**74.3**	**81.7**	**242.4**	**89.5**	**100**	**83.6**

Table 4-9a. Exceedances of PRGs in Soil Samples in EA1
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFSB-278	CFSB-287	CFSB-287
			Sample Depth	0.5-2	17-19	22-24
	Analyte	PRG	Unit			
HH	Benzo(a)anthracene	280	mg/kg	--	--	--
	Benzo[a]pyrene	20	mg/kg	--	--	--
	Benzo[b]fluoranthene	280	mg/kg	--	--	--
	Indeno(1,2,3-C,D)Pyrene	280	mg/kg	--	--	--
ECO	Copper	490	mg/kg	--	--	--
	Zinc	810	mg/kg	--	--	--
	LMW PAHs	175	mg/kg	--	**184.9**	**218.6**
	HMW PAHs	69	mg/kg	**71.6**	--	--

Table 4-9b. Exceedances of PRGs in Soil Samples in EA2
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFMW-027	CFMW-027	CFSB-016	CFSB-016	CFSB-019	CFSB-019	CFSB-025	CFSB-025	CFSB-026	CFSB-026
			Sample Depth	0-0.5	0.5-2	0-0.5	0.5-2	0-0.5	0.5-2	0-0.5	0.5-2	0-0.5	0.5-2
	Analyte	PRG	Unit										
HH	Benzo(a)anthracene	1400	mg/kg	--	--	--	--	--	--	--	--	--	--
	Benzo[a]pyrene	140	mg/kg	**320**	--	--	--	--	--	--	**170**	--	--
	Benzo(b)fluoranthene	1400	mg/kg	--	--	--	--	--	--	--	--	--	--
	Dibenz(a,h)anthracene	140	mg/kg	--	--	--	--	--	--	--	--	--	--
	Indeno(1,2,3-c,d)pyrene	1400	mg/kg	--	--	--	--	--	--	--	--	--	--
ECO	Barium	1000	mg/kg	--	--	--	--	--	--	--	--	--	--
	Nickel	140	mg/kg	--	**151**	**171**	--	**153**	--	**1250 J+**	**358 J+**	**377 J+**	**213 J+**
	Thallium	0.5	mg/kg	--	**0.65**	--	--	--	--	**4.2**	**2.8**	**4.6**	**3**
	Vanadium	80	mg/kg	--	**85.9**	--	--	--	--	**348 J-**	**109 J-**	**140 J-**	--
	LMW PAHs	175	mg/kg	**738.3**	--	--	--	--	--	**429.3**	**1984.6**	**379.02**	**426.75**
	HMW PAHs	69	mg/kg	**2580**	**383.3**	**139.3**	**99.7**	--	**499**	**1261**	**2892**	**1064**	**1097**

Table 4-9b. Exceedances of PRGs in Soil Samples in EA2
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFSB-027	CFSB-027	CFSB-030	CFSB-030	CFSB-199	CFSB-199	CFSB-202	CFSB-203	CFSB-203	CFSB-203
			Sample Depth	0-0.5	0.5-2	0-0.5	0.5-2	0-0.5	0.5-2	0-0.5	0-0.5	0-0.05	0.5-2
	Analyte	PRG	Unit										
HH	Benzo(a)anthracene	1400	mg/kg	--	--	--	--	--	--	--	--	**1700**	--
	Benzo[a]pyrene	140	mg/kg	--	--	--	--	--	--	--	--	**2000**	**480 J**
	Benzo(b)fluoranthene	1400	mg/kg	--	--	--	--	--	--	--	--	**2800**	--
	Dibenz(a,h)anthracene	140	mg/kg	--	--	--	--	--	--	--	--	**490**	--
	Indeno(1,2,3-c,d)pyrene	1400	mg/kg	--	--	--	--	--	--	--	--	**1600**	--
ECO	Barium	1000	mg/kg	--	--	--	--	--	--	--	--	--	--
	Nickel	140	mg/kg	--	--	--	--	**181**	**--**	**163**	--	--	--
	Thallium	0.5	mg/kg	--	--	**0.64**	--	**0.7**	**1.2 J**	--	--	--	--
	Vanadium	80	mg/kg	--	--	--	--	--	--	--	--	--	--
	LMW PAHs	175	mg/kg	--	--	--	--	**343.84**	--	--	**4196.8**	--	**1154.6**
	HMW PAHs	69	mg/kg	**119.8**	**501**	**70**	**123.1**	**1031**	**137.2**	--	**15860**	--	**4020**

Table 4-9b. Exceedances of PRGs in Soil Samples in EA2
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFSB-204	CFSB-272	CFSB-272	CFSB-272	CFSB-273	CFSB-273	CFSB-279	CFSB-280	CFSB-281	CFSB-281
			Sample Depth	0-0.5	0-0.5	0.5-2	0.5-2	0-0.5	0.5-2	0-0.5	0-0.5	0-0.5	0.5-2
	Analyte	PRG	Unit										
HH	Benzo(a)anthracene	1400	mg/kg	--	--	--	--	--	--	--	--	--	--
	Benzo[a]pyrene	140	mg/kg	--	**590**	**490**	--	--	--	--	--	--	--
	Benzo(b)fluoranthene	1400	mg/kg	--	--	--	--	--	--	--	--	--	--
	Dibenz(a,h)anthracene	140	mg/kg	--	--	--	--	--	--	--	--	--	--
	Indeno(1,2,3-c,d)pyrene	1400	mg/kg	--	--	--	--	--	--	--	--	--	--
ECO	Barium	1000	mg/kg	--	--	--	--	--	**1560**	--	--	--	--
	Nickel	140	mg/kg	**213**	--	--	--	**276**	**305**	--	**170**	**566**	**719**
	Thallium	0.5	mg/kg	--	--	--	--	**0.99**	**2.3**	--	--	**0.78**	**4.5**
	Vanadium	80	mg/kg	--	--	--	--	**101**	**125**	--	--	**167**	**186**
	LMW PAHs	175	mg/kg	--	**1315.1**	--	**964.8**	**676.55**	**586.65**	--	--	**330.715**	**47.729**
	HMW PAHs	69	mg/kg	**311**	**4780**	--	**3681**	**1298**	**818**	**491**	--	**695**	**221.6**

Table 4-9b. Exceedances of PRGs in Soil Samples in EA2
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFSDP-023	CFSDP-024
			Sample Depth	--	--
	Analyte	PRG	Unit		
HH	Benzo(a)anthracene	1400	mg/kg	--	--
	Benzo[a]pyrene	140	mg/kg	--	--
	Benzo(b)fluoranthene	1400	mg/kg	--	--
	Dibenz(a,h)anthracene	140	mg/kg	--	--
	Indeno(1,2,3-c,d)pyrene	1400	mg/kg	--	--
ECO	Barium	1000	mg/kg	--	--
	Nickel	140	mg/kg	**208**	**771**
	Thallium	0.5	mg/kg	--	**1.2**
	Vanadium	80	mg/kg	--	**233**
	LMW PAHs	175	mg/kg	--	**178.64**
	HMW PAHs	69	mg/kg	**156.8**	**1050**

Table 4-9c. Exceedances of PRGs in Soil Samples in EA3
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFISS-003	CFISS-003	CFISS-004	CFISS-004	CFISS-005	CFISS-005	CFISS-006	CFISS-011	CFISS-012	CFISS-012
			Sample Depth	0-0.5	0.5-2	0-0.5	0.5-2	0-0.5	0.5-2	0.5-2	0.5-2	0-0.5	0.5-2
	Analyte	PRG	Unit										
HH	Benzo[a]pyrene	28	mg/kg	--	**92**	--	--	--	**35**	--	--	--	--
	Dibenz(a,h)anthracene	28	mg/kg	--	--	--	--	--	--	--	--	--	--
ECO	Copper	490	mg/kg	--	--	--	--	--	--	**721**	--	--	--
	Nickel	140	mg/kg	--	--	--	--	--	--	--	--	--	--
	Selenium	3.4	mg/kg	--	--	--	--	--	--	--	--	--	--
	LMW PAHs	175	mg/kg	--	**470.28**	--	--	--	**209.937**	--	--	--	--
	HMW PAHs	69	mg/kg	**93**	**711**	**95**	**108.9**	**111.6**	**280.3**	--	--	**85**	**184.1**

Table 4-9c. Exceedances of PRGs in Soil Samples in EA3
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFISS-013	CFISS-013	CFISS-020	CFISS-020	CFISS-021	CFISS-022	CFISS-027	CFISS-033	CFISS-034	CFISS-035
			Sample Depth	0-0.5	0.5-2	0-0.5	0.5-2	0-0.5	0-0.5	0-0.5	0-0.5	0-0.5	0-0.5
	Analyte	PRG	Unit										
HH	Benzo[a]pyrene	28	mg/kg	--	**240**	--	--	--	--	--	--	--	--
	Dibenz(a,h)anthracene	28	mg/kg	--	**51**	--	--	--	--	--	--	--	--
ECO	Copper	490	mg/kg	--	--	--	--	--	--	--	--	--	--
	Nickel	140	mg/kg	--	--	--	--	--	--	--	--	--	--
	Selenium	3.4	mg/kg	--	--	--	--	**3.8**	**13.3**	**5.7**	--	--	--
	LMW PAHs	175	mg/kg	**739.1**	**1342.1**	--	--	--	--	--	--	**193.71**	--
	HMW PAHs	69	mg/kg	**1131**	**1981**	**203.2**	**84.5**	**--**	**--**	**--**	**325.1**	**823**	**151.8**

Table 4-9c. Exceedances of PRGs in Soil Samples in EA3
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFLP-009	CFLP-012	CFMW-008a	CFSB-002	CFSB-004	CFSB-004	CFSB-034
			Sample Depth	0.5-2	0.5-2	0-0.5	0-0.5	0-0.5	0.5-2	0-0.5
	Analyte	PRG	Unit							
HH	Benzo[a]pyrene	28	mg/kg	--	--	--	--	**100**	**75**	--
	Dibenz(a,h)anthracene	28	mg/kg	--	--	--	--	--	--	--
ECO	Copper	490	mg/kg	--	--	--	**7260**	--	--	--
	Nickel	140	mg/kg	**534**	**276**	--	--	--	--	--
	Selenium	3.4	mg/kg	--	--	--	--	--	--	--
	LMW PAHs	175	mg/kg	--	--	--	--	**515.14**	**595.9**	--
	HMW PAHs	69	mg/kg	**211.2**	--	**70**	--	**789**	**665**	**197.2**

Table 4-9d. Exceedances of PRGs in Soil Samples in EA4
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFLP-003	CFLP-005	CFLP-005	CFLP-006
			Sample Depth	0.5-2	0-0.5	0.5-2	0-0.5
	Analyte	PRG	Unit				
HH	Benzo[a]pyrene	28	mg/kg	--	--	--	**53**
ECO	Nickel	140	mg/kg	--	**463 J**	**513 J**	--
	Vanadium	80	mg/kg	--	**169 J**	**163**	--
	HMW PAHs	69	mg/kg	**99.9**	**166.6**	**91.2**	**388**

Table 4-10a. Exceedances of PRGs in Sediment Samples in EA2
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFSDP-023	CFSDP-024	CFMW-027	CFSB-014	CFSB-016	CFSB-019	CFSB-025	CFSB-026	CFSB-027	CFSB-028	CFSB-030
			Sample Round	P1 R1	P1 R1	P1 R1	P1 R1	P1 R1	P1 R1	P1 R1	P1 R1	P1 R1	P1 R1	P1 R1
	Analyte	PRG	Unit											
ECO	Barium	300	mg/kg	**539**	**317**	-	-	-	-	-	**461**	-	-	-
ECO	Cadmium	4.9	mg/kg	-	**8**	-	-	-	-	-	**8.3**	-	-	-
ECO	Lead	120	mg/kg	-	-	-	-	-	-	**221 J+**	**238 J+**	-	-	-
ECO	Nickel	48	mg/kg	**208**	**771**	**84.5**	**73.4**	**171**	**153**	**1250 J+**	**377 J+**	-	**56.4**	**81.3 J+**
ECO	Selenium	1.38	mg/kg	-	**3.4 J**	-	-	-	-	**3.3 J**	**1.6 J**	-	-	-
ECO	Vanadium	38	mg/kg	**66.1**	**233**	-	-	**54.2**	**60.3**	**348 J-**	**140 J-**	-	-	**41.3 J-**
ECO	Zinc	450	mg/kg	-	**871**	-	-	-	-	-	-	-	-	-
ECO	LMW PAHs	196	mg/kg	-	-	**738.3**	-	-	-	**429.3**	**379.02**	-	-	-
ECO	HMW PAHs	28.2	mg/kg	**156.8**	**1050**	**2580**	-	**139.3**	-	**1261**	**1064**	**119.8**	**50.4**	**70**

Table 4-10a. Exceedances of PRGs in Sediment Samples in EA2
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFSB-199	CFSB-201	CFSB-202	CFSB-203	CFSB-204	CFSB-214	CFSB-272	CFSB-273	CFSB-279	CFSB-280	CFSB-281
			Sample Round	P2 R1	P2 R1	P2 R1	P2 R1	P2 R1	P2 R1	P2 R1	P2 R1	P2 R1	P2 R1	P2 R1
	Analyte	PRG	Unit											
ECO	Barium	300	mg/kg	-	-	-	-	-	-	-	-	-	-	-
	Cadmium	4.9	mg/kg	-	-	-	-	-	-	-	-	-	-	**5.4**
	Lead	120	mg/kg	-	-	-	-	-	-	-	-	-	-	-
	Nickel	48	mg/kg	**181**	**131**	**163**	-	**213**	**103**	**136**	**276**	**49.5**	**170**	**566**
	Selenium	1.38	mg/kg	-	-	-	-	-	-	-	-	-	-	**2.3 J**
	Vanadium	38	mg/kg	**76.8**	-	**51.2**	-	**57.4**	-	**61**	**101**	-	**40**	**167**
	Zinc	450	mg/kg	-	-	-	-	-	-	-	-	-	-	**694**
	LMW PAHs	196	mg/kg	**343.84**	-	-	**4196.8**	-	-	**1315.1**	**676.55**	-	-	**330.715**
	HMW PAHs	28.2	mg/kg	**1031**	-	-	**15860**	**311**	**32.17**	**4780**	**1298**	**491**	**56.7**	**695**

Table 4-10b. Exceedances of PRGs in Sediment Samples in EA12
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFSB-104	CFSB-109	CFSB-110	CFSB-113	CFSB-115	CFSB-150	CFSB-152	CFSB-153	CFSDP-018	CFSDP-018	CFSDP-018
			Sample Round	P1 R1	P1 R1	P1 R1	P1 R1	P1 R1	SSPA	SSPA	SSPA	P1 R1	P2 R2	SSPA
	Analyte	PRG	Unit	-	-	-	-	-	-	-	-	-	-	-
ECO	Barium	300	mg/kg	**459**	**653**	**911**	**972**	**371**	**693**	**706**	**380**	**758**	**700**	**762**

Table 4-10b. Exceedances of PRGs in Sediment Samples in EA12
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

			Sample Name	CFSDP-019	CFSDP-019	CFSDP-019	CFSDP-020	CFSDP-020	CFSDP-020	CFSDP-058	CFSDP-059	CFSDP-060
			Sample Round	P1 R1	SSPA	P2 R2	P1 R1	SSPA	P2 R2	P2 R2	P2 R2	P2 R2
	Analyte	PRG	Unit	-	-	-						
ECO	Barium	300	mg/kg	**476**	**969**	**711**	**548**	**744**	**579**	**321**	**572**	**879**

Table 4-11. Exceedances of PRGs in Groundwater Samples
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Analyte	PRG	Round	Unit	CFMW-002	CFMW-010	CFMW-011	CFMW-012	CFMW-012a	CFMW-014	CFMW-015	CFMW-017	CFMW-019
Total Cyanide	200	P1 R1	µg/L	**2060 J**	**7320 J**	-	**2280 J**	-	**2750 J**	**6240 J**	NS	**961 J**
		P1 R2	µg/L	NS	**2120**	-	**972**	-	**3360**	**3100**	NS	**791**
		P1 R3	µg/L	**1370**	**1020**	**235**	**2340**	-	**3320**	**6600**	**1880**	**1770**
		P1 R4	µg/L	**985**	**1190**	-	**5780**	-	**720**	**8120**	-	**1230**
		P2 R1	µg/L	**440 J-**	**615 J+**	-	**1810**	-	**410 J+**	**5500 J+**	-	**1080**
		P2 R2	µg/L	NS	**10800**	-	**6500**	-	**2140 J-**	**5180 J-**	NS	**1210**
Free Cyanide	200	P1 R3	µg/L	**306**	-	-	-	NS	-	-	NS	-
		P1 R4	µg/L	-	-	-	-	NS	-	-	-	-
		P2 R1	µg/L	-	-	-	-	-	-	-	-	-
		P2 R2	µg/L	-	-	-	-	-	-	-	NS	-
Flouride	4,000	P1 R1	µg/L	**18900**	**30900**	-	**12400**	-	**8300**	**38400**	NS	-
		P1 R2	µg/L	NS	-	-	**5750 J**	-	**17300 J-**	**16800 J-**	NS	-
		P1 R3	µg/L	**8900**	**17200**	-	**12600 J+**	-	**13000**	**4740**	**13400**	-
		P1 R4	µg/L	**4930**	**6810**	-	**30600**	-	-	**52900**	-	-
		P2 R1	µg/L	**5050 J-**	-	-	**47800 J**	-	**8100 J-**	**36300 J-**	-	-
		P2 R2	µg/L	NS	**20000**	-	**24900**	-	**8010 J-**	**18700 J-**	-	-
Dissolved Arsenic	10	P1 R1	µg/L	-	-	-	**15.5**	-	-	**47.7**	-	-
		P1 R2	µg/L	-	-	-	**10.7**	-	-	**50.8**	-	-
		P1 R3	µg/L	-	-	-	-	-	-	**38.1**	-	-
		P1 R4	µg/L	-	-	-	**92.6**	-	-	**92.1**	-	-
		P2 R1	µg/L	-	-	-	**70**	-	-	**91.6**	-	-
		P2 R2	µg/L	-	-	-	-	-	-	**61.1**	-	-

Table 4-11. Exceedances of PRGs in Groundwater Samples
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Analyte	PRG	Round	Unit	CFMW-021	CFMW-022	CFMW-023	CFMW-027	CFMW-028	CFMW-028a	CFMW-029	CFMW-031	CFMW-032
Total Cyanide	200	P1 R1	µg/L	**400 J**	-	-	**603**	-	-	**366**	**233**	**412 J-**
		P1 R2	µg/L	**1560**	**279**	-	**793**	-	-	-	**690**	-
		P1 R3	µg/L	**1020**	-	-	**755**	**283**	-	**258**	**520**	**238**
		P1 R4	µg/L	**321**	-	-	**560**	**315**	-	-	-	**478**
		P2 R1	µg/L	**565**	-	**203**	**895**	**389**	-	**365**	**268**	**675**
		P2 R2	µg/L	**737**	-	-	**575 J-**	**329**	-	**227**	**201**	**565**
Free Cyanide	200	P1 R3	µg/L	-	-	-	-	-	-	-	-	-
		P1 R4	µg/L	-	-	-	-	-	-	-	-	-
		P2 R1	µg/L	-	-	-	-	-	-	-	-	-
		P2 R2	µg/L	-	-	-	-	-	-	-	-	-
Flouride	4,000	P1 R1	µg/L	-	-	-	-	-	-	-	-	**5210 J-**
		P1 R2	µg/L	-	-	-	-	-	-	**4180 J**	-	-
		P1 R3	µg/L	**4500**	-	-	-	**4400**	-	-	-	-
		P1 R4	µg/L	-	-	-	**5160**	-	-	-	-	**8570**
		P2 R1	µg/L	-	-	-	-	-	-	**3590 J**	-	**5550**
		P2 R2	µg/L	-	-	-	**4530 J-**	-	-	-	-	**5290**
Dissolved Arsenic	10	P1 R1	µg/L	-	-	-	-	-	-	-	-	-
		P1 R2	µg/L	-	-	-	-	-	-	-	-	-
		P1 R3	µg/L	-	-	-	-	-	-	-	-	-
		P1 R4	µg/L	-	-	-	-	-	-	-	-	-
		P2 R1	µg/L	-	-	-	-	-	**12.3**	-	-	-
		P2 R2	µg/L	-	-	-	-	-	**12.6**	-	-	-

Table 4-11. Exceedances of PRGs in Groundwater Samples
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Analyte	PRG	Round	Unit	CFMW-033	CFMW-034	CFMW-035	CFMW-037	CFMW-038	CFMW-040	CFMW-042	CFMW-043	CFMW-044
Total Cyanide	200	P1 R1	µg/L	**478**	**327**	-	-	**260**	**304**	**402**	**510**	**430**
		P1 R2	µg/L	**483**	**255**	-	-	**286**	**288**	NS	**423**	**220**
		P1 R3	µg/L	**515**	**275**	-	-	-	**288**	NS	**477**	**233**
		P1 R4	µg/L	-	**287**	-	-	**298**	**385**	**395**	**535**	-
		P2 R1	µg/L	**436**	**645**	-	-	**307**	**320**	**620**	**445 J+**	**342 J+**
		P2 R2	µg/L	**396**	**412**	-	**261**	**508**	**429**	**705**	**657 J-**	**766**
Free Cyanide	200	P1 R3	µg/L	-	-	-	-	-	-	NS	-	-
		P1 R4	µg/L	-	-	-	-	-	-	-	-	-
		P2 R1	µg/L	-	-	-	-	-	-	-	-	-
		P2 R2	µg/L	-	-	-	-	-	-	-	-	-
Flouride	4,000	P1 R1	µg/L	-	**4530 J-**	-	-	-	-	-	-	-
		P1 R2	µg/L	-	-	-	-	-	-	-	-	-
		P1 R3	µg/L	-	-	-	-	-	-	-	-	-
		P1 R4	µg/L	-	**6590**	-	-	-	-	-	-	-
		P2 R1	µg/L	-	**5280**	-	-	-	-	-	-	-
		P2 R2	µg/L	-	-	-	-	-	-	-	-	-
Dissolved Arsenic	10	P1 R1	µg/L	-	-	-	-	-	-	-	-	-
		P1 R2	µg/L	-	-	**10.4**	-	-	-	-	-	-
		P1 R3	µg/L	-	-	-	-	-	-	-	-	-
		P1 R4	µg/L	-	-	**11.3**	-	-	-	-	-	-
		P2 R1	µg/L	-	-	-	-	-	-	-	-	-
		P2 R2	µg/L	-	-	-	-	-	-	-	-	-

Table 4-11. Exceedances of PRGs in Groundwater Samples
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Analyte	PRG	Round	Unit	CFMW-045	CFMW-047	CFMW-053	CFMW-054	CFMW-070
Total Cyanide	200	P1 R1	µg/L	**365**	-	**363**	**327**	NS
		P1 R2	µg/L	**392**	-	**386**	**382**	NS
		P1 R3	µg/L	**381**	-	NS	**391**	NS
		P1 R4	µg/L	**450**	-	**239**	**302**	NS
		P2 R1	µg/L	**645**	-	**447**	**296**	**1010**
		P2 R2	µg/L	**605**	**246**	**474**	**384**	**825**
Free Cyanide	200	P1 R3	µg/L	-	-	NS	-	NS
		P1 R4	µg/L	-	-	-	-	NS
		P2 R1	µg/L	-	-	-	-	**305 J-**
		P2 R2	µg/L	-	-	-	-	-
Flouride	4,000	P1 R1	µg/L	-	-	-	-	-
		P1 R2	µg/L	-	-	-	-	-
		P1 R3	µg/L	-	-	-	-	-
		P1 R4	µg/L	-	-	-	-	-
		P2 R1	µg/L	-	-	-	-	-
		P2 R2	µg/L	-	-	-	-	-
Dissolved Arsenic	10	P1 R1	µg/L	-	-	-	-	-
		P1 R2	µg/L	-	-	-	-	-
		P1 R3	µg/L	-	-	-	-	-
		P1 R4	µg/L	-	-	-	-	-
		P2 R1	µg/L	-	-	-	-	-
		P2 R2	µg/L	-	-	-	-	-

Table 4-12a. Exceedances of PRGs in Surface Water Samples in EA2
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Analyte	Chronic Criterion PRG	Acute Criterion PRG	Round	Unit	CFSWP-023	CFSWP-024
Dissolved Aluminum	87	**750**	P1 R4	µg/L	NS	**4780**
			SSPA	µg/L	NS	NS
			P2 R1	µg/L	NS	NS
			P2 R2	µg/L	NS	NS
Barium	220	**2,000**	P1 R1	µg/L	NS	NS
			P1 R2	µg/L	NS	NS
			P1 R3	µg/L	234	NS
			P1 R4	µg/L	NS	-
			SSPA	µg/L	NS	NS
			P2 R1	µg/L	NS	NS
			P2 R2	µg/L	NS	NS
Cadmium	0.45	**0.96**	P1 R1	µg/L	NS	NS
			P1 R2	µg/L	NS	NS
			P1 R3	µg/L	-	NS
			P1 R4	µg/L	NS	**3**
			SSPA	µg/L	NS	NS
			P2 R1	µg/L	NS	NS
			P2 R2	µg/L	NS	NS
Copper	5.16	**7.29**	P1 R1	µg/L	NS	NS
			P1 R2	µg/L	NS	NS
			P1 R3	µg/L	-	NS
			P1 R4	µg/L	NS	**16.5**
			SSPA	µg/L	NS	NS
			P2 R1	µg/L	NS	NS
			P2 R2	µg/L	NS	NS
Zinc	66.6	**66.6**	P1 R1	µg/L	NS	NS
			P1 R2	µg/L	NS	NS
			P1 R3	µg/L	-	NS
			P1 R4	µg/L	NS	**537**
			SSPA	µg/L	NS	NS
			P2 R1	µg/L	NS	NS
			P2 R2	µg/L	NS	NS
Benzo[a]anthracene	2.23	**9.25**	P1 R1	µg/L	-	-
			P1 R4	µg/L	-	3
			SSPA	µg/L	-	-
			P2 R2	µg/L	**-**	**-**
Benzo[a]pyrene	0.96	**3.98**	P1 R1	µg/L	**-**	**-**
			P1 R4	µg/L	-	3.9
			SSPA	µg/L	-	-
			P2 R2	µg/L	**-**	**-**
Benzo[b]fluoranthene	0.68	**2.81**	P1 R1	µg/L	**-**	**-**
			P1 R4	µg/L	-	**10**
			SSPA	µg/L	-	-
			P2 R2	µg/L	**-**	**-**

Table 4-12a. Exceedances of PRGs in Surface Water Samples in EA2
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Analyte	Chronic Criterion PRG	Acute Criterion PRG	Round	Unit	CFSWP-023	CFSWP-024
Benzo[g,h,i]perylene	0.44	**1.82**	P1 R1	µg/L	-	-
			P1 R4	µg/L	-	**3.9 J**
			SSPA	µg/L	-	-
			P2 R2	µg/L	-	-
Chrysene	2.04	**8.49**	P1 R1	µg/L	-	-
			P1 R4	µg/L	-	7.6
			SSPA	µg/L	-	-
			P2 R2	µg/L	-	-
Fluoranthene	7.11	**29.5**	P1 R1	µg/L	-	-
			P1 R4	µg/L	-	9.3 J
			SSPA	µg/L	-	-
			P2 R2	µg/L	-	-
Indeno[1,2,3-c,d]pyrene	0.28	**1.14**	P1 R1	µg/L	-	-
			P1 R4	µg/L	-	3.1
			SSPA	µg/L	-	-
			P2 R2	µg/L	-	-

Table 4-12b. Exceedances of PRGs in Surface Water Samples in EA8
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Analyte	Chronic Criterion PRG	Acute Criterion PRG	Round	Unit	CFSWP-026	CFSWP-027	CFSWP-029	CFSWP-030	CFSWP-031	CFSWP-032	CFSWP-033
Dissolved Aluminum	87	**750**	P1 R4	µg/L	NS	NS	NS	NS	NS	NS	NS
			SSPA	µg/L	-	-	-	245	614	586	-
			P2 R1	µg/L	-	-	-	-	-	-	-
			P2 R2	µg/L	-	-	-	-	594	238	242
Barium	220	**2,000**	P1 R1	µg/L	NS	NS	NS	NS	NS	NS	NS
			P1 R2	µg/L	NS	NS	NS	NS	NS	NS	NS
			P1 R3	µg/L	NS	NS	NS	NS	NS	NS	NS
			P1 R4	µg/L	NS	NS	NS	NS	NS	NS	NS
			SSPA	µg/L	-	-	-	347	424	1230	466
			P2 R1	µg/L	-	-	-	-	247	254	241
			P2 R2	µg/L	-	-	-	-	285	260	283
Total Cyanide	5.2	**22**	P1 R1	µg/L	NS	NS	NS	NS	NS	NS	NS
			P1 R2	µg/L	NS	NS	NS	NS	NS	NS	NS
			P1 R3	µg/L	NS	NS	NS	NS	NS	NS	NS
			P1 R4	µg/L	NS	NS	NS	NS	NS	NS	NS
			SSPA	µg/L	17.8	**25.7**	253	113	13.7	98.6	95.8
			P2 R1	µg/L	-	-	363	630	273	283	285
			P2 R2	µg/L	19.8	**28.6**	**59.4 J**	**35.9 J**	-	16.5 J	10 J
Dissolved Total Cyanide	5.2	**22**	P1 R4	µg/L	NS	NS	NS	NS	NS	NS	NS
			SSPA	µg/L	**22.7**	**23.2**	245	104	9.9 J	**26.6**	**91.4**
			P2 R2	µg/L	NS	NS	NS	NS	NS	NS	NS
Free Cyanide	5.2	**22**	P1 R3	µg/L	NS	NS	NS	NS	NS	NS	NS
			P1 R4	µg/L	NS	NS	NS	NS	NS	NS	NS
			SSPA	µg/L	-	-	**65.1**	**26.1**	-	-	-
			P2 R1	µg/L	-	-	**39.8 J-**	21.7 J	14.3 J-	8.8 J-	**56.4 J-**
			P2 R2	µg/L	-	-	**140**	14.4	-	-	-
Dissolved Free Cyanide	5.2	**22**	P1 R4	µg/L	NS	NS	NS	NS	NS	NS	NS
			SSPA	µg/L	-	-	**63.5**	**26.1**	-	-	-

Table 4-12c. Exceedances of PRGs in Surface Water Samples in EA9
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Analyte	Chronic Criterion PRG	Acute Criterion PRG	Round	Unit	CFSWP-003	CFSWP-004	CFSWP-005	CFSWP-028
Dissolved Aluminum	87	**750**	P1 R4	µg/L	-	-	-	NS
			SSPA	µg/L	-	-	-	-
			P2 R1	µg/L	-	-	-	-
			P2 R2	µg/L	-	-	-	-
Total Cyanide	5.2	**22**	P1 R1	µg/L	18.8	**209**	**213**	NS
			P1 R2	µg/L	**36.2**	**178**	**192**	NS
			P1 R3	µg/L	7.7 J	21.3	**24.7**	NS
			P1 R4	µg/L	9.5 J	11.5	**197**	NS
			SSPA	µg/L	**74.6**	**323**	**327**	**24.1**
			P2 R1	µg/L	**36.9 J+**	**76.6 J+**	**88 J+**	-
			P2 R2	µg/L	**123**	**378**	**321 J**	**33.9**
Dissolved Total Cyanide	5.2	**22**	P1 R4	µg/L	12.5	11.7	162	NS
			SSPA	µg/L	**88.3**	**328**	**303**	**27.3**
			P2 R2	µg/L	NS	NS	NS	NS
Free Cyanide	5.2	**22**	P1 R3	µg/L	-	6.4	8	NS
			P1 R4	µg/L	3.5 J	4.1 J	**45.6**	NS
			SSPA	µg/L	12.5	21.5	5.3	6.1
			P2 R1	µg/L	**27.4**	**35**	23.8	-
			P2 R2	µg/L	**43.7**	**87**	**139**	14.1
Dissolved Free Cyanide	5.2	**22**	P1 R4	µg/L	5.4	5.6	**42.2**	NS
			SSPA	µg/L	12.5	20.3	5.3	5.7

Table 4-12d. Exceedances of PRGs in Surface Water Samples in EA12
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Analyte	Chronic Criterion PRG	Acute Criterion PRG	Round	Unit	CFSWP-018	CFSWP-019	CFSWP-020	CFSWP-058	CFSWP-059	CFSWP-060
Dissolved Aluminum	87	**750**	P1 R4	µg/L	-	-	-	NS	NS	NS
			SSPA	µg/L	NS	**2360**	265	NS	NS	NS
			P2 R1	µg/L	-	-	-	-	-	-
			P2 R2	µg/L	288	198	326	**752**	-	-
Barium	220	**2,000**	P1 R1	µg/L	268	265	305	NS	NS	NS
			P1 R2	µg/L	225	--	424	NS	NS	NS
			P1 R3	µg/L	237	244	239	NS	NS	NS
			P1 R4	µg/L	237	250	275	NS	NS	NS
			SSPA	µg/L	NS	713	**2710**	NS	NS	NS
			P2 R1	µg/L	-	273	255	263	286	264
			P2 R2	µg/L	262	-	-	358	283	272
Copper	15.27	**24.10**	P1 R1	µg/L	-	-	-	NS	NS	NS
			P1 R2	µg/L	-	-	-	NS	NS	NS
			P1 R3	µg/L	-	-	-	NS	NS	NS
			P1 R4	µg/L	-	-	-	NS	NS	NS
			SSPA	µg/L	NS	**75.9**	**183**	NS	NS	NS
			P2 R1	µg/L	-	-	-	-	-	-
			P2 R2	µg/L	20.1	19.6	12.9	-	-	-
Iron	1,000	**NA**	P1 R1	µg/L	-	-	-	NS	NS	NS
			P1 R2	µg/L	-	-	-	NS	NS	NS
			P1 R3	µg/L	-	-	-	NS	NS	NS
			P1 R4	µg/L	-	-	-	NS	NS	NS
			SSPA	µg/L	NS	2790	22500	NS	NS	NS
			P2 R1	µg/L	-	-	-	-	-	-
			P2 R2	µg/L	-	-	3150	2950	-	-
Total Cyanide	5.2	**22**	P1 R1	µg/L	-	-	12.5	NS	NS	NS
			P1 R2	µg/L	-	-	16.4	NS	NS	NS
			P1 R3	µg/L	-	-	11.3	NS	NS	NS
			P1 R4	µg/L	**77.2**	-	-	NS	NS	NS
			SSPA	µg/L	NS	-	**57.2**	NS	NS	NS
			P2 R1	µg/L	**139**	-	9.9 J	9.6 J	8.2 J	9.2 J
			P2 R2	µg/L	-	-	-	**30.8 J+**	-	-
Dissolved Total Cyanide	5.2	**22**	P1 R4	µg/L	**68.2**	-	5.3 J	NS	NS	NS
			SSPA	µg/L	NS	-	**58.8**	NS	NS	NS
			P2 R2	µg/L	NS	NS	NS	NS	NS	NS
Free Cyanide	5.2	**22**	P1 R3	µg/L	NS	NS	9	NS	NS	NS
			P1 R4	µg/L	NS	NS	-	NS	NS	NS
			SSPA	µg/L	NS	-	-	NS	NS	NS
			P2 R1	µg/L	-	-	4.9 J-	-	5.9 J-	NS
			P2 R2	µg/L	-	-	-	10	-	-
Dissolved Free Cyanide	5.2	**22**	P1 R4	µg/L	NS	NS	-	NS	NS	NS
			SSPA	µg/L	NS	-	-	NS	NS	NS

Table 4-13a. Exceedances of PRGs in Sediment Porewater Samples in EA8
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Analyte	Chronic Criterion PRG	Acute Criterion PRG	Phase	Unit	CFPWP-029	CFPWP-030	CFPWP-031	CFPWP-032	CFPWP-033
Barium	220	**2,000**	P2	µg/L	--	285	389	394	--
Dissolved Free Cyanide	5.2	**22**	P2	µg/L	**38.7 J-**	**36.5 J-**	--	--	19.6

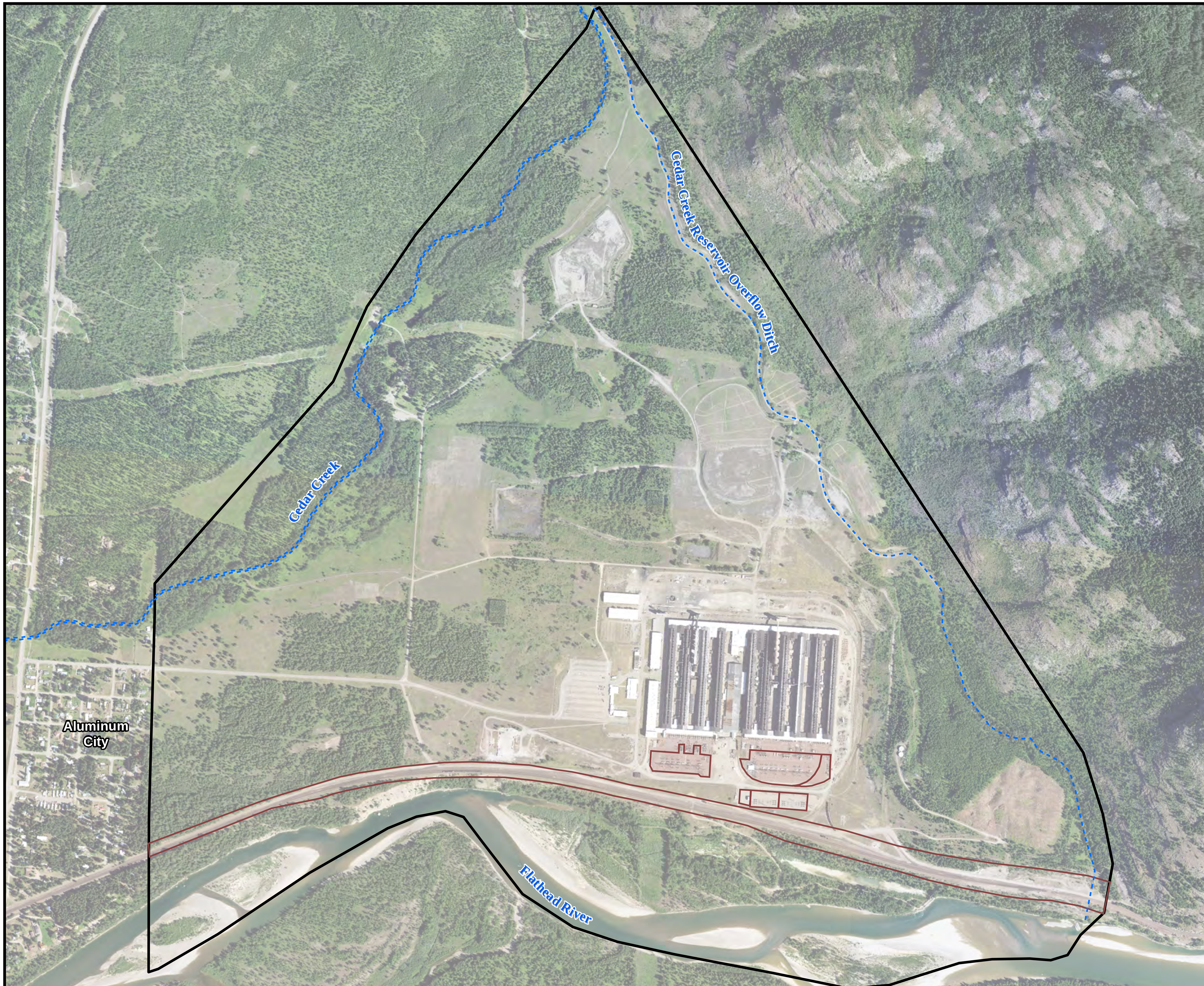
Table 4-13b. Exceedances of PRGs in Sediment Porewater Samples in EA9
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Analyte	Chronic Criterion PRG	Acute Criterion PRG	Phase	Unit	CFPWP-003	CFPWP-004	CFPWP-005
Dissolved Free Cyanide	5.2	**22**	P2	µg/L	21.3	**46.5**	**62.4 J-**

Table 4-13c. Exceedances of PRGs in Sediment Porewater Samples in EA12
Columbia Falls Aluminum Company, LLC, Feasibility Study Work Plan, 2000 Aluminum Drive, Columbia Falls, MT

Analyte	Chronic Criterion PRG	Acute Criterion PRG	Phase	Unit	CFPWP-019	CFPWP-020	CFPWP-058	CFPWP-059	CFPWP-060
Barium	220	**2,000**	P2	µg/L	332	421	301	270	223

FIGURES



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LEGEND

- CREEK FEATURES
- APPROXIMATE THIRD-PARTY PROPERTY BOUNDARIES
- SITE BOUNDARY

1,000 0 1,000'

Title:

RI/FS SITE BOUNDARY

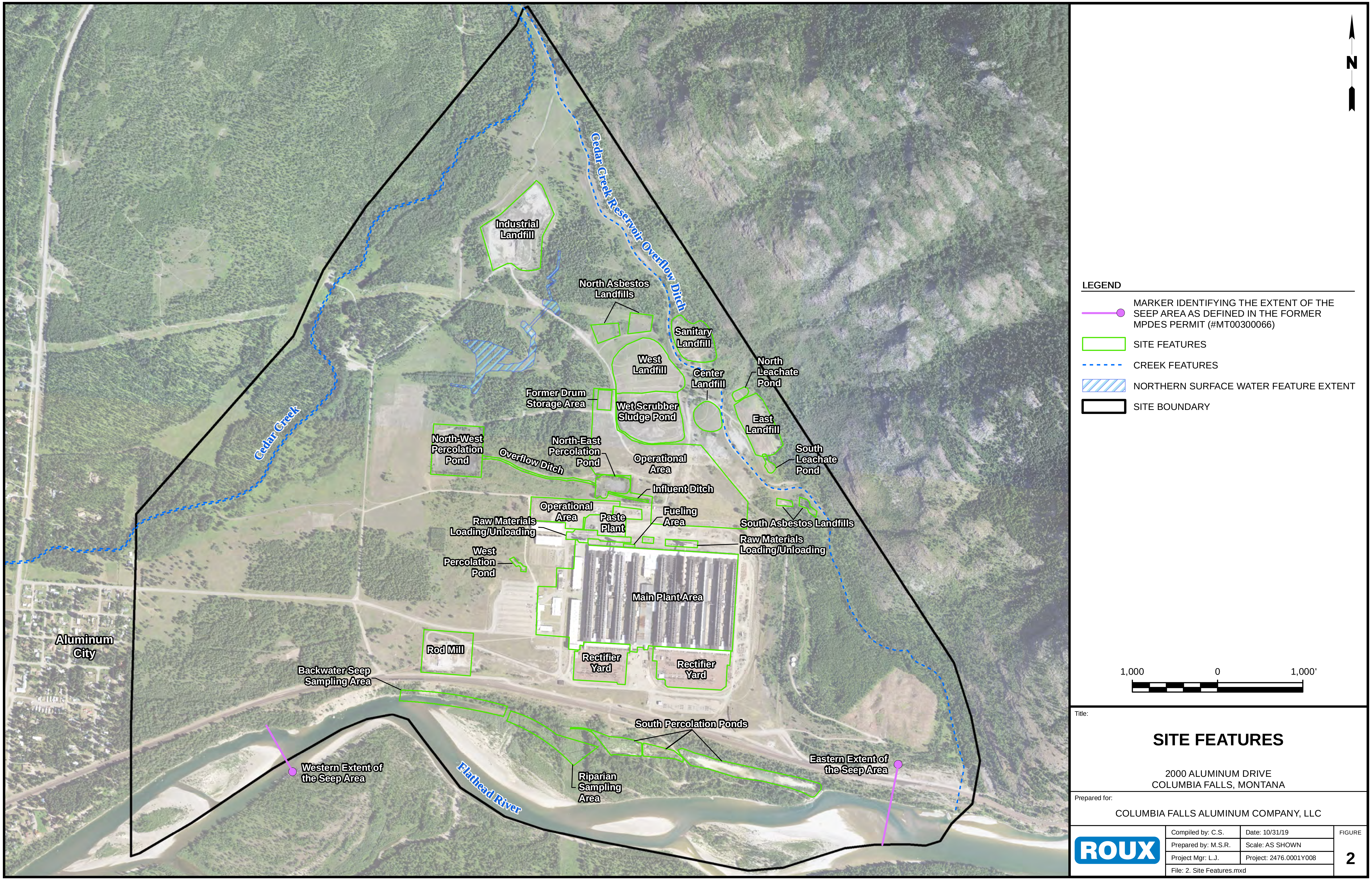
2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: MB.L.	Date: 10/31/19	FIGURE
Prepared by: M.S.R.	Scale: AS SHOWN	
Project Mgr: L.J.	Project: 2476.0001Y008	1
File: 1. RIFS Site Boundary.mxd		



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Title:

SITE FEATURES

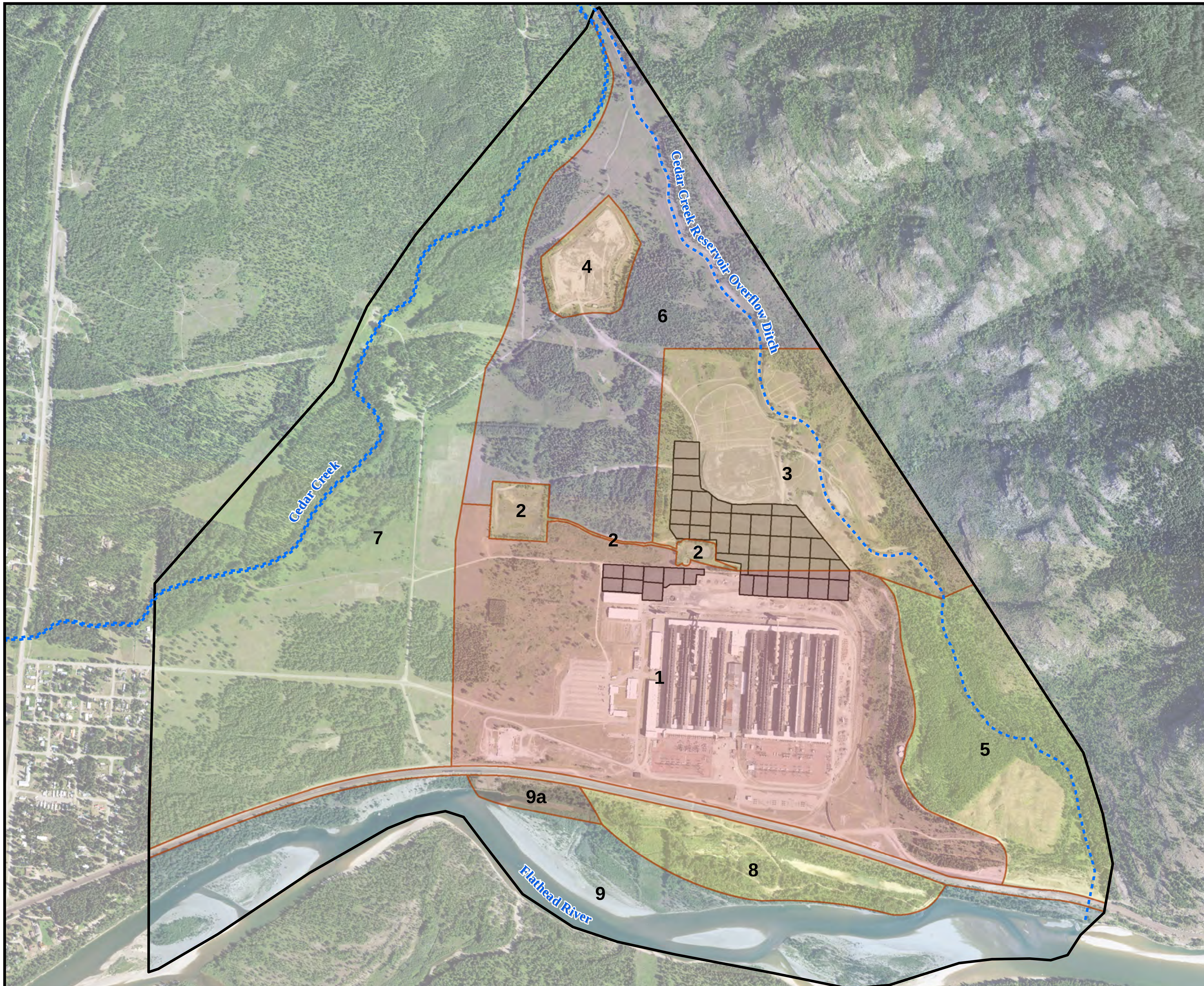
2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 10/31/19	FIGURE
Prepared by: M.S.R.	Scale: AS SHOWN	2
Project Mgr: L.J.	Project: 2476.0001Y008	
File: 2. Site Features.mxd		



LEGEND

- CREEK FEATURES
- SITE BOUNDARY
- 1 MAIN PLANT AREA
- 2 NORTH PERCOLATION POND AREA
- 3 CENTRAL LANDFILLS AREA
- 4 INDUSTRIAL LANDFILL AREA
- 5 EASTERN UNDEVELOPED AREA
- 6 NORTH-CENTRAL UNDEVELOPED AREA
- 7 WESTERN UNDEVELOPED AREA
- 8 SOUTH PERCOLATION POND AREA
- 9 FLATHEAD RIVER AREA
- 9A BACKWATER SEEP SAMPLING AREA
- ISM GRID AREA

N

1,000 0 1,000'

Title:

HUMAN HEALTH EXPOSURE AREAS

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 02/11/20	FIGURE
Prepared by: M.S.R.	Scale: AS SHOWN	3
Project Mgr: L.J.	Project: 2476.0001Y008	
File: 3. HH Risk Exposure Area.mxd		

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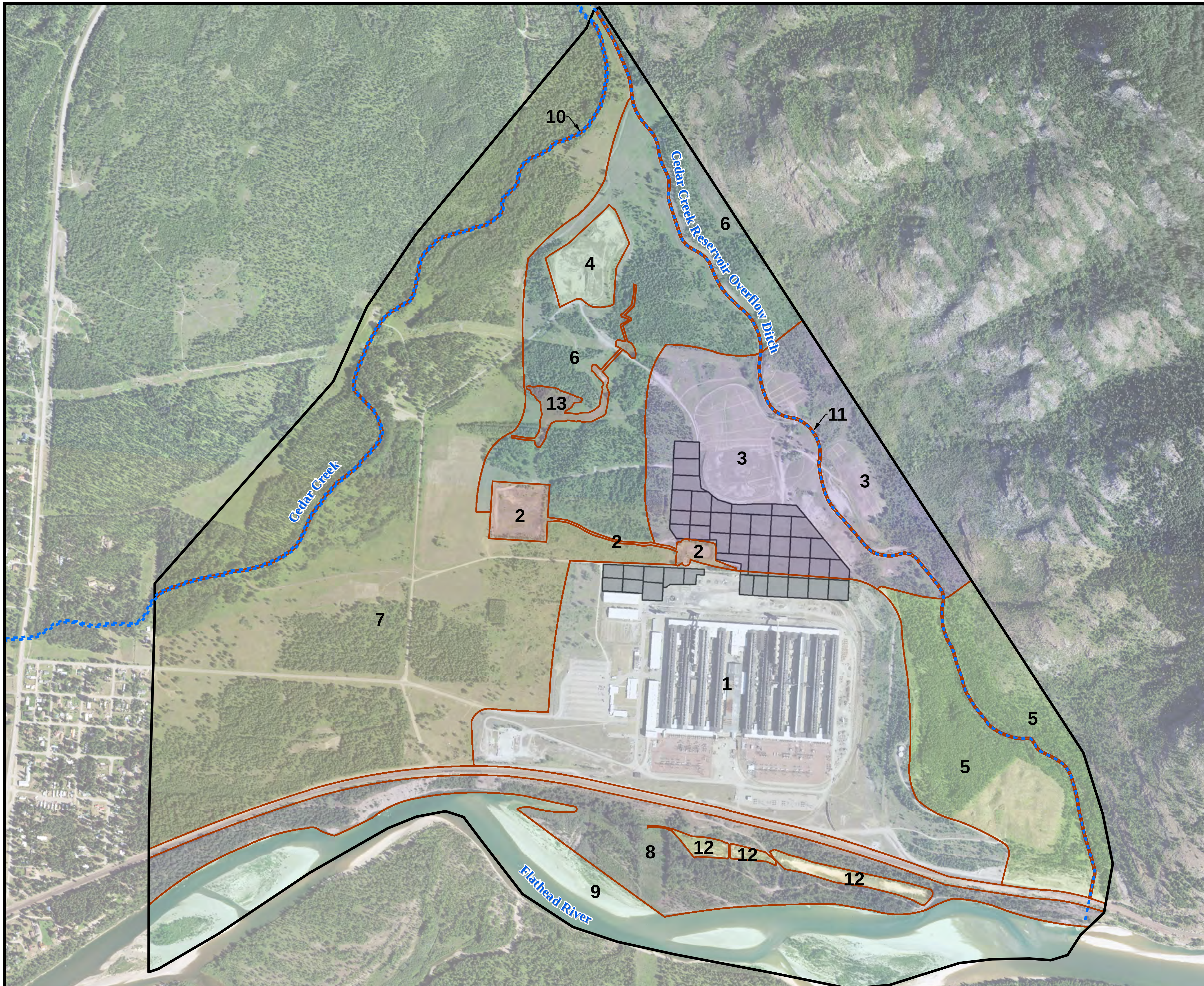

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LEGEND

- CREEK FEATURES
- SITE BOUNDARY
- 1 MAIN PLANT AREA
- 2 NORTH PERCOLATION POND AREA
- 3 CENTRAL LANDFILLS AREA
- 4 INDUSTRIAL LANDFILL AREA
- 5 EASTERN UNDEVELOPED AREA
- 6 NORTH-CENTRAL UNDEVELOPED AREA
- 7 WESTERN UNDEVELOPED AREA
- 8 FLATHEAD RIPARIAN AREA
- 9 FLATHEAD RIVER AREA
- 10 CEDAR CREEK
- 11 CEDAR CREEK RESERVOIR OVERFLOW DITCH
- 12 SOUTH PERCOLATION PONDS
- 13 NORTHERN SURFACE WATER FEATURE
- ISM GRID AREA

1,000 0 1,000'

Title:

ECOLOGICAL EXPOSURE AREAS

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 02/11/20	FIGURE
Prepared by: M.S.R.	Scale: AS SHOWN	4
Project Mgr: L.J.	Project: 2476.0001Y008	
File: 4. Eco Risk Exposure Area.mxd		

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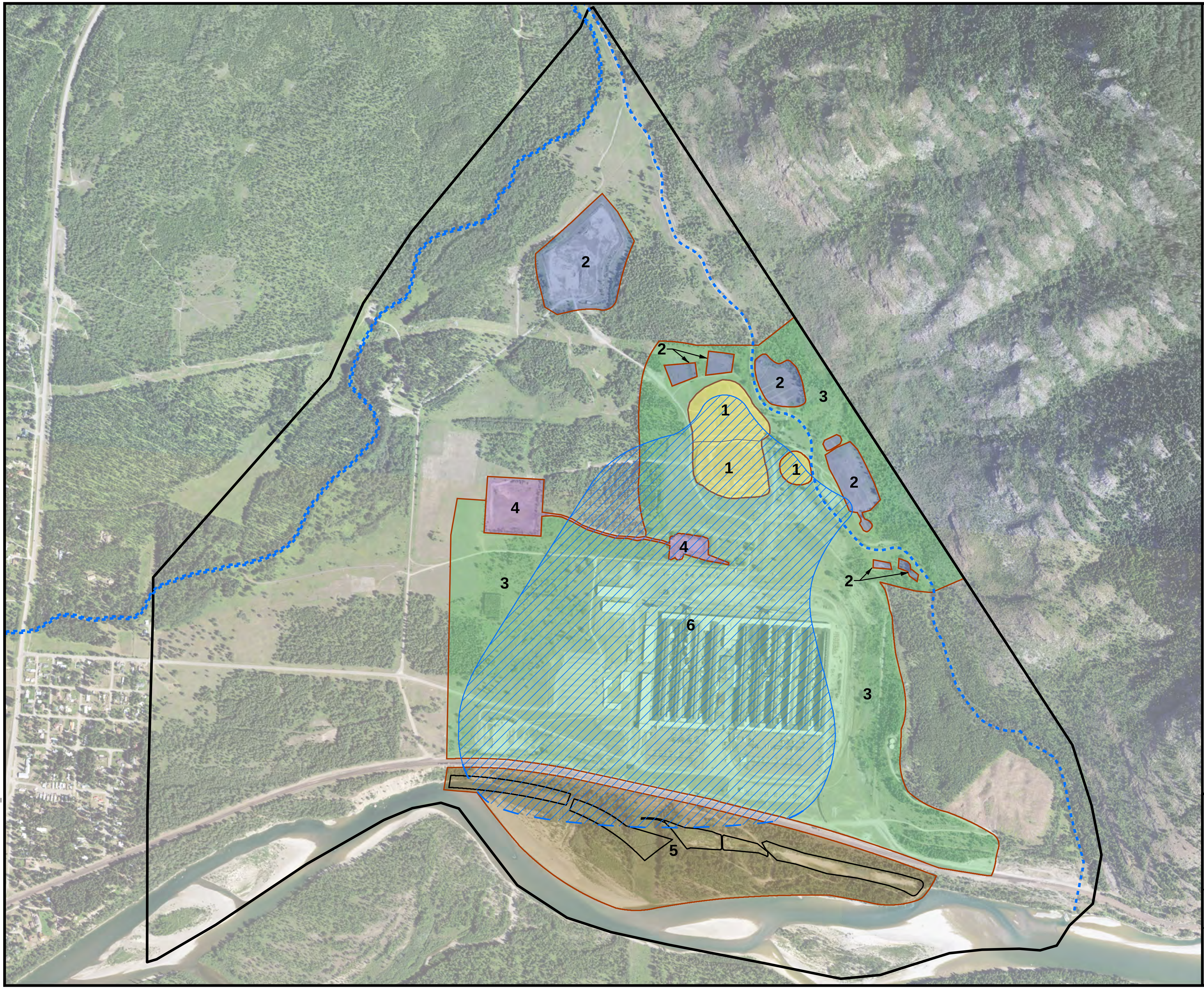

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LEGEND

- CREEK FEATURES
- 1 LANDFILLS DECISION UNIT1
- 2 LANDFILLS DECISION UNIT2
- 3 SOIL DECISION UNIT
- 4 NORTH PERCOLATION POND DECISION UNIT
- 5 RIVER AREA DECISION UNIT
- 6 GROUNDWATER DECISION UNIT
- SITE FEATURES WITHIN RIVER AREA DU
- SITE BOUNDARY

NOTES

1. THE EXTENT OF THE GROUNDWATER DU FOR THE EVALUATION OF REMEDIAL ALTERNATIVES IS THE SITE-WIDE GROUNDWATER WITHIN THE UPPER HYDROGEOLOGIC UNIT UNDERLYING THE SITE. THE CONTOUR SHOWN REPRESENTS THE COMBINED AREAL FOOTPRINT OF ARSENIC, CYANIDE, AND FLUORIDE EXCEEDANCES OF PRGS.
2. LANDFILLS DU1 INCLUDES THE WEST LANDFILL, THE WET SCRUBBER SLUDGE POND, AND THE CENTER LANDFILL.
3. LANDFILLS DU2 INCLUDES THE EAST LANDFILL, THE INDUSTRIAL LANDFILL, THE SANITARY LANDFILL, AND THE NORTH AND SOUTH ASBESTOS LANDFILLS.

1,000 0 1,000'

Title:

DECISION UNITS

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/12/20	FIGURE
Prepared by: M.S.R.	Scale: AS SHOWN	5
Project Mgr: L.J.	Project: 2476.0001Y008	
File: 5. Decision_Units.mxd		

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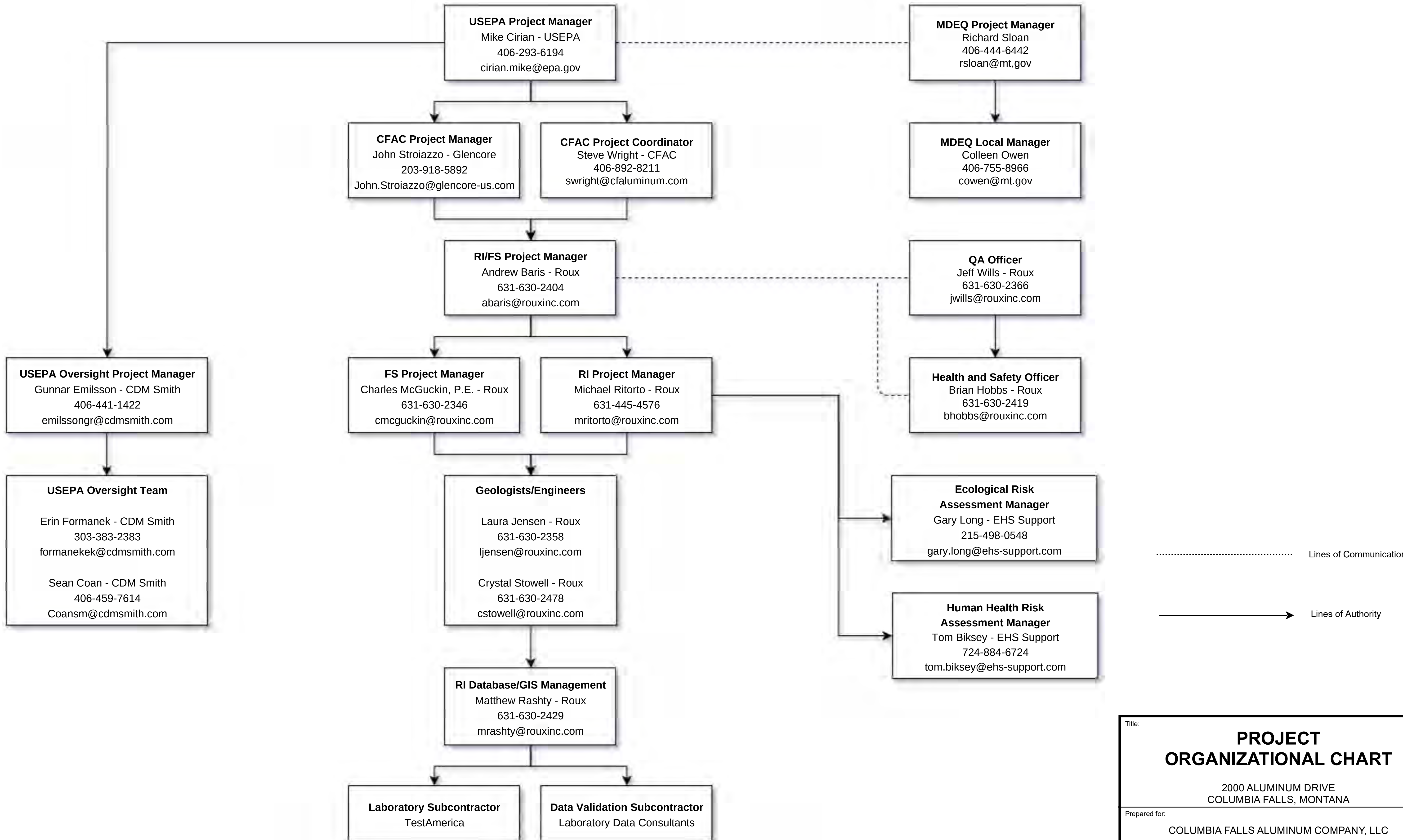

Title:

PROJECT ORGANIZATIONAL CHART

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

		FIGURE
Compiled by: C.S.	Date: 10/31/19	6
Prepared by: M.S.R.	Scale: N/A	
Project Mgr: L.J.	Project: 2476.0001Y008	
File: 6. Organizational Chart.mxd		

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APPENDICES

A. Development of Preliminary Remediation Goals (PRGs) for Human Health Risk Drivers Memorandum

B. Development of Preliminary Remediation Goals (PRGs) for Ecological Risk Drivers Memorandum

C. Human Health PRG Comparison – Soil Thematic Maps

   1. Exceedances of Human Health PRGs in Soil Samples
   2. Concentrations of Arsenic in Soil Samples – Human Health PRG Comparison
   3. Concentrations of Benzo[A]Anthracene in Soil Samples – Human Health PRG Comparison
   4. Concentrations of Benzo[A]Pyrene in Soil Samples – Human Health PRG Comparison
   5. Concentrations of Benzo[B]Fluoranthene in Soil Samples – Human Health PRG Comparison
   6. Concentrations of Dibenz[A,H]Anthracene in Soil Samples – Human Health PRG Comparison
   7. Concentrations of Indeno[1,2,3-C,D]Pyrene in Soil Samples – Human Health PRG Comparison

D. Human Health PRG Comparison – Sediment Thematic Maps

   1. Exceedances of Human Health PRGs in Sediment Samples
   2. Concentrations of Arsenic in Sediment – Human Health PRG Comparison
   3. Concentrations of Benzo[A]Pyrene in Sediment – Human Health PRG Comparison
   4. Concentrations of Benzo[B]Fluoranthene in Sediment – Human Health PRG Comparison
   5. Concentrations of Dibenz[A,H]Anthracene in Sediment – Human Health PRG Comparison
   6. Concentrations of Indeno[1,2,3-C,D]Pyrene in Sediment – Human Health PRG Comparison

E. Human Health PRG Comparison – Groundwater Contour Maps
   1. Concentrations of Arsenic in Upper Hydrogeologic Unit Groundwater – Human Health PRG Comparison
   2. Concentrations of Total Cyanide in Upper Hydrogeologic Unit Groundwater – Human Health PRG Comparison
   3. Concentrations of Fluoride in Upper Hydrogeologic Unit Groundwater – Human Health PRG Comparison
F. Ecological PRG Comparison – Soil Thematic Maps
   1. Exceedances of Ecological PRGs in Soil Samples
   2. Concentrations of Barium in Soil Samples – Ecological PRG Comparison
   3. Concentrations of Copper in Soil Samples – Ecological PRG Comparison
   4. Concentrations of Nickel in Soil Samples – Ecological PRG Comparison
   5. Concentrations of Selenium in Soil Samples – Ecological PRG Comparison
   6. Concentrations of Thallium in Soil Samples – Ecological PRG Comparison
   7. Concentrations of Vanadium in Soil Samples – Ecological PRG Comparison
   8. Concentrations of Zinc in Soil Samples – Ecological PRG Comparison
   9. Concentrations of LMW PAHs in Soil Samples – Ecological PRG Comparison
   10. Concentrations of HMW PAHs in Soil Samples – Ecological PRG Comparison
G. Ecological PRG Comparison – Sediment Thematic Maps
   1. Exceedances of Ecological PRGs in Sediment Samples
   2. Concentrations of Barium in Sediment – Ecological PRG Comparison
   3. Concentrations of Cadmium in Sediment – Ecological PRG Comparison
   4. Concentrations of Lead in Sediment – Ecological PRG Comparison
   5. Concentrations of Nickel in Sediment – Ecological PRG Comparison
   6. Concentrations of Selenium in Sediment – Ecological PRG Comparison
   7. Concentrations of Vanadium in Sediment – Ecological PRG Comparison
   8. Concentrations of Zinc in Sediment – Ecological PRG Comparison
   9. Concentrations of LMW PAHs in Sediment – Ecological PRG Comparison
   10. Concentrations of HMW PAHs in Sediment – Ecological PRG Comparison

H. Ecological PRG Comparison – Surface Water Thematic Maps

1. Exceedances of Ecological PRGs in Surface Water Samples
2. Concentrations of Dissolved Aluminum in Surface Water – Ecological PRG Comparison
3. Concentrations of Barium in Surface Water – Ecological PRG Comparison
4. Concentrations of Cadmium in Surface Water – Ecological PRG Comparison
5. Concentrations of Copper in Surface Water – Ecological PRG Comparison
6. Concentrations of Iron in Surface Water – Ecological PRG Comparison
7. Concentrations of Zinc in Surface Water – Ecological PRG Comparison
8. Concentrations of Total Cyanide in Surface Water – Ecological PRG Comparison
9. Concentrations of Dissolved Cyanide in Surface Water – Ecological PRG Comparison
10. Concentrations of Free Cyanide in Surface Water – Ecological PRG Comparison
11. Concentrations of Dissolved Free Cyanide in Surface Water – Ecological PRG Comparison
12. Concentrations of Benzo(a)anthracene in Surface Water – Ecological PRG Comparison
13. Concentrations of Benzo(a)pyrene in Surface Water – Ecological PRG Comparison
14. Concentrations of Benzo(b)fluoranthene in Surface Water – Ecological PRG Comparison
15. Concentrations of Benzo(g,h,i)perylene in Surface Water – Ecological PRG Comparison
16. Concentrations of Chrysene in Surface Water – Ecological PRG Comparison
17. Concentrations of Fluoranthene in Surface Water – Ecological PRG Comparison
18. Concentrations of Indeno(1,2,3-c,d)pyrene in Surface Water – Ecological PRG Comparison

I. Ecological PRG Comparison – Porewater Thematic Maps

1. Exceedances of Ecological PRGs in Porewater Samples
2. Concentrations of Dissolved Barium in Porewater – Ecological PRG Comparison
3. Concentrations of Dissolved Cyanide in Porewater – Ecological PRG Comparison
4. Concentrations of Dissolved Free Cyanide in Porewater – Ecological PRG Comparison

APPENDIX A

Development of Preliminary Remediation Goals (PRGs) for
Human Health Risk Drivers Memorandum

MEMO

To: Andrew Baris, Roux Environmental Engineering and Geology D.P.C.

From: Chrissy Peterson, EHS Support
Tom Biksey, EHS Support

CC: Michael Ritorto, Roux Environmental Engineering and Geology D.P.C.
Laura Jensen, Roux Environmental Engineering and Geology D.P.C.
Charlie McGuckin, Roux Environmental Engineering and Geology D.P.C.
Crystal Stowell, Roux Environmental Engineering and Geology D.P.C.
Gary Long, EHS Support

Date: January 27, 2020

Re: Development of Preliminary Remediation Goals (PRGs) for Human Health Risk Drivers at the Former Columbia Falls Aluminum Company Aluminum Reduction Facility, Columbia Falls, Montana

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Introduction

This technical memorandum describes the approach for development of risk-based preliminary remediation goals (PRGs) for human health chemicals of concern (COCs) for the Columbia Falls Aluminum Company (CFAC) Superfund Site in Columbia Falls, Montana (henceforth referred to as "the Site") that were identified in the Baseline Human Health Risk Assessment (BHHRA) (EHS Support, 2019). Sources of chemical-specific PRGs include concentrations based on applicable or relevant and appropriate requirements (ARARs) and concentrations based on risk assessment (USEPA, 1991a). The ARAR-based PRGs are considered first in the development of PRGs because they are protective of human health unless there are extenuating circumstances such as exposure to multiple COCs or pathways (USEPA, 1991b and 1997). The ARAR-based PRGs are developed in the Feasibility Study (FS) with coordination of USEPA. Risk-based PRGs are developed for those COCs without defined ARARs. The remainder of this technical memorandum is focused on the development of risk-based PRGs.

A BHHRA was conducted as part of the ongoing Remedial Investigation/Feasibility Study (RI/FS) of the Site (EHS Support, 2019). The objective of the BHHRA was to characterize potential risk to human receptors posed by exposure to contaminants of potential concern (COPCs) in affected environmental media at the Site in the absence of any remedial action. The results of the BHHRA form the basis for determining whether remedial action is necessary to address potential risk to human health in the various exposure areas identified at the Site, as well as the extent of remedial action required.

The BHHRA identified potentially complete exposure pathways for receptors with potential carcinogenic risks or non-carcinogenic hazards greater than the acceptable risk levels that may warrant additional investigation and/or remediation (EHS Support, 2019). The *de minimis* level of acceptable carcinogenic risk for the BHHRA was 10^{-6}, and the acceptable non-carcinogenic risk threshold was less than 1 for hazards (hazard quotient [HQ] or hazard index [HI]). To assist in the evaluation of potential additional investigation and/or remediation activities, Preliminary Remediation Goals (PRGs) were calculated for these potentially complete exposure pathways for the following receptors (EHS Support, 2019):

- Trespassers
- Stormwater Management Workers
- Industrial/Landfill Management Workers
- Construction Workers
- Residents

The pathways resulting in risks and/or hazards greater than the *de minimis* target levels were direct contact (incidental ingestion and dermal contact) with soils and sediment and direct contact (ingestion and dermal contact) with groundwater used as a potable water source.

The COCs identified in the BHHRA as primary risk drivers include COCs with risks exceeding the *de minimis* level of 10^{-6} and HQs exceeding 1. The primary risk drivers identified in the BHHRA include the following:

- Soil
    - Arsenic
    - Benzo(a)anthracene
    - Benzo(a)pyrene
    - Benzo(b)fluoranthene
    - Dibenz(a,h)anthracene
    - Indeno(1,2,3-c,d)pyrene
- Sediment
    - Arsenic
    - Benzo(a)pyrene
    - Benzo(b)fluoranthene
    - Dibenz(a,h)anthracene
    - Indeno(1,2,3-c,d)pyrene

In one exposure area (the Eastern Undeveloped Area), the HQ for manganese in soil (HQ = 2) exceeded the target HQ of 1 for the construction worker. However, manganese concentrations within the soil in this exposure area were found to be comparable to background. Therefore, a PRG was not calculated for manganese.

The BHHRA identified the following COCs in the upper hydrogeologic unit groundwater exposure scenarios with risks exceeding the *de minimis* level of 10^{-6} or HQs exceeding 1: cyanide (and free cyanide), fluoride, arsenic, bis(2-ethylhexyl)phthalate. However, risk-based PRGs for groundwater are not developed in this technical memorandum because these COCs have ARAR-based PRGs (e.g., Montana Department of Environmental Quality [MDEQ] and federal drinking water standards) and will be addressed in the FS.

The PRGs were calculated for the following media and receptors:

- Soil

  - Resident
  - Industrial Worker/Landfill Management Workers
  - Stormwater Management Worker
  - Construction Worker
  - Trespasser
- Sediment
  - Industrial/Landfill Management Workers
  - Stormwater Management Worker
  - Trespasser

The following section discusses the development of the PRGs. **Attachments A** through **D** present the exposure equations, assumptions, chemical-specific inputs and toxicity values, and the PRGs.

Preliminary Remediation Goal Development

The risk-based PRGs are calculated target levels using carcinogenic and non-carcinogenic toxicity values for specific exposure scenarios. The chemical-specific risk-based PRGs were developed for each media for each receptor listed above. The risk-based PRGs were developed in accordance with the United States Environmental Protection Agency (USEPA) *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals)* (USEPA, 1991a).

The equations used to calculate the risk-based PRGs for the receptors and exposure pathways are presented in **Attachment A** and are based on the equations presented in the USEPA Regional Screening Levels (RSLs) User's Guide (USEPA, 2019). The risk-based PRGs were developed for ingestion, dermal contact, and inhalation with COCs for the applicable receptors.

In accordance with the guidance (USEPA, 1991a), if both carcinogenic and non-carcinogenic risk-based PRGs are developed, the lower of the two values will be used as the risk-based PRG for the chemicals. The exposure assumptions used to calculate the risk-based PRGs were consistent with those used in the BHHRA and are presented in **Attachment B**. For residential exposures, consistent with the guidance (USEPA, 1991a) and the BHHRA, time-weighted average intake rates were calculated for lifetime cancer risks for the resident as this receptor spans a range of age groups (e.g., child, adolescent, adult). Additionally, for the resident exposure scenario the non-carcinogenic risk PRG was calculated based on the resident child as this is a more sensitive receptor than the resident adult.

Chemical-specific inputs to the equations that are consistent with those used in the BHHRA (EHS Support, 2019) are presented in **Attachment C**: **Table C-1**. Toxicity values used in the development of the PRGs are consistent with those used in the BHHRA (EHS Support, 2019). **Attachment C: Tables C-2** and **C-3** present the non-cancer and cancer oral toxicity values, respectively. The non-cancer and cancer inhalation toxicity values are presented in **Attachment C: Tables C-4** and **C-5**.

Two sets of risk-based PRGs were calculated using different target incremental excess lifetime cancer risk values of 10^{-6} and 10^{-5}. The target non-carcinogenic risk for each set of PRGs was based on an HQ of 1. The risk-based PRGs are presented for each media and receptor in **Table 1** and **Table 2**. **Attachment D: Tables D-1** through **D-4** present the supplemental PRG calculations.

PRG Application

It should be noted that the risk-based PRGs presented in this technical memorandum, or any risk-based PRGs developed for the protection of human receptors, should not necessarily be regarded as not-to-exceed values. Rather, based on the assumptions and endpoints presented in the BHHRA, the risk-based PRGs represent a conservative estimate of the average concentration that receptors could be exposed to that would be expected to result in minimal risk. Thus, a risk-based PRG may be achieved at an area by remediating portions of the exposure area with elevated levels of constituents such that the conservative estimate of remaining concentrations (as reflected by a 95 percent upper confidence limit of the mean, for example) do not exceed the risk-based PRG. This scenario may result (and often does) in constituents remaining in place at concentrations that exceed the risk-based PRG. A risk assessor should be consulted regarding additional details and appropriate applications of risk-based PRGs during remedial decision making to ensure that the assumptions and conditions that are inherent in the risk-based PRGs are considered at an early stage of the remedial decision-making process.

References

EHS Support. 2019. Baseline Human Health Risk Assessment. Columbia Falls Aluminum Company. Columbia Falls, Flathead County, MT. July 29.

TechLaw. 2017. Final 2017 Sampling and Analysis Plan/Quality Assurance Project Plan. Nelson Tunnel Superfund Site, Mineral County, Colorado. April.

USEPA. 1991a. Risk Assessment Guidance for Superfund: Volume 1 – Human Health Evaluation Manual Part B, Development of Risk Based Preliminary Remediation Goals, December.

USEPA. 1991b. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. OSWER Directive 9355.0-30. April 22, 1991.

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USEPA. 2019. Regional Screening Levels for Chemical Contaminants at Superfund Sites and User's Guide. DOE Oak Ridge National Laboratory (ORNL). November.

Tables

Table 1 – Summary of PRGs (Target Risk 10^{-6})

Table 2 – Summary of PRGs (Target Risk 10^{-5})

Attachments

Attachment A – Equations

Attachment B – Exposure Assumptions

Attachment C – Chemical-Specific Parameters and Toxicity Values

Attachment D – Supplemental PRG Tables

Tables

Table 1
Summary of PRGs (Target Risk 10^{-6})
Columbia Falls Aluminum Facility
Columbia Falls, Montana

Target Risk 10-6, THQ = 1

CAS Number	Chemical Name	Industrial/ Landfill Management Worker	Basis	Stormwater Management Worker	Basis	Construction Worker	Basis	Trespasser	Basis	Resident	Basis
Soil SLs (mg/kg)											
7440-38-2	Arsenic	4.0E+00	c	2.0E+01	c	3.8E+01	c	1.5E+02	c	8.8E-01	c
56-55-3	Benzo(A)Anthracene	2.8E+01	c	1.4E+02	c	3.4E+02	c	3.5E+02	c	1.5E+00	c
50-32-8	Benzo(A)Pyrene	2.8E+00	c	1.4E+01	c	2.0E+01	nc	3.5E+01	c	1.5E-01	c
205-99-2	Benzo(B)Fluoranthene	2.8E+01	c	1.4E+02	c	3.4E+02	c	3.5E+02	c	1.5E+00	c
53-70-3	Dibenz(A,H)Anthracene	2.8E+00	c	1.4E+01	c	3.4E+01	c	3.5E+01	c	1.5E-01	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	2.8E+01	c	1.4E+02	c	3.4E+02	c	3.5E+02	c	1.5E+00	c
Sediment SLs (mg/kg)											
CAS Number	**Chemical Name**	**Industrial/ Landfill Management Worker**	**Basis**	**Stormwater Management Worker**	**Basis**	**Construction Worker**	**Basis**	**Trespasser**	**Basis**	**Resident**	**Basis**
7440-38-2	Arsenic	4.0E+00	c	2.0E+01	c	NA	NA	1.5E+02	c	NA	NA
50-32-8	Benzo(A)Pyrene	2.8E+00	c	1.4E+01	c	NA	NA	3.5E+01	c	NA	NA
205-99-2	Benzo(B)Fluoranthene	2.8E+01	c	1.4E+02	c	NA	NA	3.5E+02	c	NA	NA
53-70-3	Dibenz(A,H)Anthracene	2.8E+00	c	1.4E+01	c	NA	NA	3.5E+01	c	NA	NA
193-39-5	Indeno(1,2,3-C,D)Pyrene	2.8E+01	c	1.4E+02	c	NA	NA	3.5E+02	c	NA	NA

Notes:
c = cancer
CAS = Chemical Abstracts Service
NA - not applicable
nc = non-cancer
PRG = preliminary remediation guideline
SL = screening level
SL units - milligrams per kilogram (mg/kg)
THQ = target hazard quotient

EHS Support

Table 2
Summary of PRGs (Target Risk 10^{-5})
Columbia Falls Aluminum Facility
Columbia Falls, Montana

Target Risk 10-5, THQ = 1

Soil SLs (mg/kg)											
CAS Number	**Chemical Name**	**Industrial/ Landfill Management Worker**	**Basis**	**Stormwater Management Worker**	**Basis**	**Construction Worker**	**Basis**	**Trespasser**	**Basis**	**Resident**	**Basis**
7440-38-2	Arsenic	4.0E+01	c	2.0E+02	c	1.1E+02	nc	1.5E+03	c	8.8E+00	c
56-55-3	Benzo(A)Anthracene	2.8E+02	c	1.4E+03	c	3.4E+03	c	3.5E+03	c	1.5E+01	c
50-32-8	Benzo(A)Pyrene	2.8E+01	c	1.4E+02	c	2.0E+01	nc	3.5E+02	c	1.5E+00	c
205-99-2	Benzo(B)Fluoranthene	2.8E+02	c	1.4E+03	c	3.4E+03	c	3.5E+03	c	1.5E+01	c
53-70-3	Dibenz(A,H)Anthracene	2.8E+01	c	1.4E+02	c	3.4E+02	c	3.5E+02	c	1.5E+00	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	2.8E+02	c	1.4E+03	c	3.4E+03	c	3.5E+03	c	1.5E+01	c
Sediment SLs (mg/kg)											
CAS Number	**Chemical Name**	**Industrial/ Landfill Management Worker**	**Basis**	**Stormwater Management Worker**	**Basis**	**Construction Worker**	**Basis**	**Trespasser**	**Basis**	**Resident**	**Basis**
7440-38-2	Arsenic	4.0E+01	c	2.0E+02	c	NA	NA	1.5E+03	c	NA	NA
50-32-8	Benzo(A)Pyrene	2.8E+01	c	1.4E+02	c	NA	NA	3.5E+02	c	NA	NA
205-99-2	Benzo(B)Fluoranthene	2.8E+02	c	1.4E+03	c	NA	NA	3.5E+03	c	NA	NA
53-70-3	Dibenz(A,H)Anthracene	2.8E+01	c	1.4E+02	c	NA	NA	3.5E+02	c	NA	NA
193-39-5	Indeno(1,2,3-C,D)Pyrene	2.8E+02	c	1.4E+03	c	NA	NA	3.5E+03	c	NA	NA

Notes:
c = cancer
CAS = Chemical Abstracts Service
NA - not applicable
nc = non-cancer
PRG = preliminary remediation guideline
SL = screening level
SL units - milligrams per kilogram (mg/kg)
THQ = target hazard quotient

Attachment A – Equations

Attachment A-1 – Soil Equations

Soil – Resident

Non-carcinogenic Child

Incidental Ingestion of Soil

$$SL_{res-soil-nc-ing} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{res-c}} \times \mathrm{BW}_{\mathrm{res-c}}}{\mathrm{EF}_{res-c} \times \mathrm{ED}_{res-c} \times \frac{RBA}{RfD_o} \times IRS_{res-c} \times \frac{10^{-6}kg}{1\ mg}}$$

Dermal Contact with Soil

$$SL_{res-soil-nc-der} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{res-c}} \times \mathrm{BW}_{\mathrm{res-c}}}{\mathrm{EF}_{res-c} \times \mathrm{ED}_{res-c} \times \frac{1}{RfD_o \times GIABS} \times SA_{res-c} \times AF_{res-c} \times ABS_d \times \frac{10^{-6}kg}{1\ mg}}$$

Inhalation of Soil Particulate and Volatiles

$$SL_{res-soil-nc-inh} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{res-c}}}{\mathrm{EF}_{res-c} \times \mathrm{ED}_{res-c} \times \mathrm{ET}_{res-c} \times \frac{1\ day}{24\ hours} \times \frac{1}{RfC_i} \times \left(\frac{1}{VF} + \frac{1}{PEF}\right)}$$

Total

$$SL_{res-soil-nc-tot} = \frac{1}{\frac{1}{SL_{res-soil-nc-ing}} + \frac{1}{SL_{res-soil-nc-der}} + \frac{1}{SL_{res-soil-nc-inh}}}$$

Carcinogenic

Incidental Ingestion of Soil

$$SL_{res-soil-ca-ing} = \frac{\mathrm{TR} \times \mathrm{AT}_{\mathrm{res}}}{\mathrm{CSF}_o \times RBA \times IRS_{res-adj} \times \frac{10^{-6}kg}{1\ mg}}$$

- Where:

$$IRS_{res-adj} = \left(\frac{EF_{res-c} \times ED_{res-c} \times IRS_{res-c}}{\mathrm{BW}_{res-c}} + \frac{EF_{res-a} \times ED_{res-a} \times IRS_{res-a}}{\mathrm{BW}_{res-a}}\right)$$

Soil – Resident (continued)

Carcinogenic

Dermal Contact with Soil

$$SL_{res-soil-ca-der} = \frac{\mathrm{TR} \times \mathrm{AT_{res}}}{\frac{CSF_o}{GIABS} \times DFS_{res-adj} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

- Where:

$$DFS_{res-adj} = \left(\frac{EF_{res-c} \times ED_{res-c} \times SA_{res-c} \times AF_{res-c}}{\mathrm{BW}_{res-c}} + \frac{EF_{res-a} \times ED_{res-a} \times SA_{res-a} \times AF_{res-a}}{\mathrm{BW}_{res-a}}\right)$$

Inhalation of Soil Particulate and Volatiles

$$SL_{res-soil-ca-inh} = \frac{\mathrm{THQ} \times \mathrm{AT_{res-c}}}{IUR \times \frac{1000\ \mu g}{1\ mg} \times \mathrm{EF}_{res} \times \left(\frac{1}{VF} + \frac{1}{PEF}\right) \times \mathrm{ED}_{res} \times \mathrm{ET}_{res} \times \frac{1\ day}{24\ hours}}$$

Total

$$SL_{res-soil-ca-tot} = \frac{1}{\frac{1}{SL_{res-soil-ca-ing}} + \frac{1}{SL_{res-soil-ca-der}} + \frac{1}{SL_{res-soil-ca-inh}}}$$

Soil – Resident (continued)

Mutagenic

Incidental Ingestion of Soil

$$SL_{res-soil-mu-ing} = \frac{\mathrm{TR} \times \mathrm{AT_{res}}}{\mathrm{CSF}_o \times RBA \times IRSM_{res-adj} \times \frac{10^{-6} kg}{1\ mg}}$$

- Where:

$$IRSM_{res-adj} = \left(\begin{array}{c} \frac{EF_{0-2} \times ED_{0-2} \times IRS_{0-2} \times 10}{\mathrm{BW_{0-2}}} + \\ \frac{EF_{2-6} \times ED_{2-6} \times IRS_{2-6} \times 3}{\mathrm{BW_{2-6}}} + \\ \frac{EF_{6-16} \times ED_{6-16} \times IRS_{6-16} \times 3}{\mathrm{BW_{6-16}}} + \\ \frac{EF_{16-26} \times ED_{16-26} \times IRS_{16-26} \times 1}{\mathrm{BW_{16-26}}} \end{array} \right)$$

Dermal Contact with Soil

$$SL_{res-soil-mu-der} = \frac{\mathrm{TR} \times \mathrm{AT_{res}}}{\frac{CSF_o}{GIABS} \times DFSM_{res-adj} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

- Where:

$$DFSM_{res-adj} = \left(\begin{array}{c} \frac{EF_{0-2} \times ED_{0-2} \times AF_{0-2} \times SA_{0-2} \times 10}{\mathrm{BW_{0-2}}} + \\ \frac{EF_{2-6} \times ED_{2-6} \times AF_{2-6} \times SA_{2-6} \times 3}{\mathrm{BW_{2-6}}} + \\ \frac{EF_{6-16} \times ED_{6-16} \times AF_{6-16} \times SA_{6-16} \times 3}{\mathrm{BW_{6-16}}} + \\ \frac{EF_{16-26} \times ED_{16-26} \times AF_{16-26} \times SA_{16-26} \times 1}{\mathrm{BW_{16-26}}} \end{array} \right)$$

Soil – Resident (continued)

Mutagenic

Inhalation of Soil Particulate and Volatiles

$$SL_{res-soil-mu-inh} = \frac{\mathrm{TR} \times \mathrm{AT_{res}}}{IUR \times \left(\frac{1}{VF} + \frac{1}{PEF}\right) \times \frac{1000\ \mu g}{1\ mg} \times \begin{pmatrix} ET_{0-2} \times \frac{1\ day}{24\ hours} \times EF_{0-2} \times ED_{0-2} \times 10 + \\ ET_{2-6} \times \frac{1\ day}{24\ hours} \times EF_{2-6} \times ED_{2-6} \times 3 + \\ ET_{6-16} \times \frac{1\ day}{24\ hours} \times EF_{6-16} \times ED_{6-16} \times 3 + \\ ET_{16-26} \times \frac{1\ day}{24\ hours} \times EF_{16-26} \times ED_{16-26} \times 1 \end{pmatrix}}$$

Total

$$SL_{res-soil-mu-tot} = \frac{1}{\frac{1}{SL_{res-soil-mu-ing}} + \frac{1}{SL_{res-soil-mu-der}} + \frac{1}{SL_{res-soil-mu-inh}}}$$

Soil – Industrial Worker/Landfill Management Worker

Non-carcinogenic

Incidental Ingestion of Soil

$$SL_{ind-soil-nc-ing} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{ind-n}} \times \mathrm{BW}_{\mathrm{ind}}}{\mathrm{EF}_{ind} \times \mathrm{ED}_{ind} \times \frac{RBA}{RfD_o} \times IRS_{ind} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Soil

$$SL_{ind-soil-nc-der} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{ind-n}} \times \mathrm{BW}_{\mathrm{ind}}}{\mathrm{EF}_{ind} \times \mathrm{ED}_{ind} \times \frac{1}{RfD_o \times GIABS} \times SA_{ind} \times AF_{ind} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Inhalation of Soil Particulate and Volatiles

$$SL_{ind-soil-nc-inh} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{ind-n}}}{\mathrm{EF}_{ind} \times \mathrm{ED}_{ind} \times \mathrm{ET}_{ind} \times \frac{1\ day}{24\ hours} \times \frac{1}{RfC_i} \times \left(\frac{1}{VF} + \frac{1}{PEF}\right)}$$

Total

$$SL_{ind-soil-nc-tot} = \frac{1}{\frac{1}{SL_{ind-soil-nc-ing}} + \frac{1}{SL_{ind-soil-nc-der}} + \frac{1}{SL_{ind-soil-nc-inh}}}$$

Carcinogenic

Incidental Ingestion of Soil

$$SL_{ind-soil-ca-ing} = \frac{\mathrm{TR} \times \mathrm{AT}_{\mathrm{ind-c}} \times \mathrm{BW}_{ind}}{EF_{ind} \times ED_{ind} \times \mathrm{CSF}_o \times RBA \times IRS_{ind} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Soil

$$SL_{ind-soil-ca-der} = \frac{\mathrm{TR} \times \mathrm{AT}_{\mathrm{ind-c}} \times \mathrm{BW}_{ind}}{EF_{ind} \times ED_{ind} \times \frac{CSF_o}{GIABS} \times SA_{ind} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Soil – Industrial Worker/Landfill Management Worker

Carcinogenic

Inhalation of Soil Particulate and Volatiles

$$SL_{ind-soil-ca-inh} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{ind-c}}}{IUR \ \times \frac{1000\ \mu g}{1\ mg} \times \ \mathrm{EF}_{ind} \times \left(\frac{1}{VF} + \frac{1}{PEF}\right) \times \mathrm{ED}_{ind} \times \mathrm{ET}_{ind} \times \frac{1\ day}{24\ hours}}$$

Total

$$SL_{ind-soil-ca-tot} = \frac{1}{\frac{1}{SL_{ind-soil-ca-ing}} + \frac{1}{SL_{ind-soil-ca-der}} + \frac{1}{SL_{ind-soil-ca-inh}}}$$

Soil – Stormwater Management Worker

Non-carcinogenic

Incidental Ingestion of Soil

$$SL_{storm-soil-nc-ing} = \frac{\text{THQ} \times \text{AT}_{\text{storm-n}} \times \text{BW}_{\text{storm}}}{\text{EF}_{storm} \times \text{ED}_{storm} \times \frac{RBA}{RfD_o} \times IRS_{storm} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Soil

$$SL_{storm-soil-nc-der} = \frac{\text{THQ} \times \text{AT}_{\text{storm-n}} \times \text{BW}_{\text{storm}}}{\text{EF}_{storm} \times \text{ED}_{storm} \times \frac{1}{RfD_o \times GIABS} \times SA_{storm} \times AF_{storm} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Inhalation of Soil Particulate and Volatiles

$$SL_{storm-soil-nc-inh} = \frac{\text{THQ} \times \text{AT}_{\text{storm-n}}}{\text{EF}_{storm} \times \text{ED}_{storm} \times \text{ET}_{storm} \times \frac{1\ day}{24\ hours} \times \frac{1}{RfC_i} \times \left(\frac{1}{VF} + \frac{1}{PEF}\right)}$$

Total

$$SL_{storm-soil-nc-tot} = \frac{1}{\frac{1}{SL_{storm-soil-nc-ing}} + \frac{1}{SL_{storm-soil-nc-der}} + \frac{1}{SL_{storm-soil-nc-inh}}}$$

Carcinogenic

Incidental Ingestion of Soil

$$SL_{storm-soil-ca-ing} = \frac{\text{TR} \times \text{AT}_{\text{storm-c}} \times \text{BW}_{storm}}{EF_{storm} \times ED_{storm} \times \text{CSF}_o \times RBA \times IRS_{storm} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Soil

$$SL_{storm-soil-ca-der} = \frac{\text{TR} \times \text{AT}_{\text{storm-c}} \times \text{BW}_{storm}}{EF_{storm} \times ED_{storm} \times \frac{CSF_o}{GIABS} \times SA_{storm} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Soil – Stormwater Management Worker

Carcinogenic

Inhalation of Soil Particulate and Volatiles

$$SL_{storm-soil-ca-inh} = \frac{\mathrm{THQ} \times \mathrm{AT_{storm-c}}}{IUR \times \frac{1000\ \mu g}{1\ mg} \times \mathrm{EF}_{storm} \times \left(\frac{1}{VF} + \frac{1}{PEF}\right) \times \mathrm{ED}_{storm} \times \mathrm{ET}_{storm} \times \frac{1\ day}{24\ hours}}$$

Total

$$SL_{storm-soil-ca-tot} = \frac{1}{\frac{1}{SL_{storm-soil-ca-ing}} + \frac{1}{SL_{storm-soil-ca-der}} + \frac{1}{SL_{storm-soil-ca-inh}}}$$

Soil – Construction Worker

Non-carcinogenic

Incidental Ingestion of Soil

$$SL_{cw-soil-nc-ing} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{cw-n}} \times \mathrm{BW}_{\mathrm{cw}}}{\mathrm{EF}_{cw} \times \mathrm{ED}_{cw} \times \frac{RBA}{RfD_o} \times IRS_{cw} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Soil

$$SL_{cw-soil-nc-der} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{cw-n}} \times \mathrm{BW}_{\mathrm{cw}}}{\mathrm{EF}_{cw} \times \mathrm{ED}_{cw} \times \frac{1}{RfD_o \times GIABS} \times SA_{cw} \times AF_{cw} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Inhalation of Soil Particulate and Volatiles

$$SL_{cw-soil-nc-inh} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{cw-n}}}{\mathrm{EF}_{cw} \times \mathrm{ED}_{cw} \times \mathrm{ET}_{cw} \times \frac{1\ day}{24\ hours} \times \frac{1}{RfC_i} \times \left(\frac{1}{VF} + \frac{1}{PEF_{cw}}\right)}$$

Total

$$SL_{cw-soil-nc-tot} = \frac{1}{\frac{1}{SL_{cw-soil-nc-ing}} + \frac{1}{SL_{cw-soil-nc-der}} + \frac{1}{SL_{cw-soil-nc-inh}}}$$

Carcinogenic

Incidental Ingestion of Soil

$$SL_{cw-soil-ca-ing} = \frac{\mathrm{TR} \times \mathrm{AT}_{\mathrm{cw-c}} \times \mathrm{BW}_{cw}}{EF_{cw} \times ED_{cw} \times \mathrm{CSF}_o \times RBA \times IRS_{cw} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Soil

$$SL_{cw-soil-ca-der} = \frac{\mathrm{TR} \times \mathrm{AT}_{\mathrm{cw-c}} \times \mathrm{BW}_{cw}}{EF_{cw} \times ED_{cw} \times \frac{CSF_o}{GIABS} \times SA_{cw} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Soil – Construction Worker (continued)

Carcinogenic

Inhalation of Soil Particulate and Volatiles

$$SL_{cw-soil-ca-inh} = \frac{\mathrm{THQ} \times \mathrm{AT_{cw-c}}}{IUR \ \times \frac{1000\ \mu g}{1\ mg} \times \ \mathrm{EF}_{cw} \times \left(\frac{1}{VF} + \frac{1}{PEF_{cw}}\right) \times \mathrm{ED}_{cw} \times \mathrm{ET}_{cw} \times \frac{1\ day}{24\ hours}}$$

Total

$$SL_{cw-soil-ca-tot} = \frac{1}{\frac{1}{SL_{cw-soil-ca-ing}} + \frac{1}{SL_{cw-soil-ca-der}} + \frac{1}{SL_{cw-soil-ca-inh}}}$$

Soil – Trespasser

Non-carcinogenic

Incidental Ingestion of Soil

$$SL_{tres-soil-nc-ing} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{tres-n}} \times \mathrm{BW}_{\mathrm{tres}}}{\mathrm{EF}_{tres} \times \mathrm{ED}_{tres} \times \frac{RBA}{RfD_o} \times IRS_{tres} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Soil

$$SL_{tres-soil-nc-der} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{tres-n}} \times \mathrm{BW}_{\mathrm{tres}}}{\mathrm{EF}_{tres} \times \mathrm{ED}_{tres} \times \frac{1}{RfD_o \times GIABS} \times SA_{tres} \times AF_{tres} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Inhalation of Soil Particulate and Volatiles

$$SL_{tres-soil-nc-inh} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{tres-n}}}{\mathrm{EF}_{tres} \times \mathrm{ED}_{tres} \times \mathrm{ET}_{tres} \times \frac{1\ day}{24\ hours} \times \frac{1}{RfC_i} \times \left(\frac{1}{VF} + \frac{1}{PEF}\right)}$$

Total

$$SL_{tres-soil-nc-tot} = \frac{1}{\frac{1}{SL_{tres-soil-nc-ing}} + \frac{1}{SL_{tres-soil-nc-der}} + \frac{1}{SL_{tres-soil-nc-inh}}}$$

Carcinogenic

Incidental Ingestion of Soil

$$SL_{tres-soil-ca-ing} = \frac{\mathrm{TR} \times \mathrm{AT}_{\mathrm{tres-c}} \times \mathrm{BW}_{tres}}{EF_{tres} \times ED_{tres} \times \mathrm{CSF}_o \times RBA \times IRS_{tres} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Soil

$$SL_{tres-soil-ca-der} = \frac{\mathrm{TR} \times \mathrm{AT}_{\mathrm{tres-c}} \times \mathrm{BW}_{tres}}{EF_{tres} \times ED_{tres} \times \frac{CSF_o}{GIABS} \times SA_{tres} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Soil – Trespasser (continued)

Carcinogenic

Inhalation of Soil Particulate and Volatiles

$$SL_{tres-soil-ca-inh} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{tres-c}}}{IUR \ \times \frac{1000\ \mu g}{1\ mg} \times \ \mathrm{EF}_{tres} \times \left(\frac{1}{VF} + \frac{1}{PEF}\right) \times \mathrm{ED}_{tres} \times \mathrm{ET}_{tres} \times \frac{1\ day}{24\ hours}}$$

Total

$$SL_{tres-soil-ca-tot} = \frac{1}{\frac{1}{SL_{tres-soil-ca-ing}} + \frac{1}{SL_{tres-soil-ca-der}} + \frac{1}{SL_{tres-soil-ca-inh}}}$$

Attachment A-2 – Sediment Equations

Sediment – Industrial Worker/Landfill Management Worker

Non-carcinogenic

Incidental Ingestion of Sediment

$$SL_{ind-sediment-nc-ing} = \frac{\mathrm{THQ} \times \mathrm{AT_{ind-n}} \times \mathrm{BW_{ind}}}{\mathrm{EF}_{ind} \times \mathrm{ED}_{ind} \times \frac{RBA}{RfD_o} \times IRS_{ind} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Sediment

$$SL_{ind-sediment-nc-der} = \frac{\mathrm{THQ} \times \mathrm{AT_{ind-n}} \times \mathrm{BW_{ind}}}{\mathrm{EF}_{ind} \times \mathrm{ED}_{ind} \times \frac{1}{RfD_o \times GIABS} \times SA_{ind} \times AF_{ind} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Total

$$SL_{ind-sediment-nc-tot} = \frac{1}{\frac{1}{SL_{ind-sediment-nc-ing}} + \frac{1}{SL_{ind-sediment-nc-der}}}$$

Carcinogenic

Incidental Ingestion of Sediment

$$SL_{ind-sediment-ca-ing} = \frac{\mathrm{TR} \times \mathrm{AT_{ind-c}} \times \mathrm{BW}_{ind}}{EF_{ind} \times ED_{ind} \times \mathrm{CSF}_o \times RBA \times IRS_{ind} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Sediment

$$SL_{ind-sediment-ca-der} = \frac{\mathrm{TR} \times \mathrm{AT_{ind-c}} \times \mathrm{BW}_{ind}}{EF_{ind} \times ED_{ind} \times \frac{CSF_o}{GIABS} \times SA_{ind} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Total

$$SL_{ind-sediment-ca-tot} = \frac{1}{\frac{1}{SL_{ind-sediment-ca-ing}} + \frac{1}{SL_{ind-sediment-ca-der}}}$$

Sediment – Stormwater Management Worker

Non-carcinogenic

Incidental Ingestion of Sediment

$$SL_{storm-sediment-nc-ing} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{storm-n}} \times \mathrm{BW}_{\mathrm{storm}}}{\mathrm{EF}_{storm} \times \mathrm{ED}_{storm} \times \frac{RBA}{RfD_o} \times IRS_{storm} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Sediment

$$SL_{storm-sediment-nc-der} = \frac{\mathrm{THQ} \times \mathrm{AT}_{\mathrm{storm-n}} \times \mathrm{BW}_{\mathrm{storm}}}{\mathrm{EF}_{storm} \times \mathrm{ED}_{storm} \times \frac{1}{RfD_o \times GIABS} \times SA_{storm} \times AF_{storm} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Total

$$SL_{storm-sediment-nc-tot} = \frac{1}{\frac{1}{SL_{storm-sediment-nc-ing}} + \frac{1}{SL_{storm-sediment-nc-der}}}$$

Carcinogenic

Incidental Ingestion of Sediment

$$SL_{storm-sediment-ca-ing} = \frac{\mathrm{TR} \times \mathrm{AT}_{\mathrm{storm-c}} \times \mathrm{BW}_{storm}}{EF_{storm} \times ED_{storm} \times \mathrm{CSF}_o \times RBA \times IRS_{storm} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Sediment

$$SL_{storm-sediment-ca-der} = \frac{\mathrm{TR} \times \mathrm{AT}_{\mathrm{storm-c}} \times \mathrm{BW}_{storm}}{EF_{storm} \times ED_{storm} \times \frac{CSF_o}{GIABS} \times SA_{storm} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Total

$$SL_{storm-sediment-ca-tot} = \frac{1}{\frac{1}{SL_{storm-sediment-ca-ing}} + \frac{1}{SL_{storm-sediment-ca-der}}}$$

Sediment – Trespasser

Non-carcinogenic

Incidental Ingestion of Sediment

$$SL_{tres-sediment-nc-ing} = \frac{\mathrm{THQ} \times \mathrm{AT_{tres-n}} \times \mathrm{BW_{tres}}}{\mathrm{EF}_{tres} \times \mathrm{ED}_{tres} \times \frac{RBA}{RfD_o} \times IRS_{tres} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Sediment

$$SL_{tres-sediment-nc-der} = \frac{\mathrm{THQ} \times \mathrm{AT_{tres-n}} \times \mathrm{BW_{tres}}}{\mathrm{EF}_{tres} \times \mathrm{ED}_{tres} \times \frac{1}{RfD_o \times GIABS} \times SA_{tres} \times AF_{tres} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Total

$$SL_{tres-sediment-nc-tot} = \frac{1}{\frac{1}{SL_{tres-sediment-nc-ing}} + \frac{1}{SL_{tres-sediment-nc-der}}}$$

Carcinogenic

Incidental Ingestion of Sediment

$$SL_{tres-sediment-ca-ing} = \frac{\mathrm{TR} \times \mathrm{AT_{tres-c}} \times \mathrm{BW}_{tres}}{EF_{tres} \times ED_{tres} \times \mathrm{CSF}_o \times RBA \times IRS_{tres} \times \frac{10^{-6} kg}{1\ mg}}$$

Dermal Contact with Sediment

$$SL_{tres-sediment-ca-der} = \frac{\mathrm{TR} \times \mathrm{AT_{tres-c}} \times \mathrm{BW}_{tres}}{EF_{tres} \times ED_{tres} \times \frac{CSF_o}{GIABS} \times SA_{tres} \times ABS_d \times \frac{10^{-6} kg}{1\ mg}}$$

Total

$$SL_{tres-sediment-ca-tot} = \frac{1}{\frac{1}{SL_{tres-sediment-ca-ing}} + \frac{1}{SL_{tres-sediment-ca-der}}}$$

Attachment B – Exposure Assumptions

Symbol	Definition (units)	Value
	Screening Levels	
$SL_{res-soil-nc-tot}$	Screening Level, Residential Soil Noncarcinogenic (mg/kg)	Calculated
$SL_{res-soil-nc-ing}$	Screening Level, Residential Soil Noncarcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{res-soil-nc-der}$	Screening Level, Residential Soil Noncarcinogenic Dermal Component (mg/kg)	Calculated
$SL_{res-soil-nc-inh}$	Screening Level, Residential Soil Noncarcinogenic Inhalation Component (mg/kg)	Calculated
$SL_{res-soil-ca-tot}$	Screening Level, Residential Soil Carcinogenic (mg/kg)	Calculated
$SL_{res-soil-ca-ing}$	Screening Level, Residential Soil Carcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{res-soil-ca-der}$	Screening Level, Residential Soil Carcinogenic Dermal Component (mg/kg)	Calculated
$SL_{res-soil-ca-inh}$	Screening Level, Residential Soil Carcinogenic Inhalation Component (mg/kg)	Calculated
$SL_{res-soil-mu-ing}$	Screening Level, Residential Soil Mutagenic Ingestion Component (mg/kg)	Calculated
$SL_{res-soil-mu-der}$	Screening Level, Residential Soil Mutagenic Dermal Component (mg/kg)	Calculated
$SL_{res-soil-mu-inh}$	Screening Level, Residential Soil Mutagenic Inhalation Component (mg/kg)	Calculated
$SL_{ind-soil-nc-ing}$	Screening Level, Industrial Soil Noncarcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{ind-soil-nc-der}$	Screening Level, Industrial Soil Noncarcinogenic Dermal Component (mg/kg)	Calculated
$SL_{ind-soil-nc-inh}$	Screening Level, Industrial Soil Noncarcinogenic Inhalation Component (mg/kg)	Calculated
$SL_{ind-soil-ca-ing}$	Screening Level, Industrial Soil Carcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{ind-soil-ca-der}$	Screening Level, Industrial Soil Carcinogenic Dermal Component (mg/kg)	Calculated
$SL_{ind-soil-ca-inh}$	Screening Level, Industrial Soil Carcinogenic Inhalation Component (mg/kg)	Calculated
$SL_{storm-soil-nc-ing}$	Screening Level, Stormwater Management Soil Noncarcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{storm-soil-nc-der}$	Screening Level, Stormwater Management Soil Noncarcinogenic Dermal Component (mg/kg)	Calculated
$SL_{storm-soil-nc-inh}$	Screening Level, Stormwater Management Soil Noncarcinogenic Inhalation Component (mg/kg)	Calculated
$SL_{storm-soil-ca-tot}$	Screening Level, Stormwater Management Soil Carcinogenic (mg/kg)	Calculated
$SL_{storm-soil-ca-ing}$	Screening Level, Stormwater Management Soil Carcinogenic Ingestion Component (mg/kg)	Calculated

Symbol	Definition (units)	Value
$SL_{storm-soil-ca-der}$	Screening Level, Stormwater Management Soil Carcinogenic Dermal Component (mg/kg)	Calculated
$SL_{storm-soil-ca-inh}$	Screening Level, Stormwater Management Soil Carcinogenic Inhalation Component (mg/kg)	Calculated
$SL_{cw-soil-nc-tot}$	Screening Level, Construction Worker Soil Noncarcinogenic (mg/kg)	Calculated
$SL_{cw-soil-nc-ing}$	Screening Level, Construction Worker Soil Noncarcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{cw-soil-nc-der}$	Screening Level, Construction Worker Soil Noncarcinogenic Dermal Component (mg/kg)	Calculated
$SL_{cw-soil-nc-inh}$	Screening Level, Construction Worker Soil Noncarcinogenic Inhalation Component (mg/kg)	Calculated
$SL_{cw-soil-ca-tot}$	Screening Level, Construction Worker Soil Carcinogenic (mg/kg)	Calculated
$SL_{cw-soil-ca-ing}$	Screening Level, Construction Worker Soil Carcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{cw-soil-ca-der}$	Screening Level, Construction Worker Soil Carcinogenic Dermal Component (mg/kg)	Calculated
$SL_{cw-soil-ca-inh}$	Screening Level, Construction Worker Soil Carcinogenic Inhalation Component (mg/kg)	Calculated
$SL_{tres-soil-nc-tot}$	Screening Level, Trespasser Soil Noncarcinogenic (mg/kg)	Calculated
$SL_{tres-soil-nc-ing}$	Screening Level, Trespasser Soil Noncarcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{tres-soil-nc-der}$	Screening Level, Trespasser Soil Noncarcinogenic Dermal Component (mg/kg)	Calculated
$SL_{tres-soil-nc-inh}$	Screening Level, Trespasser Soil Noncarcinogenic Inhalation Component (mg/kg)	Calculated
$SL_{tres-soil-ca-tot}$	Screening Level, Trespasser Soil Carcinogenic (mg/kg)	Calculated
$SL_{tres-soil-ca-ing}$	Screening Level, Trespasser Soil Carcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{tres-soil-ca-der}$	Screening Level, Trespasser Soil Carcinogenic Dermal Component (mg/kg)	Calculated
$SL_{tres-soil-ca-inh}$	Screening Level, Trespasser Soil Carcinogenic Inhlatation Component (mg/kg)	Calculated
$SL_{res-soil-ca-tot}$	Screening Level, Residential Soil Carcinogenic (mg/kg)	Calculated
$SL_{res-soil-ca-ing}$	Screening Level, Residential Soil Carcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{res-soil-ca-der}$	Screening Level, Residential Soil Carcinogenic Dermal Component (mg/kg)	Calculated
$SL_{ind-sediment-nc-tot}$	Screening Level, Industrial Sediment Noncarcinogenic (mg/kg)	Calculated
$SL_{ind-sediment-nc-ing}$	Screening Level, Industrial Sediment Noncarcinogenic Ingestion Component (mg/kg)	Calculated

Symbol	Definition (units)	Value
$SL_{ind-sediment-nc-der}$	Screening Level, Industrial Sediment Noncarcinogenic Dermal Component (mg/kg)	Calculated
$SL_{ind-sediment-ca-tot}$	Screening Level, Industrial Sediment Carcinogenic (mg/kg)	Calculated
$SL_{ind-sediment-ca-ing}$	Screening Level, Industrial Sediment Carcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{ind-sediment-ca-der}$	Screening Level, Industrial Sediment Carcinogenic Dermal Component (mg/kg)	Calculated
$SL_{storm-sediment-nc-tot}$	Screening Level, Stormwater Management Sediment Noncarcinogenic (mg/kg)	Calculated
$SL_{storm-sediment-nc-ing}$	Screening Level, Stormwater Management Sediment Noncarcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{storm-sediment-nc-der}$	Screening Level, Stormwater Management Sediment Noncarcinogenic Dermal Component (mg/kg)	Calculated
$SL_{storm-sediment-ca-tot}$	Screening Level, Stormwater Management Sediment Carcinogenic (mg/kg)	Calculated
$SL_{storm-sediment-ca-ing}$	Screening Level, Stormwater Management Sediment Carcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{storm-sediment-ca-der}$	Screening Level, Stormwater Management Sediment Carcinogenic Dermal Component (mg/kg)	Calculated
$SL_{tres-sediment-nc-tot}$	Screening Level, Trespasser Sediment Noncarcinogenic (mg/kg)	Calculated
$SL_{tres-sediment-nc-ing}$	Screening Level, Trespasser Sediment Noncarcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{tres-sediment-nc-der}$	Screening Level, Trespasser Sediment Noncarcinogenic Dermal Component (mg/kg)	Calculated
$SL_{tres-sediment-ca-tot}$	Screening Level, Trespasser Sediment Carcinogenic (mg/kg)	Calculated
$SL_{tres-sediment-ca-ing}$	Screening Level, Trespasser Sediment Carcinogenic Ingestion Component (mg/kg)	Calculated
$SL_{tres-sediment-ca-der}$	Screening Level, Trespasser Sediment Carcinogenic Dermal Component (mg/kg)	Calculated
Toxicity Values		
RfD_o	Oral Reference Dose (mg/kg-day)	Chemical-specific
RfC_i	Inhalation Reference Concentration (mg/m^3)	Chemical-specific
CSF_o	Oral Cancer Slope Factor (mg/kg-day)$^{-1}$	Chemical-specific
IUR	Inhalation Unit Risk (µg/m^3)$^{-1}$	Chemical-specific
Miscellaneous Variables		
THQ	Target hazard quotient (unitless)	Refer to Tables
TR	Target Risk (unitless)	Refer to Tables
RBA	Relative Bioavailability Factor (unitless)	Chemical-specific
AT_{res-c}	Averaging Time, resident child (days) 365 x ED_{res-c}	2,190
AT_{res}	Averaging Time, resident (days) 365 x LT	25,550

Symbol	Definition (units)	Value
AT_{ind-n}	Averaging Time, industrial worker/landfill management worker – non-carcinogenic (days) 365 x ED_{ind}	9,125
AT_{ind-c}	Averaging Time, industrial worker/landfill management worker – carcinogenic (days) 365 x LT	25,550
$AT_{storm-n}$	Averaging Time, stormwater management worker – non-carcinogenic (days) 365 x ED_{storm}	9,125
$AT_{storm-c}$	Averaging Time, stormwater management worker – carcinogenic (days) 365 x LT	25,550
AT_{cw-n}	Averaging Time, stormwater management worker – non-carcinogenic (days) 365 x ED_{cw}	365
AT_{cw-c}	Averaging Time, stormwater management worker – carcinogenic (days) 365 x LT	25,550
AT_{tres-n}	Averaging Time, trespasser – non-carcinogenic (days) 365 x ED_{tres}	3,650
AT_{tres-c}	Averaging Time, trespasser – carcinogenic (days) 365 x LT	25,550
LT	Lifetime (years)	70
K_p	Dermal Permeability Constant (cm/hr)	Chemical-Specific
VF	Volatilization Factor (m^3/kg)	Chemical-Specific
PEF	Particulate Emission Factor (m^3/kg)	$1.36 \times 10^{+9}$
PEF_{cw}	Particulate Emission Factor – construction worker (m^3/kg)	$1.3 \times 10^{+6}$
	Ingestion and Dermal Contact Rates	
IRS_{res-c}	Ingestion Rate of Soil, resident child (mg/day)	200
IRS_{res-a}	Ingestion Rate of Soil, resident adult (mg/day)	100
IRS_{0-2}	Ingestion Rate of Soil, resident age-segment 0-2 (mg/day)	200
IRS_{2-6}	Ingestion Rate of Soil, resident age-segment 2-6 (mg/day)	200
IRS_{6-16}	Ingestion Rate of Soil, resident age-segment 6-16 (mg/day)	100
IRS_{16-26}	Ingestion Rate of Soil, resident age-segment 16-26 (mg/day)	100
$IRS_{res-adj}$	Ingestion Rate of Soil, resident age-adjusted (mg/kg)	28,350
$IRSM_{res-adj}$	Ingestion Rate of Soil, resident mutagenic age-adjusted (mg/kg)	128,700
IRS_{ind}	Ingestion Rate of Soil, industrial worker/landfill management worker (mg/day)	100
IRS_{storm}	Ingestion Rate of Soil, stormwater management worker (mg/day)	100
IRS_{cw}	Ingestion Rate of Soil, construction worker (mg/day)	100
IRS_{tres}	Ingestion Rate of Soil, trespasser (mg/day)	100
$DFS_{res-adj}$	Dermal Contact Rate of Soil. resident age-adjusted (mg/day)	79,758

Symbol	Definition (units)	Value
$DFSM_{res-adj}$	Dermal Contact Rate of Soil. resident mutagenic age-adjusted (mg/day)	330,372
SA_{res-c}	Surface Area for Soil, resident child (cm^2/day)	2,373
SA_{res-a}	Surface Area for Soil, resident adult (cm^2/day)	6,032
SA_{0-2}	Surface Area for Soil, resident age-segment 0-2 (cm^2/day)	2,373
SA_{2-6}	Surface Area for Soil, resident age-segment 2-6 (cm^2/day)	2,373
SA_{6-16}	Surface Area for Soil, resident age-segment 6-16 (cm^2/day)	6,032
SA_{16-26}	Surface Area for Soil, resident age-segment 16-26 (cm^2/day)	6,032
SA_{ind}	Surface Area for Soil, industrial worker/landfill management worker (cm^2/day)	3,527
SA_{storm}	Surface Area for Soil, stormwater management worker (cm^2/day)	3,527
SA_{cw}	Surface Area for Soil, construction worker (cm^2/day)	3,527
SA_{tres}	Surface Area for Soil, trespasser (cm^2/day)	6,032
AF_{res-c}	Adherence Factor, resident child (mg/cm^2)	0.20
AF_{res-a}	Adherence Factor, resident adult (mg/cm^2)	0.07
AF_{0-2}	Adherence Factor, resident age-segment 0-2 (mg/cm^2)	0.20
AF_{2-6}	Adherence Factor, resident age-segment 2-6 (mg/cm^2)	0.20
AF_{6-16}	Adherence Factor, resident age-segment 6-16 (mg/cm^2)	0.07
AF_{16-26}	Adherence Factor, resident age-segment 16-26 (mg/cm^2)	0.07
AF_{ind}	Adherence Factor, industrial worker/landfill management worker (mg/cm^2)	0.12
AF_{storm}	Adherence Factor, stormwater management worker (mg/cm^2)	0.12
AF_{cw}	Adherence Factor, construction worker (mg/cm^2)	0.30
AF_{tres}	Adherence Factor, trespasser (mg/cm^2)	0.07
BW_{res-c}	Body Weight, resident child (kg)	15
BW_{res-a}	Body Weight, resident adult (kg)	80
BW_{0-2}	Body Weight, resident age-segment 0-2 (kg)	15
BW_{2-6}	Body Weight, resident age-segment 2-6 (kg)	15
BW_{6-16}	Body Weight, resident age-segment 6-16 (kg)	80
BW_{16-26}	Body Weight, resident age-segment 16-26 (kg)	80
BW_{ind}	Body Weight, industrial worker/landfill management worker (kg)	80
BW_{storm}	Body Weight, stormwater management worker (kg)	80
BW_{cw}	Body Weight, construction worker (kg)	80
BW_{tres}	Body Weight, trespasser (kg)	15

Symbol	Definition (units)	Value
$\mathrm{ABS_d}$	dermal absorption factor (unitless)	Chemical-specific
GIABS	Fraction of contaminant absorbed in gastrointestinal tract (unitless)	Chemical-specific
DA_{event}	Absorbed dose per event (µg/cm^2 – event)	Calculated
Exposure Frequency, Exposure Duration, Exposure Time		
$\mathrm{EF_{res-c}}$	Exposure Frequency Soil, resident child (days/year)	270
$\mathrm{EF_{res-a}}$	Exposure Frequency Soil, resident adult (days/year)	270
$\mathrm{EF_{res}}$	Exposure Frequency Soil, resident (days/year)	270
$\mathrm{EF_{0-2}}$	Exposure Frequency Soil, resident age-segment 0-2 (days/year)	270
$\mathrm{EF_{2-6}}$	Exposure Frequency Soil, resident age-segment 2-6 (days/year)	270
$\mathrm{EF_{6-16}}$	Exposure Frequency Soil, resident age-segment 6-16 (days/year)	270
$\mathrm{EF_{16-26}}$	Exposure Frequency Soil, resident age-segment 16-26 (days/year)	270
$\mathrm{EF_{ind}}$	Exposure Frequency Soil, industrial worker/landfill management worker (days/year)	187
$\mathrm{EF_{storm}}$	Exposure Frequency Soil, stormwater management worker (days/year)	38
$\mathrm{EF_{cw}}$	Exposure Frequency Soil, construction worker (days/year)	124
$\mathrm{EF_{tres}}$	Exposure Frequency Soil, trespasser (days/year)	7
$\mathrm{ED_{res-c}}$	Exposure Duration, resident child (years)	6
$\mathrm{ED_{res-a}}$	Exposure Duration, resident adult (years)	20
$\mathrm{ED_{res}}$	Exposure Duration, resident (years)	26
$\mathrm{ED_{0-2}}$	Exposure Duration, resident age-segment 0-2 (years)	2
$\mathrm{ED_{2-6}}$	Exposure Duration, resident age-segment 2-6 (years)	4
$\mathrm{ED_{6-16}}$	Exposure Duration, resident age-segment 6-16 (years)	10
$\mathrm{ED_{16-26}}$	Exposure Duration, resident age-segment 16-26 (years)	10
$\mathrm{ED_{ind}}$	Exposure Duration, industrial worker/landfill management worker (years)	25
$\mathrm{ED_{storm}}$	Exposure Duration, stormwater management worker (years)	25
$\mathrm{ED_{cw}}$	Exposure Duration, construction worker (years)	1
$\mathrm{ED_{tres}}$	Exposure Duration, trespasser (years)	1
ET_{res-c}	Exposure Time, resident child (hours/day)	24
ET_{res}	Exposure Time, resident (hours/day)	24
$\mathrm{ET_{0-2}}$	Exposure Time, resident age-segment 0-2 (years)	24
$\mathrm{ET_{2-6}}$	Exposure Time, resident age-segment 2-6 (years)	24
$\mathrm{ET_{6-16}}$	Exposure Time, resident age-segment 6-16 (years)	24
$\mathrm{ET_{16-26}}$	Exposure Time, resident age-segment 16-26 (years)	24

Symbol	Definition (units)	Value
ET_{ind}	Exposure Time, industrial worker/landfill management worker (hours/day)	8
ET_{storm}	Exposure Time, stormwater management worker (hours/day)	1
ET_{cw}	Exposure Time, construction worker (hours/day)	8
ET_{tres}	Exposure Time, trespasser (hours/day)	1
EV_{res-c}	Event Frequency, resident child (hours/event)	1
EV_{res-a}	Event Frequency, resident adult (hours/event)	1

Attachment C – Chemical-Specific Parameters and Toxicity Values

Table C-1
Chemical-Specific Parameters
Columbia Falls Aluminum Facility
Columbia Falls, Montana

Chemical	CAS number	Dermal Absorption Factor For Soil (ABSd)		Relative Bioavailability Factor for Soil (RBA)		Volitilzation Factor (VF)	
		(unitless)	Reference (b)	(unitless)	Reference (b)	(m^3/kg)	Reference (b)
Arsenic	7440-38-2	0.03	USEPA, 2019	0.6	USEPA, 2019	NA	USEPA, 2019
Benzo(A)Anthracene	56-55-3	0.13	USEPA, 2019	1	USEPA, 2019	4.41E+06	USEPA, 2019
Benzo(A)Pyrene	50-32-8	0.13	USEPA, 2019	1	USEPA, 2019	NA	USEPA, 2019
Benzo(B)Fluoranthene	205-99-2	0.13	USEPA, 2019	1	USEPA, 2019	NA	USEPA, 2019
Dibenz(A,H)Anthracene	53-70-3	0.13	USEPA, 2019	1	USEPA, 2019	NA	USEPA, 2019
Indeno(1,2,3-C,D)Pyrene	193-39-5	0.13	USEPA, 2019	1	USEPA, 2019	NA	USEPA, 2019

Footnotes:
a/ USEPA = US Environmental Protection Agency.
CAS = Chemical Abstracts Service
cm/hr = centimeter per hour
g/mole = grams per mole
hr = hour
m^3/kg = cubic meters per kilogram
NA = not applicable
b/ References
USEPA. 2019. Regional Screening Levels, May 2019.
TechLaw, 2017. Final 2017 Sampling and Analysis Plan/
Quality Assurance Project Plan. Nelson Tunnel Superfund
Site, Mineral County, Colorado. April

Table C-2
Non-Cancer Toxicity Data (Oral/Dermal)
Columbia Falls Aluminum Facility
Columbia Falls, Montana

COC	CAS No.	Chronic Oral RfD Value (a) (mg/kg-day)	Oral to Dermal Adjustment Factor	Chronic Oral to Dermal Adjustment Factor Source (b)	Adjusted Dermal RfD Value (mg/kg-day)	Chronic Primary Target Organ	Source (c)
Arsenic	7440-38-2	3.0E-04	1.0E+00	USEPA, 2019	3.0E-04	Skin and blood	USEPA (I)
Benzo(A)Anthracene	56-55-3	NA	1.0E+00	USEPA, 2019	NA		NA
Benzo(A)Pyrene	50-32-8	3.0E-04	1.0E+00	USEPA, 2019	3.0E-04	Developmental	USEPA (I)
Benzo(B)Fluoranthene	205-99-2	NA	1.0E+00	USEPA, 2019	NA		NA
Dibenz(A,H)Anthracene	53-70-3	NA	1.0E+00	USEPA, 2019	NA		NA
Indeno(1,2,3-C,D)Pyrene	193-39-5	NA	1.0E+00	USEPA, 2019	NA		NA

Footnotes:
a/ mg/kg-day = milligrams per kilogram per day; NA = not available/not applicable
b/ Refer to text for citation
c/ USEPA = U.S. Environmental Protection Agency
A = Agency for Toxic Substance and Disease Registry
I = Integrated Risk Information System
C = California Environmental Protection Agency
S = USEPA (2019) for user guide Section 5
Refer to text for references.

Table C-3
Cancer Toxicity Data (Oral/Dermal)
Columbia Falls Aluminum Facility
Columbia Falls, Montana

COC	CAS No.	Oral Cancer Slope Factor (a) (mg/kg-day)-1	Oral to Dermal Adjustment Factor	Oral to Dermal Adjustment Factor Source (b)	Adjusted Dermal Cancer Slope Factor (mg/kg-day)-1	Weight of Evidence/ Cancer Guideline Description (c)	Source (d)	Mutagenic Mode of Action
Arsenic	7440-38-2	1.5E+00	1.00E+00	USEPA, 2019	1.5E+00	A	USEPA (I)	N
Benzo(A)Anthracene	56-55-3	1.0E-01	1.00E+00	USEPA, 2019	1.0E-01	Carcinogenic to humans	USEPA (E)	Y
Benzo(A)Pyrene	50-32-8	1.0E+00	1.00E+00	USEPA, 2019	1.0E+00	Carcinogenic to humans	USEPA (I)	Y
Benzo(B)Fluoranthene	205-99-2	1.0E-01	1.00E+00	USEPA, 2019	1.0E-01	Carcinogenic to humans	USEPA (E)	Y
Dibenz(A,H)Anthracene	53-70-3	1.0E+00	1.00E+00	USEPA, 2019	1.0E+00	Carcinogenic to humans	USEPA (E)	Y
Indeno(1,2,3-C,D)Pyrene	193-39-5	1.0E-01	1.00E+00	USEPA, 2019	1.0E-01	Carcinogenic to humans	USEPA (E)	Y

Footnotes:
a/ mg/kg-day = milligrams per kilogram per day; NA = not available/not applicable
b/ Refer to text for citation
c/ Weight of evidence abbreviations:
USEPA classification
A - human carcinogen
d/ USEPA = U.S. Environmental Protection Agency
E = see USEPA (2019) for user guide Section 2.3.5
I = Integrated Risk Information System
Refer to text for references.

Table C-4
Non-Cancer Toxicity Data (Inhalation)
Columbia Falls Aluminum Facility
Columbia Falls, Montana

COC	CAS No.	Chronic Inhalation RfC Value (a) mg/m3	Primary Target Organ	Source (b)
Arsenic	7440-38-2	1.5E-05	cardiovascular, nervous, and skin	USEPA (C)
Benzo(A)Anthracene	56-55-3	NA	NA	NA
Benzo(A)Pyrene	50-32-8	2.0E-06	Developmental	USEPA (I)
Benzo(B)Fluoranthene	205-99-2	NA	NA	NA
Dibenz(A,H)Anthracene	53-70-3	NA	NA	NA
Indeno(1,2,3-C,D)Pyrene	193-39-5	NA	NA	NA

Footnotes:
a/ mg/kg-day = milligrams per kilogram per day; NA = not available/not applicable
b/ Refer to text for citation
c/ USEPA = U.S. Environmental Protection Agency
C = Cal EPA
I = Integrated Risk Information System
c/ OEHHA = California Office of Environmental He
Refer to text for references.

Table C-5
Cancer Toxicity Data (Inhalation)
Columbia Falls Aluminum Facility
Columbia Falls, Montana

COC	CAS No.	Inhalation Unit Risk (µg/m3)-1	Weight of Evidence/ Cancer Guideline Description (b)	Source (c)	Mutagenic Mode of Action
Arsenic	7440-38-2	4.3E-03	A	USEPA (IRIS)	N
Benzo(A)Anthracene	56-55-3	6.0E-05	Carcinogenic to humans	USEPA (IRIS)	Y
Benzo(A)Pyrene	50-32-8	6.0E-04	Carcinogenic to humans	USEPA (IRIS)	Y
Benzo(B)Fluoranthene	205-99-2	6.0E-05	Carcinogenic to humans	USEPA (IRIS)	Y
Dibenz(A,H)Anthracene	53-70-3	6.0E-04	Carcinogenic to humans	USEPA (IRIS)	Y
Indeno(1,2,3-C,D)Pyrene	193-39-5	6.0E-05	Carcinogenic to humans	USEPA (IRIS)	Y

Footnotes:
a/ µg/m3 = micrograms per cubic meter. NA = not available/not applicable, N = no, Y = Yes.
b/ Weight of evidence abbreviations:
USEPA classification
A - human carcinogen
c/ USEPA = U.S. Environmental Protection Agency
IRIS = Integrated Risk Information System
CAL EPA = California EPA
Refer to text for references.

Attachment D – Supplemental PRG Tables

Table D-1
Soil PRGs
(Target Risk 10^{-6}, Target Hazard Quotient 1)
Columbia Falls Aluminum Facility Columbia Falls, Montana

				Resident									
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer Inhalation SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer Inhalation SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-06	1	5.1E+01	4.3E+02	2.8E+04	4.5E+01	1.0E+00	7.1E+00	1.2E+03	8.8E-01	8.8E-01	c
56-55-3	Benzo(A)Anthracene	1E-06	1	NA	NA	NA	NA	2.0E+00	5.9E+00	9.6E+01	1.5E+00	1.5E+00	c
50-32-8	Benzo(A)Pyrene	1E-06	1	3.0E+01	9.9E+01	3.7E+03	2.3E+01	2.0E-01	5.9E-01	3.0E+03	1.5E-01	1.5E-01	c
205-99-2	Benzo(B)Fluoranthene	1E-06	1	NA	NA	NA	NA	2.0E+00	5.9E+00	3.0E+04	1.5E+00	1.5E+00	c
53-70-3	Dibenz(A,H)Anthracene	1E-06	1	NA	NA	NA	NA	2.0E-01	5.9E-01	3.0E+03	1.5E-01	1.5E-01	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-06	1	NA	NA	NA	NA	2.0E+00	5.9E+00	3.0E+04	1.5E+00	1.5E+00	c

				Industrial/Landfill Management Worker									
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer Inhalation SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer Inhalation SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-06	1	7.8E+02	3.7E+03	1.2E+05	6.4E+02	4.9E+00	2.3E+01	5.2E+03	4.0E+00	4.0E+00	c
56-55-3	Benzo(A)Anthracene	1E-06	1	NA	NA	NA	NA	4.4E+01	7.9E+01	1.2E+03	2.8E+01	2.8E+01	c
50-32-8	Benzo(A)Pyrene	1E-06	1	4.7E+02	8.5E+02	1.6E+04	3.0E+02	4.4E+00	7.9E+00	3.7E+04	2.8E+00	2.8E+00	c
205-99-2	Benzo(B)Fluoranthene	1E-06	1	NA	NA	NA	NA	4.4E+01	7.9E+01	3.7E+05	2.8E+01	2.8E+01	c
53-70-3	Dibenz(A,H)Anthracene	1E-06	1	NA	NA	NA	NA	4.4E+00	7.9E+00	3.7E+04	2.8E+00	2.8E+00	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-06	1	NA	NA	NA	NA	4.4E+01	7.9E+01	3.7E+05	2.8E+01	2.8E+01	c

				Stormwater Management Worker									
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer Inhalation SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer Inhalation SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-06	1	3.8E+03	1.8E+04	4.7E+06	3.2E+03	2.4E+01	1.1E+02	2.0E+05	2.0E+01	2.0E+01	c
56-55-3	Benzo(A)Anthracene	1E-06	1	NA	NA	NA	NA	2.2E+02	3.9E+02	4.7E+04	1.4E+02	1.4E+02	c
50-32-8	Benzo(A)Pyrene	1E-06	1	2.3E+03	4.2E+03	6.3E+05	1.5E+03	2.2E+01	3.9E+01	1.5E+06	1.4E+01	1.4E+01	c
205-99-2	Benzo(B)Fluoranthene	1E-06	1	NA	NA	NA	NA	2.2E+02	3.9E+02	1.5E+07	1.4E+02	1.4E+02	c
53-70-3	Dibenz(A,H)Anthracene	1E-06	1	NA	NA	NA	NA	2.2E+01	3.9E+01	1.5E+06	1.4E+01	1.4E+01	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-06	1	NA	NA	NA	NA	2.2E+02	3.9E+02	1.5E+07	1.4E+02	1.4E+02	c

Notes:
c = cancer
CAS = Chemical Abstracts Service
NA = not applicable
nc = non-cancer
PRG = preliminary remediation guideline
SL = screening level
SL units - milligrams per kilogram (mg/kg)

Table D-1
Soil PRGs
(Target Risk 10^{-6}, Target Hazard Quotient 1)
Columbia Falls Aluminum Facility
Columbia Falls, Montana

				Construction Worker									
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer Inhalation SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer Inhalation SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-06	1	3.6E+02	2.2E+03	1.7E+02	1.1E+02	5.6E+01	3.5E+02	1.9E+02	3.8E+01	3.8E+01	c
56-55-3	Benzo(A)Anthracene	1E-06	1	NA	NA	NA	NA	5.0E+02	1.2E+03	1.0E+04	3.4E+02	3.4E+02	c
50-32-8	Benzo(A)Pyrene	1E-06	1	2.1E+02	5.1E+02	2.3E+01	2.0E+01	5.0E+01	1.2E+02	1.3E+03	3.4E+01	2.0E+01	nc
205-99-2	Benzo(B)Fluoranthene	1E-06	1	NA	NA	NA	NA	5.0E+02	1.2E+03	1.3E+04	3.4E+02	3.4E+02	c
53-70-3	Dibenz(A,H)Anthracene	1E-06	1	NA	NA	NA	NA	5.0E+01	1.2E+02	1.3E+03	3.4E+01	3.4E+01	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-06	1	NA	NA	NA	NA	5.0E+02	1.2E+03	1.3E+04	3.4E+02	3.4E+02	c

				Trespasser									
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer Inhalation SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer Inhalation SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-06	1	1.1E+04	5.4E+04	2.6E+07	9.5E+03	1.8E+02	8.5E+02	2.8E+06	1.5E+02	1.5E+02	c
56-55-3	Benzo(A)Anthracene	1E-06	1	NA	NA	NA	NA	5.4E+02	9.8E+02	2.1E+05	3.5E+02	3.5E+02	c
50-32-8	Benzo(A)Pyrene	1E-06	1	6.9E+03	1.3E+04	3.4E+06	4.4E+03	5.4E+01	9.8E+01	6.6E+06	3.5E+01	3.5E+01	c
205-99-2	Benzo(B)Fluoranthene	1E-06	1	NA	NA	NA	NA	5.4E+02	9.8E+02	6.6E+07	3.5E+02	3.5E+02	c
53-70-3	Dibenz(A,H)Anthracene	1E-06	1	NA	NA	NA	NA	5.4E+01	9.8E+01	6.6E+06	3.5E+01	3.5E+01	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-06	1	NA	NA	NA	NA	5.4E+02	9.8E+02	6.6E+07	3.5E+02	3.5E+02	c

Notes:
c = cancer
CAS = Chemical Abstracts Service
NA = not applicable
nc = non-cancer
PRG = preliminary remediation guideline
SL = screening level
SL units - milligrams per kilogram (mg/kg)

Table D-2
Soil PRGs
(Target Risk 10^{-5}, Target Hazard Quotient 1)
Columbia Falls Aluminum Facility
Columbia Falls, Montana

				Resident									
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer Inhalation SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer Inhalation SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-05	1	5.1E+01	4.3E+02	2.8E+04	4.5E+01	1.0E+01	7.1E+01	1.2E+04	8.8E+00	8.8E+00	c
56-55-3	Benzo(A)Anthracene	1E-05	1	NA	NA	NA	NA	2.0E+01	5.9E+01	9.6E+02	1.5E+01	1.5E+01	c
50-32-8	Benzo(A)Pyrene	1E-05	1	3.0E+01	9.9E+01	3.7E+03	2.3E+01	2.0E+00	5.9E+00	3.0E+04	1.5E+00	1.5E+00	c
205-99-2	Benzo(B)Fluoranthene	1E-05	1	NA	NA	NA	NA	2.0E+01	5.9E+01	3.0E+05	1.5E+01	1.5E+01	c
53-70-3	Dibenz(A,H)Anthracene	1E-05	1	NA	NA	NA	NA	2.0E+00	5.9E+00	3.0E+04	1.5E+00	1.5E+00	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-05	1	NA	NA	NA	NA	2.0E+01	5.9E+01	3.0E+05	1.5E+01	1.5E+01	c

				Industrial/Landfill Management Worker									
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer Inhalation SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer Inhalation SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-05	1	7.8E+02	3.7E+03	1.2E+05	6.4E+02	4.9E+01	2.3E+02	5.2E+04	4.0E+01	4.0E+01	c
56-55-3	Benzo(A)Anthracene	1E-05	1	NA	NA	NA	NA	4.4E+02	7.9E+02	1.2E+04	2.8E+02	2.8E+02	c
50-32-8	Benzo(A)Pyrene	1E-05	1	4.7E+02	8.5E+02	1.6E+04	3.0E+02	4.4E+01	7.9E+01	3.7E+05	2.8E+01	2.8E+01	c
205-99-2	Benzo(B)Fluoranthene	1E-05	1	NA	NA	NA	NA	4.4E+02	7.9E+02	3.7E+06	2.8E+02	2.8E+02	c
53-70-3	Dibenz(A,H)Anthracene	1E-05	1	NA	NA	NA	NA	4.4E+01	7.9E+01	3.7E+05	2.8E+01	2.8E+01	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-05	1	NA	NA	NA	NA	4.4E+02	7.9E+02	3.7E+06	2.8E+02	2.8E+02	c

				Stormwater Management Worker									
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer Inhalation SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer Inhalation SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-05	1	3.8E+03	1.8E+04	4.7E+06	3.2E+03	2.4E+02	1.1E+03	2.0E+06	2.0E+02	2.0E+02	c
56-55-3	Benzo(A)Anthracene	1E-05	1	NA	NA	NA	NA	2.2E+03	3.9E+03	4.7E+05	1.4E+03	1.4E+03	c
50-32-8	Benzo(A)Pyrene	1E-05	1	2.3E+03	4.2E+03	6.3E+05	1.5E+03	2.2E+02	3.9E+02	1.5E+07	1.4E+02	1.4E+02	c
205-99-2	Benzo(B)Fluoranthene	1E-05	1	NA	NA	NA	NA	2.2E+03	3.9E+03	1.5E+08	1.4E+03	1.4E+03	c
53-70-3	Dibenz(A,H)Anthracene	1E-05	1	NA	NA	NA	NA	2.2E+02	3.9E+02	1.5E+07	1.4E+02	1.4E+02	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-05	1	NA	NA	NA	NA	2.2E+03	3.9E+03	1.5E+08	1.4E+03	1.4E+03	c

Notes:
c = cancer
mg/kg = milligrams per kilogram
NA = not applicable
nc = non-cancer
PRG = preliminary remediation guideline
SL = screening level
SL units - milligrams per kilogram (mg/kg)

Table D-2
Soil PRGs
(Target Risk 10^{-5}, Target Hazard Quotient 1)
Columbia Falls Aluminum Facility
Columbia Falls, Montana

				Construction Worker									
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer Inhalation SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer Inhalation SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-05	1	3.6E+02	2.2E+03	1.7E+02	1.1E+02	5.6E+02	3.5E+03	1.9E+03	3.8E+02	1.1E+02	nc
56-55-3	Benzo(A)Anthracene	1E-05	1	NA	NA	NA	NA	5.0E+03	1.2E+04	1.0E+05	3.4E+03	3.4E+03	c
50-32-8	Benzo(A)Pyrene	1E-05	1	2.1E+02	5.1E+02	2.3E+01	2.0E+01	5.0E+02	1.2E+03	1.3E+04	3.4E+02	2.0E+01	nc
205-99-2	Benzo(B)Fluoranthene	1E-05	1	NA	NA	NA	NA	5.0E+03	1.2E+04	1.3E+05	3.4E+03	3.4E+03	c
53-70-3	Dibenz(A,H)Anthracene	1E-05	1	NA	NA	NA	NA	5.0E+02	1.2E+03	1.3E+04	3.4E+02	3.4E+02	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-05	1	NA	NA	NA	NA	5.0E+03	1.2E+04	1.3E+05	3.4E+03	3.4E+03	c

				Trespasser									
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer Inhalation SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer Inhalation SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-05	1	1.1E+04	5.4E+04	2.6E+07	9.5E+03	1.8E+03	8.5E+03	2.8E+07	1.5E+03	1.5E+03	c
56-55-3	Benzo(A)Anthracene	1E-05	1	NA	NA	NA	NA	5.4E+03	9.8E+03	2.1E+06	3.5E+03	3.5E+03	c
50-32-8	Benzo(A)Pyrene	1E-05	1	6.9E+03	1.3E+04	3.4E+06	4.4E+03	5.4E+02	9.8E+02	6.6E+07	3.5E+02	3.5E+02	c
205-99-2	Benzo(B)Fluoranthene	1E-05	1	NA	NA	NA	NA	5.4E+03	9.8E+03	6.6E+08	3.5E+03	3.5E+03	c
53-70-3	Dibenz(A,H)Anthracene	1E-05	1	NA	NA	NA	NA	5.4E+02	9.8E+02	6.6E+07	3.5E+02	3.5E+02	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-05	1	NA	NA	NA	NA	5.4E+03	9.8E+03	6.6E+08	3.5E+03	3.5E+03	c

Notes:
c = cancer
mg/kg = milligrams per kilogram
NA = not applicable
nc = non-cancer
PRG = preliminary remediation guideline
SL = screening level
SL units - milligrams per kilogram (mg/kg)

Table D-3
Sediment PRGs
(Target Risk 10^{-6}, Target Hazard Quotient 1)
Columbia Falls Aluminum Facility
Columbia Falls, Montana

				Industrial/Landfill Management Worker							
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-06	1	7.8E+02	3.7E+03	6.4E+02	4.9E+00	2.3E+01	4.0E+00	4.0E+00	c
50-32-8	Benzo(A)Pyrene	1E-06	1	4.7E+02	8.5E+02	3.0E+02	4.4E+00	7.9E+00	2.8E+00	2.8E+00	c
205-99-2	Benzo(B)Fluoranthene	1E-06	1	NA	NA	NA	4.4E+01	7.9E+01	2.8E+01	2.8E+01	c
53-70-3	Dibenz(A,H)Anthracene	1E-06	1	NA	NA	NA	4.4E+00	7.9E+00	2.8E+00	2.8E+00	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-06	1	NA	NA	NA	4.4E+01	7.9E+01	2.8E+01	2.8E+01	c

				Stormwater Management Worker							
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-06	1	3.8E+03	1.8E+04	3.2E+03	2.4E+01	1.1E+02	2.0E+01	2.0E+01	c
50-32-8	Benzo(A)Pyrene	1E-06	1	2.3E+03	4.2E+03	1.5E+03	2.2E+01	3.9E+01	1.4E+01	1.4E+01	c
205-99-2	Benzo(B)Fluoranthene	1E-06	1	NA	NA	NA	2.2E+02	3.9E+02	1.4E+02	1.4E+02	c
53-70-3	Dibenz(A,H)Anthracene	1E-06	1	NA	NA	NA	2.2E+01	3.9E+01	1.4E+01	1.4E+01	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-06	1	NA	NA	NA	2.2E+02	3.9E+02	1.4E+02	1.4E+02	c

				Trespasser							
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-06	1	1.1E+04	5.4E+04	9.5E+03	1.8E+02	8.5E+02	1.5E+02	1.5E+02	c
50-32-8	Benzo(A)Pyrene	1E-06	1	6.9E+03	1.3E+04	4.4E+03	5.4E+01	9.8E+01	3.5E+01	3.5E+01	c
205-99-2	Benzo(B)Fluoranthene	1E-06	1	NA	NA	NA	5.4E+02	9.8E+02	3.5E+02	3.5E+02	c
53-70-3	Dibenz(A,H)Anthracene	1E-06	1	NA	NA	NA	5.4E+01	9.8E+01	3.5E+01	3.5E+01	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-06	1	NA	NA	NA	5.4E+02	9.8E+02	3.5E+02	3.5E+02	c

Notes:
c = cancer
CAS = Chemical Abstracts Service
NA = not applicable
nc = non-cancer
PRG = preliminary remediation guideline
SL = screening level
SL units - milligrams per kilogram (mg/kg)

Table D-4
Sediment PRGs
(Target Risk 10^{-5}, Target Hazard Quotient 1)
Columbia Falls Aluminum Facility
Columbia Falls, Montana

				Industrial/Landfill Management Worker							
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-05	1	7.8E+02	3.7E+03	6.4E+02	4.9E+01	2.3E+02	4.0E+01	4.0E+01	c
50-32-8	Benzo(A)Pyrene	1E-05	1	4.7E+02	8.5E+02	3.0E+02	4.4E+01	7.9E+01	2.8E+01	2.8E+01	c
205-99-2	Benzo(B)Fluoranthene	1E-05	1	NA	NA	NA	4.4E+02	7.9E+02	2.8E+02	2.8E+02	c
53-70-3	Dibenz(A,H)Anthracene	1E-05	1	NA	NA	NA	4.4E+01	7.9E+01	2.8E+01	2.8E+01	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-05	1	NA	NA	NA	4.4E+02	7.9E+02	2.8E+02	2.8E+02	c

				Stormwater Management Worker							
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-05	1	3.8E+03	1.8E+04	3.2E+03	2.4E+02	1.1E+03	2.0E+02	2.0E+02	c
50-32-8	Benzo(A)Pyrene	1E-05	1	2.3E+03	4.2E+03	1.5E+03	2.2E+02	3.9E+02	1.4E+02	1.4E+02	c
205-99-2	Benzo(B)Fluoranthene	1E-05	1	NA	NA	NA	2.2E+03	3.9E+03	1.4E+03	1.4E+03	c
53-70-3	Dibenz(A,H)Anthracene	1E-05	1	NA	NA	NA	2.2E+02	3.9E+02	1.4E+02	1.4E+02	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-05	1	NA	NA	NA	2.2E+03	3.9E+03	1.4E+03	1.4E+03	c

				Trespasser							
CAS number	Chemical Name	Target Risk	Target Hazard Quotient	Non-Cancer Oral SL (mg/kg)	Non-Cancer Dermal SL (mg/kg)	Non-Cancer SL (mg/kg)	Cancer Oral SL (mg/kg)	Cancer Dermal SL (mg/kg)	Cancer SL (mg/kg)	SL (mg/kg)	Basis
7440-38-2	Arsenic	1E-05	1	1.1E+04	5.4E+04	9.5E+03	1.8E+03	8.5E+03	1.5E+03	1.5E+03	c
50-32-8	Benzo(A)Pyrene	1E-05	1	6.9E+03	1.3E+04	4.4E+03	5.4E+02	9.8E+02	3.5E+02	3.5E+02	c
205-99-2	Benzo(B)Fluoranthene	1E-05	1	NA	NA	NA	5.4E+03	9.8E+03	3.5E+03	3.5E+03	c
53-70-3	Dibenz(A,H)Anthracene	1E-05	1	NA	NA	NA	5.4E+02	9.8E+02	3.5E+02	3.5E+02	c
193-39-5	Indeno(1,2,3-C,D)Pyrene	1E-05	1	NA	NA	NA	5.4E+03	9.8E+03	3.5E+03	3.5E+03	c

Notes:
c = cancer
CAS = Chemical Abstracts Service
mg/kg = milligrams per kilogram
NA - not applicable
nc = non-cancer
PRG = preliminary remediation guideline
SL = screening level
SL units - milligrams per kilogram (mg/kg)

APPENDIX B

Development of Preliminary Remediation Goals (PRGs) for
Ecological Risk Drivers Memorandum

MEMO

To: Andrew Baris, Roux Environmental Engineering and Geology D.P.C.

From: Gary Long, EHS Support

CC: Michael Ritorto, Roux Environmental Engineering and Geology D.P.C.
Laura Jensen, Roux Environmental Engineering and Geology D.P.C.
Charlie McGuckin, Roux Environmental Engineering and Geology D.P.C.
Crystal Stowell, Roux Environmental Engineering and Geology D.P.C.
Tom Biksey, EHS Support

Date: March 17, 2020

Re: Development of Preliminary Remediation Goals (PRGs) for Ecological Risk Drivers at the Former Columbia Falls Aluminum Company Aluminum Reduction Facility, Columbia Falls, Montana

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Introduction

This technical memorandum describes the approach for development of risk-based preliminary remediation goals (PRGs) for ecological constituents of concern (COCs) for the Columbia Falls Aluminum Company (CFAC) Superfund Site in Columbia Falls, Montana (henceforth referred to as "the Site") (EHS Support, 2019). The COCs are a subset of the constituents of potential ecological concern (COPECs) that were identified in the Baseline Ecological Risk Assessment (BERA; EHS Support, 2019) that was submitted to the United States Environmental Protection Agency (USEPA) and the Montana Department of Environmental Quality (MDEQ) on July 29, 2019 as part of the ongoing Remedial Investigation/Feasibility Study at the Site.

Following the submission of the BERA, the list of COPECs was reviewed by EHS Support, and the constituents that were considered the most likely to drive remedial decisions or further investigation at the Site were identified as potential COCs. Draft ecological risk-based preliminary remediation goals were presented in the *Development of Preliminary Remediation Goals for Ecological Risk Drivers at the Former Columbia Falls Aluminum Company Aluminum Reduction Facility, Columbia Falls, Montana* (October 18, 2019), submitted as Appendix B of the Draft Feasibility Study Work Plan (FSWP) prepared by Roux Environmental Engineering and Geology, D.P.C. (Roux; December 4, 2019) on behalf of CFAC.

This technical memorandum presents revisions to the draft ecological PRGs based on comments on the Draft FSWP provided by the USEPA and MDEQ on January 14, 2020 (preliminary comments) and February 7, 2020 (final comments). Conference calls related to the draft ecological PRGs were held with CDM Smith (on behalf of the USEPA) on February 3, 2020 and with USEPA and MDEQ on February 13, 2020.

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Identification of Ecological COCs

The risk characterization and associated uncertainties in the BERA were reviewed, and a list of COCs was created for soil, sediment, sediment porewater, and surface water in each exposure area evaluated at the Site. The COCs identified for soil in terrestrial exposure areas are presented in **Table 1**. Also included in **Table 1** are COCs for soil or sediment samples from four transitional exposure areas, which are seasonally wetted areas that were evaluated under both a "wet" and "dry" scenario in the BERA. Under the "dry" scenario, the sediment was treated as soil for evaluation using terrestrial exposure scenarios and receptors.

Soil COCs were selected based on the three main criteria used in the risk characterization portion of the BERA to develop conclusions about the potential risk associated with each constituent: direct contact risk to receptors at the base of the food chain, wildlife ingestion risk for bioaccumulative compounds, and risk to small-range receptors. Professional judgement was also used in the development of the list of COCs, and some constituents with minor or highly infrequent exceedances were not included as COCs. For example, if a constituent was identified in a single sample at a concentration that only marginally exceeded a lowest-observed effect endpoint, that constituent may not have been identified as a COC because the magnitude and spatial distribution of concentrations that exceed risk-based criteria are unlikely to adversely impact ecological receptor populations. Hazard quotients (HQs) were used in the BERA as a means of comparing the concentration in site media (for direct contact pathways) or the modeled estimated daily dose (EDD) of terrestrial wildlife receptors (for wildlife ingestion pathways) to protective benchmark values. HQs that exceeded 1 using lowest-observed effect benchmarks (i.e., lowest-observed effects concentrations [LOECs] for direct contact pathways or lowest-observed adverse effects levels [LOAELs] for wildlife ingestion pathways) were generally identified as COCs in soil. Also, constituents that were present at concentrations that exceeded the back-calculated LOAEL-based benchmarks for small-range receptors (i.e., the short-tailed shrew and meadow vole) that were presented in the BERA were also identified as COCs. An exception to using lowest-observed effect benchmarks in COC selection was made for the yellow-billed cuckoo, which is a receptor that was included for evaluation in the BERA because it is a state-threatened species that may occur at the Site. This species was evaluated only for results reflecting a comparison of EDDs to more conservative no-observed adverse effects level (NOAEL) endpoints as an acknowledgment of its status as a federally threatened species. Therefore, COPECs that resulted in EDDs that exceeded the NOAEL for the yellow-billed cuckoo were considered COCs in soil as well.

Sediment COCs are presented in **Table 2** for aquatic exposure scenarios within permanent aquatic habitats and within transitional habitats during wet conditions. Constituents in sediment with concentrations exceeding LOECs protective of aquatic life or with concentrations resulting in EDDs for semi-aquatic wildlife receptors that exceeded available LOAELs were identified as COCs. Additionally, polycyclic aromatic hydrocarbons (PAHs), which lack direct contact LOEC values for sediment, were identified as COCs if their no-observed effect concentrations (NOECs) were exceeded by a factor of 10. Although there is some uncertainty with the use of this factor because it is not known how much above a no-effect benchmark that adverse effects would be observed, 10 is a commonly used extrapolation factor for calculating no-effect benchmarks from low-effect benchmarks in the absence of empirical data (e.g., LANL, 2017a; Dourson and Stara, 1983). Selection criteria for sediment porewater COCs mirror the selection criteria for sediment COCs, and identified the following as porewater COCs: barium and cyanide (total) in the South Percolation Ponds (SPP), barium and cyanide (total and free) in the Flathead

River Riparian Area Channel (Riparian Area Channel), and cyanide (total and free) in the Backwater Seep Sampling Area (BSSA).

Surface water COCs are identified for aquatic and transitional exposure areas in **Table 3.**

Ecological PRG Development

Ecological PRGs were based on low-effect (rather than no-effect) endpoints. This is consistent with the derivation of PRGs at the Los Alamos National Laboratory (LANL) and other commonly cited guidance (LANL, 2017b; Efroymson et al., 1997). As stated in Efroymson et al. (1997), PRGs are thresholds for significant effects, and are anticipated to correspond to minimal and acceptable levels of effects. The advantages of using low-effect endpoints for PRGs included the following:

- No-effect endpoints give no indication as to how much higher a concentration must be before adverse effects are observed, whereas low-effect endpoints are presumed to be the threshold at which effects become evident.
- No-effect endpoints have greater uncertainty.
- Low-effect PRGs based on effect to individual wildlife are expected to correspond to no-effect or negligible effect when the endpoints to be protected are populations or communities (PRGs based on no-effect endpoints should be used for the protection of rare, sensitive, or threatened or endangered species).

Ecological risk assessment databases, such as the LANL EcoRisk Database (LANL, 2017a) also use low-effect endpoints in the development of their recommended PRGs. LANL (2017b) PRG guidance recommends using LOAELs and LOECs to develop PRGs to be protective of wildlife populations, which are common endpoints in ecological risk assessments and were used in the CFAC BERA.

Rare or sensitive species may be an exception to the use of LOAEL- or LOEC-based PRGs, depending on the likelihood of exposure of special status species at the site. As stated above, potential risks to the yellow-billed cuckoo were evaluated in the BERA and during COC selection using NOAELs rather than LOAELs due to its status as a sensitive species. However, as discussed in the BERA (EHS Support, 2019), there is a low probability that yellow-billed cuckoo would be present in the vicinity of the site due to its rarity in Montana in general, and an even lower probability of occurrence within exposure areas where risk was identified due to the absence of basic habitat requirements. Due to its low likelihood of exposure, PRGs specifically based on the protection of yellow-billed cuckoo were calculated using based on NOAELs (see **Attachment A**) but were not included in **Table 4** as candidate PRGs for the Site.

The following sections present the technical rationale and supporting documentation for the development of ecological PRGs for soil, sediment, sediment porewater, and surface water that deviate from lowest observed effects concentration ecological screening levels (ESL_{LOEC}) provided in the LANL EcoRisk Database (Version 4.1; LANL, 2017b) or LOECs/LOAELs derived in the CFAC BERA (EHS Support, 2019). As discussed during the February 13, 2020 conference call with the USEPA and MDEQ, LANL PRGs derived from endpoints that are site-specific to LANL have been excluded from the revised PRG calculations for CFAC.

Full documentation of toxicity endpoints supporting the calculation of LANL ESL_{LOEC} values used as the basis for ecological PRGs for CFAC, including source study citations, is provided in the LANL EcoRisk database (LANL, 2017b); documentation of toxicity endpoints for LOECs or LOAELs derived in the CFAC BERA that were the basis of CFAC PRGs is provided in the CFAC BERA Report (EHS Support, 2019). Further documentation of toxicity endpoints used to derive LANL ESL_{LOEC} values or CFAC BERA LOEC/LOAEL values are not provided in this technical memorandum. However, the technical rationale and supporting documentation for ecological PRGs that deviate from LANL ESL_{LOEC} values or LOEC/LOAEL values from the CFAC BERA are presented in the following sections.

Ecological PRGs for COCs in Soil

Ecological PRGs for soil COCs are presented in **Table 4**. Soil PRGs were developed for the receptors identified in the BERA with the potential for adverse effects based on the criteria presented previously. PRGs for soil COCs consisted of the following:

- **Direct Contact PRGs**: Direct contact soil PRGs for the protection of terrestrial plants and soil invertebrates were based on LANL ESL_{LOEC} values provided in the LANL EcoRisk Database (Version 4.1; LANL, 2017b) or LOECs derived in the CFAC BERA (EHS Support, 2019), except for the PRG for barium for the protection of terrestrial plants (**Table 4**).

  The terrestrial plant PRG for barium (Ba) was derived based on the geometric mean of LANL LOEC endpoints for terrestrial plant exposure to test chemical forms that are more relevant to the barium forms that are likely to predominate in Site soils. As summarized in the table below, LOEC endpoints for terrestrial plants identified in the LANL EcoRisk Database were highly variable, ranging from 87.1 to 2000 mg Ba/kg. The lowest LOECs for plants were reported in studies that exposed plants to barium chloride ($BaCl_2$). Plant LOECs based on $BaCl_2$ exposure were below the range of background threshold values (BTVs; 300 mg Ba/kg to 733 mg Ba/kg) calculated during the Background Investigation conducted during the Phase II Site Characterization (Roux, 2019).

Test Organism	Endpoint Category	Test Chemical Form	Solubility (g Ba/g water @ 25°C)	LOEC (mg Ba/kg)	Reference
Bean, Bush, Improved Tendergreen	**Plant yield**	**Barium Nitrate**	**10.5**	**2000**	**Chaudry (1977)**
Barley, Atlas 57	**Plant yield**	**Barium Nitrate**	**10.5**	**500**	**Chaudry (1977)**
			Geometric mean:	**1000**	
Barley, Spring (Julia)	Plant yield based on critical levels in solution (ppm)	Barium Chloride	37	160	Davis et al. (1978)
Pea, Smaragd	Pea grain yield	Barium Chloride Dihydrate	37	87.1	Nyarai-Horvath et al. (1997)
Pea, Smaragd	Percent dead seedlings after the 8th day	Barium Chloride Dihydrate	37	87.1	Nyarai-Horvath et al. (1997)

Under natural conditions, the dominant forms of barium in terrestrial soils are barite ($BaSO_4$) and witherite ($BaCO_3$), which are sparingly soluble and have limited toxicity to invertebrates, plants, or wildlife (Menzie et al., 2008). Solubilities of $BaSO_4$ (0.00031 g/g water) and $BaCO_3$ (0.0014 g/g water) are four to five orders of magnitude lower than the solubilities of barium nitrate ($BaNO_3$) and $BaCl_2$ used as test chemicals for the LOEC endpoints summarized in the table above for terrestrial plants. Consistent with these differences in solubilities, a review of available toxicity studies indicates that $BaSO_4$ toxicity to plants is orders of magnitude less than the toxicity associated with $BaNO_3$ indicated by value of 1,414 mg Ba/kg reported in the barium Eco-SSL documentation for plant toxicity (Menzie et al., 2008). This value was the basis for the LANL PRG of 1,400 mg Ba/kg (1,414 mg/kg truncated to two significant digits) and was proposed as the draft ecological PRG for terrestrial plants in the Draft FSWP.

Based on the differences between the solubility and toxicity of environmentally relevant forms of barium and those used in standard toxicity testing, Menzie et al. (2008) demonstrated that ecological benchmarks derived based on exposure to barium compounds that are more soluble than the predominant barium compounds found in the soils overestimate the potential for adverse ecological effects, potentially by several orders of magnitude. Therefore, the terrestrial plant LOEC endpoints in the LANL EcoRisk database based on exposure to $BaCl_2$ – the most soluble barium form in the toxicity tests – were excluded from the calculation of the terrestrial plant PRG to reduce the bias of barium forms that are not relevant to Site conditions.

As shown in the table above, the terrestrial plant PRG of 1000 mg/kg was calculated as the geometric mean of LOECs derived from $BaNO_3$ endpoints in the LANL EcoRisk database. Given that $BaNO_3$ is orders of magnitude more soluble than $BaSO_4$ and $BaCO_3$ – the predominant forms of barium in terrestrial soils under natural conditions – this PRG is likely a highly conservative and protective benchmark for potential adverse effects of barium on terrestrial plants at the Site.

- **Wildlife PRGs (LOAEL-based):** For constituents selected as COCs due to bioaccumulation potential in the food chain, the wildlife ingestion model presented in the BERA was used to back-calculate a soil concentration that resulted in an HQ of 1 using LOAEL toxicity endpoints for receptors identified as potentially at risk (i.e., receptors whose ingestion model HQs using the LOAEL exceeded 1). This approach is identical to the approach used in the BERA to develop LOAEL-based benchmarks for small home range receptors (i.e., the meadow vole and short-tailed shrew). The lowest PRG among all wildlife receptors identified in the BERA as being potentially at risk (i.e., that had LOAEL-based HQs that exceeded 1) for the constituent was selected as the PRG protective of terrestrial wildlife.
- **Background**: The background threshold value (BTV) for the constituent, if available, was also presented as a potential PRG. Because it is not appropriate to establish remedial goals that are lower than ambient levels found in surrounding areas unimpacted by the Site, BTVs were presented as alternate PRGs if risk-based levels were lower than background concentrations. BTVs were calculated in the RI/FS investigation for multiple soil areas (SO1, SO2, SO3, and SO4) unimpacted by the Site. Each terrestrial and transitional exposure area was paired with one or more background areas based on common soil type, habitat, etc. The BTVs listed in **Table 4** are the BTV(s) from the background area or areas associated with the exposure area where the consistent was identified as a COC (see the BERA [EHS Support, 2019] for details). If BTVs from multiple background areas were identified for a constituent, the greatest BTV was included in

Table 4 to represent the greatest ambient background concentration for comparison to risk-based PRGs.

PRGs based on the protection of wildlife ingestion were back-calculated from the BERA wildlife ingestion model unless otherwise stated (e.g., soil-to-earthworm uptake for Aroclor 1254 as described below). Therefore, the assumptions and model components presented in the BERA are incorporated into the calculations of protective wildlife PRGs.

The equation for deriving wildlife HQs as presented in the BERA (EHS Support, 2019) was as follows:

$$HQ = EDD/TRV$$

Thus, solving for a PRG protective of an HQ of 1 results in the calculation of an EDD that is equal to the LOAEL toxicity reference value (TRV). The EDD equation for the wildlife ingestion model is presented in Section 5.3.3.1 of the BERA (EHS Support, 2019). The general form of the dose rate model used to calculate EDDs is as follows:

$$EDD = \frac{1}{BW}\sum_{i=1}^{N}\left(FIR_{dw} \times \sum_{j=1}^{M}\left(f_j \times C_j\right) + SIR \times C_{sub} + WIR \times C_{sw}\right)_i \times AUF_i$$

where:

i	= Number of exposure areas
j	= Receptor-specific dietary items
BW	= Receptor-specific body weight
FIR_{dw}	= Receptor-specific daily food ingestion rate (dry weight)
f_j	= Proportion of dietary item *j* to total dietary composition
C_j	= COPEC concentration in dietary item *j*
SIR	= Receptor-specific incidental soil/sediment ingestion rate
C_{sub}	= COPEC concentration in substrate (soil or sediment)
WIR	= Receptor-specific daily drinking water ingestion rate *
C_{sw}	= COPEC concentration in unfiltered surface water *
AUF_i	= Area use factor *

* Not used in PRG development

The drinking water portion of the EDD equation resulted in minor risk to all receptors and was not used for calculating soil or sediment PRGs. AUFs that adjusted doses based on the ratio of the size of the exposure area to the home range of the receptor were also not included in the calculation of PRGs. However, consideration of area use may be incorporated into the application of PRGs in remedial scenarios during the Feasibility Study. Worksheets showing the back-calculated PRGs for wildlife receptors (including the variables and equations) are presented in **Attachment A**. PRGs for final COPECs from the BERA are included in these worksheets.

One adjustment to the parameters and assumptions used in the wildlife ingestion models was recommended for soil PRG development for Aroclor 1254 after reviewing the back-calculated results for the COCs. The BERA wildlife ingestion model used a model for soil-to-earthworm uptake for Aroclor

1254 that was based on the recommended uptake methods presented in the Eco-SSL guidance (USEPA, 2005). This model uses the constituent octanol-water partitioning coefficient, the organic carbon content in soil, and other variables to estimate the degree to which the constituent partitions to lipids within the earthworm. This model was used for calculating risk to the short-tailed shrew, a mammalian invertivore that was the most sensitive receptor for this constituent. The resulting PRG for the short-tailed shrew was 0.17 milligrams per kilogram (mg/kg), which was over an order of magnitude lower (more conservative) than the PRG for a similar receptor, the montane shrew, presented in the LANL (2017a) database of 2.4 mg/kg.

One key difference between the LANL and BERA shrew models was that the LANL model soil-to-earthworm uptake factor was based on an internal study using empirical data that resulted in lower estimated concentrations in earthworm prey items. The literature was reviewed, and an alternate uptake model developed by Sample et al. (1998) was identified that estimates uptake of polychlorinated biphenyls (PCBs) from soil into earthworms using a regression equation based on relationships observed from empirical data. Regression equations from Sample et al. (1998) were used as the basis for soil-to-earthworm uptake factors for other constituents (e.g., dioxins and some metals) in the BERA, but not for PCBs because Eco-SSL uptake factors were used preferentially in the wildlife modeling following the overall modeling strategy and approach (EHS Support, 2019). The resulting PRG for the short-tailed shrew when the Sample et al. (1998) regression equation was used to model the uptake of Aroclor 1254 into earthworms was 1.2 mg/kg, which aligns much more closely with the PRG of 2.4 mg/kg presented in LANL (2017a). Therefore, the Sample et al. (1998) uptake model based on empirical data was used in place of the Eco-SSL uptake model for the Aroclor 1254 PRG calculations. The resulting soil PRG for Aroclor 1254 is greater than the maximum concentration measured in the Central Landfills Area that was identified as a COPEC based on the BERA exposure model.

For each COC, the lowest risk-based PRG (i.e., the PRGs protective of direct contact risks to invertebrates or plants and the PRGs protective of wildlife ingestion) was selected as the soil PRG, unless that value was below the BTV, in which case the BTV was selected as the PRG. As presented in **Table 4**, PRGs were based on the protection of terrestrial plants for six COCs, the protection of soil invertebrates for one COC, and the protection of wildlife receptors (short-tailed shrew and American woodcock) for three COCs.

Ecological PRGs for COCs in Sediment

Ecological PRGs for sediment COCs are presented in **Table 5**. As for soil, PRGs were developed for the receptors identified in the BERA that exhibited elevated risk based on comparison to lowest-observable effects endpoints. PRGs for sediment COCs consisted of the following:

- **Direct Contact PRGs**: LOEC-based benchmark values from the literature protective of benthic invertebrates were identified for those constituents selected as COCs for direct contact concerns.
- **Wildlife PRGs (LOAEL-based):** For constituents selected as COCs due to bioaccumulation potential in the food chain, the wildlife ingestion model presented in the BERA was used to back-calculate a sediment concentration that resulted in an HQ of 1 based on the LOAEL using a similar approach as described for soil COC PRG development. Worksheets showing the back-calculated wildlife PRGs are presented in **Attachment A**.

- **Background**: Similar to soil, the sediment BTV for the constituent, if available, was also presented as a potential PRG. Consistent with the BERA (EHS Support, 2019), for transitional exposure areas, soil BTVs from exposure area-specific soil background areas were selected for use for sediment COCs. Sediment BTVs from aquatic background areas were considered for COCs that were identified in aquatic exposure areas. The greatest applicable BTV was included in **Table 5** to represent the greatest ambient background concentration that should be compared to the risk-based PRGs to ensure that clean-up goals are not below background levels.

As for soil, the lowest of the risk-based PRGs (i.e., the PRGs protective of direct contact risks to invertebrates and wildlife ingestion) was selected as the sediment PRG, unless that value was below the BTV, in which case the BTV was recommended as the PRG. As presented in **Table 5**, sediment PRGs were based on the protection of benthic invertebrates for five COCs and the protection of wildlife receptors (American Dipper) for three COCs. BTVs were selected as PRGs for barium and selenium because the minimum risk-based PRGs were below the representative background concentrations for these two metals. Given that sediment PRGs for barium and selenium were based on BTVs, the values will be applied on a point-by-point basis.

Sediment PRGs were not developed for cyanide because free cyanide, the bioavailable and toxic form of cyanide to benthic and aquatic organisms, is not expected to persist in the sediment matrix due to its high solubility and rapid degradation. As discussed in greater detail in **Attachment B**, there is strong scientific consensus that free cyanide ($HCN + CN^-$) is the bioavailable and toxic form of cyanide to aquatic receptors (Young et al., 2006; Gensemer et al., 2006; Lanno and Menzie, 2006; WDNR, 2003). While cyanide may exist in a variety of metallocyanide or organic complexes in the aquatic environment, the toxicity of these complexes is largely a function of their dissociation to free cyanide (Gensemer et al., 2006). In the presence of ultraviolet (UV) light within the water column, the photolysis of iron cyanide (ferrocyanide and ferricyanide) complexes results in the formation of free cyanide, as HCN. However, metal cyanide complexes (specifically iron cyanide) in sediment will not dissociate in response to UV light, as light is not expected to penetrate below the sediment-surface water interface to a significant degree and thus, total CN dissociation to free CN via photolysis is minimal and other cyanide complexes have been shown to be non-toxic to benthic organisms (Gensemer et al., 2006). Based on the limited persistence of free cyanide in sediment, ecotoxicity data based on total cyanide exposure to bulk sediment are considered to be a poor indicator of toxicity.

The cyanide PRG for the protection of benthic habitats in the in the BSSA, the Riparian Area Channel, and the SPP exposure areas of the Site is based on exposure to free cyanide in porewater. As discussed in **Attachment B**, the conceptual site model developed through multiple phases of the remedial investigation indicates that groundwater discharge is the source of cyanide to sediments, porewater, and surface water in the BSSA, Riparian Area Channel, and SPP (EHS Support, 2019). Therefore, the reduction of cyanide concentrations in groundwater inputs is a critical component of reducing cyanide exposure in benthic habitats. Free cyanide measurements in porewater are the most appropriate endpoints to evaluate exposure and monitor recovery in benthic habitats due to the high solubility and limited persistence of free cyanide in sediment and the consensus that free cyanide is the bioavailable and toxic form to benthic organisms. Further discussion of the technical rationale for establishing the cyanide PRG for the protection of benthic habitats based on free cyanide measurements in porewater is provided in the technical memorandum in **Attachment B**.

It should be noted that there is low confidence in the PRGs protective of benthic invertebrates for PAH mixtures in sediment. The PAH mixture PRG for sediment is based on the approach used to evaluate PAHs in sediment described in the BERA (EHS Support, 2019) that uses equilibrium partitioning sediment benchmark toxic units (ESBTUs) to estimate the likelihood of toxic effects on benthic invertebrates. As described in the BERA, samples with ESBTUs equal to or less than 1 are considered acceptable for the protection of benthic invertebrate receptors; values exceeding 1 indicate a potential for narcotic effects in benthic organisms. Therefore, a PAH mixture resulting in an ESBTU of 1 was interpreted as representing a no-effect benchmark, and a lowest-effect PRG was assumed to be 10-times that concentration, i.e., a PAH mixture concentration that results in an ESBTU of greater than 10. ESBTU values greater than 10 were interpreted as having the potential to be associated with invertebrate mortality and a reduction in abundance. Because of the complexity of PAH mixture interactions in sediment and the lack of established toxicity criteria in the literature, a relatively high level of uncertainty is associated with the development of this PRG.

Ecological PRGs for COCs in Surface Water

Promulgated MDEQ Circular DEQ-7, Montana Numeric Water Quality Standards (June 2019) will be used as surface water PRGs. Consistent with responses to MDEQ comments on the FSWP, acute and chronic aquatic life standards used as surface water PRGs are summarized in **Table 6**. Chronic and acute aquatic life standards for hardness-dependent metals (e.g., cadmium, copper, and zinc) are presented at a default hardness of 25 mg/L (as $CaCO_3$), consistent with MDEQ (2019). However, hardness-adjusted surface water PRGs will be calculated as a function of exposure area-specific hardness measurements from each exposure area using the equations provided in the footnotes of **Table 6**.

MDEQ Circular DEQ-7 aquatic life standards are not available for barium, free cyanide, and the multiple PAH compounds identified as COCs in the North Percolation Pond. Surface water PRGs for these constituents are based on the following (**Table 6**):

- Barium: Surface water PRGs are based on a chronic criterion of 220 µg/L and an acute criterion of 2000 µg/L using criteria derived by the Ohio Environmental Protection Agency, as published in the USEPA Great Lakes Initiative (GLI) Clearinghouse (OEPA, 2006).
- Free cyanide: Chronic and acute surface water PRGs for free cyanide are based on chronic and acute values of 5.2 µg/L and 22 µg/L, respectively, promulgated in the National Recommended Water Quality Criteria (NRWQC; USEPA, 2019).
- PAHs: Surface water PRGs for PAH compounds identified as COCs in the North Percolation Pond are based on final chronic values (FCVs) and final acute values (FAVs) provided in USEPA (2003). FCVs for PAHs provided in USEPA (2003) were used as no observed effect concentrations in the CFAC BERA (EHS Support, 2019). As stated in USEPA (2003), FCVs and FAVs were derived based on aquatic species and were determined to be protective of aquatic and benthic organisms.

Applicable surface water PRGs will be used as the ecological PRGs for COCs in porewater.

Ecological PRG Application

For the application of ecological PRGs, consideration of potential receptor groups will be based on the availability of ecological habitats under current and planned future land use. The application of ecological PRGs within exposure areas will also consider the size of the home (foraging) range of the most sensitive wildlife receptor used as the basis for an ecological PRG, including small range receptors.

It should be noted that the PRGs presented in this technical memorandum, or any PRGs developed for the protection of ecological receptors, should not necessarily be regarded as not-to-exceed values. Rather, based on the assumptions and endpoints presented in the BERA, PRGs represent a conservative estimate of the average concentration that receptors could be exposed to that would be expected to result in minimal risk. Thus, a PRG may be achieved at an area by remediating portions of the exposure area with elevated levels of constituents such that the conservative estimate of remaining concentrations (as reflected by a 95 percent upper confidence limit of the mean, for example) do not exceed the PRG. This scenario may result (and often does) in constituents remaining in place at concentrations that exceed the PRG. A risk assessor should be consulted regarding additional details and appropriate applications of PRGs during remedial decision making to ensure that the assumptions and conditions that are inherent in the PRGs are considered at an early stage of the remedial decision-making process.

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Tables

Attachments

Tables

Table 1
Soil Chemicals of Concern for Terrestrial and Transitional Exposure Areas
Columbia Falls Aluminum Company
Columbia Falls, Montana

	Terrestrial Exposure Areas								*Transitional Exposure Areas*			
COPEC	**Main Plant Area**	**Central Landfills Area**	**Industrial Landfills Area**	**Eastern Undeveloped Area**	**North-Central Undeveloped Area**	**Western Undeveloped Area**	**Flathead River Riparian Area**	**Operational Area/ISS Grid**	**North Percolation Pond**	**South Percolation Pond**	**Cedar Creek Reservoir**	**Northern Surface Water Feature**
Metals												
Barium									1	1		
Copper		2,3						1				
Nickel		3	2,3						1,2,3			
Selenium								1	1			
Thallium									1			
Vanadium									1			
Zinc								1				
PAHs												
LMW PAHs	1	1,3						1	1,2,3			
HMW PAHs	1, 3	1,2,3	2,3					1, 3	1,2,3			
PCBs												
Aroclor 1254		2,3						3				

Notes:
BERA, baseline ecological risk assessment
COPEC, chemical of potential ecological concern
DU, decision unit
EPC, exposure point concentration
HMW, high molecular weight
HQ, hazard quotient
LMW, low molecular weight
LOEC, lowest observable effect concentration
PAH, polycyclic aromatic hydrocarbon
PCB, polychlorinated biphenyl

Numbering convention
1 = Direct Contact risk
2 = Wildlife Ingestion risk
3 = Small-range receptor risk

Selection criteria:
Med-Large Home Range Wildlife ingestion: $HQ_{LOAEL} > 1$ based on refined exposure evaluation;
Small Home Range Wildlife: Sample points exceeding LOAEL-based back calculated value
Direct contact: LOEC exceedances based on point comparisons, except for COPECs that were addressed as part of the BERA risk characterization (e.g., background evaluation, localized exceedance)
For incremental soil samples (ISS), localized exceedance was not justification for removal based on averaged EPC across DU
PAH direct contact exposure selected based on exposure areas with points exceeding maximum acceptable toxicant concentration (MATC)

Table 2
Sediment Chemicals of Concern for Aquatic and Transitional Exposure Areas
Columbia Falls Aluminum Company
Columbia Falls, Montana

	Transitional Exposure Areas				*Aquatic Exposure Areas*		
COPEC	**North Percolation Pond**	**South Percolation Pond**	**Cedar Creek Reservoir Overflow Ditch**	**Northern Surface Water Feature**	**Flathead River**	**Flathead River-Riparian Channel**	**Cedar Creek**
Metals							
Barium	1	1,2					
Cadmium	1						
Lead	1						
Nickel	1						
Selenium	1,2						
Vanadium	2						
Zinc	1						
Other Inorganics							
Cyanide, total	1	1				1	
Cyanide, free					1**	1	
PAHs							
LMW PAHs	1,2						
HMW PAHs	1,2						

Notes:
BERA, baseline ecological risk assessment
COPEC, chemical of potential ecological concern
EPC, exposure point concentration
HMW, high molecular weight
HQ, hazard quotient
LMW, low molecular weight
LOAEL - lowest-observed-adverse-effect level
LOEC, lowest observable effect concentration
PAH, polycyclic aromatic hydrocarbon

Selection criteria:
Wildlife ingestion: HQ_{LOAEL} > 1 based on refined exposure evaluation
Direct contact: LOEC exceedances based on point comparisons, except for COPECs that were addressed as part of the BERA risk characterization (e.g., background evaluation, localized exceedance)

Numbering convention
1 = Direct Contact risk
2 = Wildlife Ingestion risk
* = Divalent metal that is likely not bioavailable, according to the results of the acid volatile sulfide-simultaneously extractable metals and pore water evaluation.
**= Focused COPEC for the Backwater Seep Sampling Area

Table 3
Surface Water Chemicals of Concern for Aquatic and Transitional Exposure Areas
Columbia Falls Aluminum Company
Columbia Falls, Montana

	Transitional Exposure Areas				*Aquatic Exposure Areas*		
COPEC	**North Percolation Pond**	**South Percolation Pond**	**Cedar Creek Reservoir Overflow Ditch**	**Northern Surface Water Feature**	**Flathead River**	**Flathead River-Riparian Channel**	**Cedar Creek**
Metals							
Aluminum	1	1				1	
Barium	1	1				1	
Cadmium	1						
Copper	1	1				1	
Iron		1				1	
Zinc	1						
Other Inorganics							
Cyanide, total		1			1*	1	
Cyanide, free		1			1*	1	
Fluoride	1						
PAHs							
Fluoranthene	1						
Benz(a)anthracene	1						
Chrysene	1						
Benzo(a)pyrene	1						
Benzo(b)fluoranthene	1						
Benzo(ghi)perylene	1						
Indeno(1,2,3-cd)pyrene	1						

Notes:
BERA, baseline ecological risk assessment
COPEC, chemical of potential ecological concern
EPC, exposure point concentration
HQ, hazard quotient
LOAEL - lowest-observed-adverse-effect level
LOEC, lowest observable effect concentration
PAH, polycyclic aromatic hydrocarbon

Selection criteria:
Wildlife ingestion: HQ_{LOAEL} > 1 based on refined exposure evaluation
Direct contact: LOEC exceedances based on point comparisons, except for COPECs that were addressed as part of the BERA risk characterization (e.g., background evaluation, localized exceedance)

Numbering convention
1 = Direct Contact risk
2 = Wildlife Ingestion risk
*= Focused COPEC for the Backwater Seep Sampling Area

Table 4
Preliminary Soil Remediation Goals for Terrestrial Exposure Scenarios[1]
Columbia Falls Aluminum Company
Columbia Falls, Montana

Constituent	Soil Invertebrate EcoPRG		Terrestrial Plant EcoPRG		Soil Wildlife EcoPRG		Background Threshold Value (BTV)		Protective Soil EcoPRG	
	PRG (mg/kg)	Basis	PRG (mg/kg)	Basis	PRG (mg/kg)	Basis	BTV (mg/kg)	Basis	PRG (mg/kg)	Basis
Metals										
Barium	3200	LANL ESL_{LOEC}/EcoPRG	1000	Derived[2]	No Unacceptable Risk	CFAC BERA	300	Max BTV (SO1, SO2, SO3)	**1000**	**Terrestrial plants**
Copper	530	LANL ESL_{LOEC}/EcoPRG	490	LANL ESL_{LOEC}/EcoPRG	537	American woodcock	17.9	BTV (SO1)	**490**	**Terrestrial plants**
Nickel	1300	LANL ESL_{LOEC}/EcoPRG	270	LANL ESL_{LOEC}/EcoPRG	140	Short-tailed shrew	17.3	BTV (SO1)	**140**	**Short-tailed shrew**
Selenium	41	LANL ESL_{LOEC}/EcoPRG	3.4	LANL ESL_{LOEC}	No Unacceptable Risk	CFAC BERA	1.4	BTV (SO1)	**3.4**	**Terrestrial plants**
Thallium	Not Identified	---	0.5	LANL ESL_{LOEC}	No Unacceptable Risk	CFAC BERA	0.15	BTV (SO1)	**0.5**	**Terrestrial plants**
Vanadium	Not Identified	---	80	LANL ESL_{LOEC}/EcoPRG	No Unacceptable Risk	CFAC BERA	15.7	BTV (SO1)	**80**	**Terrestrial plants**
Zinc	930	LANL ESL_{LOEC}/EcoPRG	810	LANL ESL_{LOEC}/EcoPRG	No Unacceptable Risk	CFAC BERA	82.9	BTV (SO1)	**810**	**Terrestrial plants**
PAHs										
Total LMW PAHs	175	EcoSSL MATC	Not Identified	---	480	American woodcock	0.1	BTV (SO1)	**175**	**Soil Invertebrates**
Total HMW PAHs	80	EcoSSL MATC	Not Identified	---	69	American woodcock	0.29	BTV (SO1)	**69**	**American woodcock**
PCBs										
Aroclor 1254	No Unacceptable Risk	CFAC BERA	No Unacceptable Risk	CFAC BERA	1.2	Short-tailed shrew	No Data	---	**1.2**	**Short-tailed shrew**

Notes:
1, Terrestrial exposure scenarios include the evalution of soil (0-2-ft interval) in terrestrial exposure areas and soil (0-2-ft interval) and sediment (0-0.5-ft) in transitional exposure areas.
2, Terrestrial Plant EcoPRG for barium was calculated based on barium nitrate ($BaNO_3$) endpoints summarized in LANL EcoRISK database; see text for further explanation.
EcoPRG values based on LOEC (direct contact) or LOAEL (wildlife) consistent with Los Alamos National Laboratory approach for the development of PRGs
Protective Soil EcoPRG is the minimum value of direct contact or wildlife if greater than the background threshold value (BTV); the BTV is selected as the EcoPRG if the minimum of the direct contact and wildlife values is less than the BTV.
Soil Wildlife EcoPRG assumptions:
1) Represents the minimum back calculated value for receptors with $HQ_{LOAEL} > 1$ based on refined exposure evaluation in the BERA
2) Wildlife EcoPRG is not a "not to exceed value" attainment of the EcoPRG is based on an average EPC (UCL95) within the receptor home range
3) Wildlife EcoPRGs presented are based on 100 percent area use; values may be adjusted for specific exposure areas.
The BTV is the highest BTV for the background areas (shown in parentheses) associated with the exposure areas where the constituent was identifed as a chemical of concern.
LANL EcoPRG - General PRG derived for Los Alamos National Laboratory
EcoSSL MATC - Maximum acceptable toxicant concentration reported in EcoSSL guidance

BERA, Baseline Ecological Risk Assessment
CFAC, Columbia Falls Aluminum Company
EcoPRG, ecological preliminary remediation goal
EcoSSL, Ecological Soil Screening Level
HMW, high molecular weight
HQ, hazard quotient
LANL, Los Alamos National Laboratory
LMW, low molecular weight
PAH, polycyclic aromatic hydrocarbons
PCB, polychlorinated biphenyls
UCL95, upper 95 percent confidence limit on the mean

Table 5
Preliminary Sediment Remediation Goals for Aquatic Exposure Areas[1]
Columbia Falls Aluminum Company
Columbia Falls, Montana

Constituent	Benthic Invertebrate EcoPRG		Sediment Wildlife EcoPRG		Background Threshold Value (BTV)		Protective Sediment EcoPRG	
	PRG (mg/kg)	Basis	PRG (mg/kg)	Basis	BTV (mg/kg)	Basis	PRG (mg/kg)	Basis
Metals								
Barium	300	LANL ESL_{LOEC}	276	American Dipper	300	Max BTV (UPS Flathead River; SO1)	**300**	**BTV**
Cadmium	4.9	LANL ESL_{LOEC}	No Unacceptable Risk	CFAC BERA	0.38	BTV (SO1)	**4.9**	**Benthic invertebrates**
Lead	120	LANL ESL_{LOEC}	No Unacceptable Risk	CFAC BERA	17.2	BTV (SO1)	**120**	**Benthic invertebrates**
Nickel	48	LANL ESL_{LOEC}	No Unacceptable Risk	CFAC BERA	17.32	BTV (SO1)	**48**	**Benthic invertebrates**
Selenium	2.9	LANL ESL_{LOEC}	1.30	American Dipper	1.38	BTV (SO1)	**1.38**	**BTV**
Vanadium	Not Identified	---	38	American Dipper	15.72	BTV (SO1)	**38**	**American Dipper**
Zinc	450	LANL ESL_{LOEC}	No Unacceptable Risk	CFAC BERA	82.9	BTV (SO1)	**450**	**Benthic invertebrates**
Other Inorganics								
Cyanide, total	Not Identified	Free CN does not persist in sediment matrix; address GW input to benthic habitats	No Unacceptable Risk	CFAC BERA	0.27	Max BTV (UPS Flathead River; SO1)	**Not Identified**	Free CN does not persist in sediment matrix; address GW input to benthic habitats
Cyanide, free	Not Identified		No Unacceptable Risk	CFAC BERA	Not Analyzed	---	**Not Identified**	
PAHs								
PAH Mixture	$ESBTU_{34}$ > 10	CFAC BERA LOEC	Not Applicable	---	Not Applicable	---	**$ESBTU_{34}$ > 10**	**CFAC BERA LOEC**
Total LMW PAHs	Not Identified	---	196	American Dipper	0.1	BTV (SO1)	**196**	**American Dipper**
Total HMW PAHs	Not Identified	---	28.2	American Dipper	0.29	BTV (SO1)	**28.2**	**American Dipper**

Notes:
1, Aquatic exposure scenarios include the evalution of sediment (0-0.5-ft interval) in aquatic exposure areas and sediment (0-0.5-ft) and soil (0-0.5-ft interval) in transitional exposure areas.
EcoPRG values based on LOEC (direct contact) or LOAEL (wildlife) consistent with Los Alamos National Laboratory approach for the development of PRGs.
Protective Sediment EcoPRG is the minimum value of direct contact or wildlife if greater than the background threshold value (BTV); the BTV is selected as the EcoPRG if the minimum of the direct contact and wildlife values is less than the BTV.
Sediment Wildlife EcoPRG assumptions:

1) Represents the minimum back calculated value for receptors with HQ_{LOAEL} > 1 based on refined exposure evaluation in the BERA
2) Wildlife EcoPRG is not a "not to exceed value" attainment of the EcoPRG is based on an average EPC (UCL95) within the receptor home range
3) Wildlife EcoPRGs presented are based on 100 percent area use; values may be adjusted for specific exposure areas.

The BTV is the highest BTV for the background areas (shown in parentheses) associated with the exposure areas where the constituent was identifed as a chemical of concern.
LANL LOEC, General LOEC derived for Los Alamos National Laboratory
BERA, Baseline Ecological Risk Assessment
CFAC, Columbia Falls Aluminum Company
CN, cyanide
EcoPRG, ecological preliminary remediation goal
EPC, exposure point concentration
ESBTU, Equilibrium Partitioning Sediment Benchmark Toxic Unit (see CFAC BERA)
GW, groundwater
HMW, high molecular weight
HQ, hazard quotient
LANL, Los Alamos National Laboratory
LMW, low molecular weight
LOAEL, lowest-observed-adverse-effect level
LOEC, lowest-observed-effect concentration
mg/kg, milligrams per kilogram
PAH, polycyclic aromatic hydrocarbon
PRG, preliminary remediation goal
UCL95, upper 95 percent confidence limit on the mean
UPS, upstream

Table 6
Preliminary Surface Water Remediation Goals for Aquatic Exposure Areas
Columbia Falls Aluminum Company
Columbia Falls, Montana

COPEC	Surface Water PRGs			
	Chronic Aquatic Life Standards (µg/L)	Basis	Acute Aquatic Life Standards (µg/L)	Basis
Metals				
Aluminum (Filtered)[1]	87	MDEQ (2019)	750	MDEQ (2019)
Barium	220	OPEA (2006)	2000	OPEA (2006)
Cadmium[2]	0.25	MDEQ (2019)	0.49	MDEQ (2019)
Copper[2]	2.85	MDEQ (2019)	3.79	MDEQ (2019)
Iron	1000	MDEQ (2019)	NA	---
Zinc[2]	37	MDEQ (2019)	37	MDEQ (2019)
Other Inorganics				
Cyanide, total	5.2	MDEQ (2019)	22	MDEQ (2019)
Cyanide, free	5.2	USEPA (2019)	22	USEPA (2019)
PAHs				
Benz(a)anthracene	2.23	USEPA (2003)	9.25	USEPA (2003)
Benzo(a)pyrene	0.957	USEPA (2003)	3.98	USEPA (2003)
Benzo(b)fluoranthene	0.677	USEPA (2003)	2.81	USEPA (2003)
Benzo(ghi)perylene	0.439	USEPA (2003)	1.82	USEPA (2003)
Chrysene	2.04	USEPA (2003)	8.49	USEPA (2003)
Fluoranthene	7.11	USEPA (2003)	29.5	USEPA (2003)
Indeno(1,2,3-cd)pyrene	0.275	USEPA (2003)	1.14	USEPA (2003)

Notes:

BERA, baseline ecological risk assessment
COPEC, chemical of potential ecological concern
EPC, exposure point concentration
HQ, hazard quotient
LOAEL - lowest-observed-adverse-effect level
LOEC, lowest observable effect concentration
NA, Acute aquatic life standard not available
PAH, polycyclic aromatic hydrocarbon
1, Except aluminum, aquatic life standards for metals in surface water are based on the analysis of unfiltered samples following a total recoverable analysis
2, Chronic and acute aquatic life standards are presented at a default harndess of 25 mg/L (as $CaCO_3$); hardness-adjusted standards are calculated as a function of surface water hardness as defined in (MDEQ, 2019):

Metal	Chronic = exp.{mc[ln(hardness)]+bc}		Acute = exp.{ma[ln(hardness)]+ba}	
	mc	bc	ma	ba
Cadmium	0.7977	-3.909	0.9789	-3.866
Copper	0.8545	-1.702	0.9422	-1.7
Zinc	0.8473	0.884	0.8473	0.884

EHS Support

Attachment A Wildlife Ingestion Variables and PRG Calculations

Table A-1
Summary of Exposure Parameters for Wildlife Receptors of Concern
Columbia Falls Aluminum Company
Columbia Falls, Montana

Representative Species			Body Weight (kg wet weight)		Dietary Composition				Ingestion Rates				
					Plant Material	Invertebrates	Fish	Small Mammals	Dietary	Drinking Water	Incidental Substrate		
Common Name	Scientific Name	Food-web classification	Mean	±SD					kg dry weight/day	L/day	Average % of Dry Intake	± SD % of Dry Intake	kg dry weight/day
Avian Receptors													
American Dipper	*Cinclus mexicanus*	semi-aquatic passerine invertivore	0.0546	0.0048		100%			0.0091	0.0084	2%	---	0.0002
American Woodcock	*Scolopax minor*	small soil probing invertivore	0.176	---	10%	90%			0.021	0.018	7.5%	6.9%	0.0016
Belted Kingfisher	*Ceryle alcyon*	small aquatic piscivore	0.148	0.0208		10%	90%		0.023	0.016	0%	---	0
Yellow-billed Cuckoo	*Coccyzus americanus*	terrestrial insectivore (Special Status)	0.064	0.0091		100%			0.010	0.0094	0%	---	0
Mammalian Receptors													
Meadow Vole	*Microtus pennsylvanicus*	small terrestrial herbivore	0.033	0.0082	100%				0.0050	0.005	1.3%	1.4%	0.00007
Short-tailed Shrew	*Blarina brevicauda*	small terrestrial invertivore	0.015	0.00078		100%			0.002	0.002	1.1%	1.5%	0.00002

Notes:
Please see the Baseline Ecological Risk Assessment (EHS Support, 2019) Appendix H, for additional details
EHS Support. 2019. Baseline Ecological Risk Assessment. Columbia Falls Aluminum Company
kg, kilogram
L/day, liters per day
SD, standard deviation

Table A-2
Estimated Concentrations in Dietary Items of Terrestrial Receptors
Columbia Falls Aluminum Company
Columbia Falls, Montana

Analyte	log K_{ow}	Refined Shallow Soil (0-0.5') Exposure Point Concentration (mg/kg, dry weight)	Estimated Concentrations in Dietary Items of Terrestrial Receptors (mg/kg, dry weight)								
			Plants			Soil Invertebrates			Small Mammals		
			Bioaccumulation Factor (BAF)	Estimated Concentration	BAF Reference	Bioaccumulation Factor (BAF)	Estimated Concentration	BAF Reference	Bioaccumulation Factor (BAF)	Estimated Concentration	BAF Reference
Inorganics - Metals											
Cobalt	NA	1.00E+01	7.50E-03	7.50E-02	See BERA	1.22E-01	1.22E+00	See BERA	Regression[c]	2.33E-01	See BERA
Nickel	NA	1.00E+01	Regression[a]	6.06E-01	See BERA	7.78E-01	7.78E+00	See BERA	Regression[c]	2.28E+00	See BERA
Vanadium	NA	1.00E+01	4.85E-03	4.85E-02	See BERA	4.20E-02	4.20E-01	See BERA	1.23E-02	1.23E-01	See BERA
Polychlorinated Biphenyls (PCBs)											
Aroclor 1254	6.98	1.00E+00	8.90E-02	8.90E-02	USEPA (2007a)	Regression[b]	4.10E+00	See BERA	2.53E-01	2.53E-01	See BERA
Semi-volatile Organic Compounds (SVOCs) - Polycyclic Aromatic Hydrocarbons (PAHs)											
Low Molecular Weight (LMW) PAHs:											
Acenaphthene	3.92	1.00E+00	Regression[a]	3.84E-03	See BERA	1.47E+00	1.47E+00	See BERA	0.00E+00	0.00E+00	See BERA
Acenaphthylene	4.07	1.00E+00	Regression[a]	3.19E-01	See BERA	2.29E+01	2.29E+01	See BERA	0.00E+00	0.00E+00	See BERA
Anthracene	4.55	1.00E+00	Regression[a]	3.72E-01	See BERA	2.42E+00	2.42E+00	See BERA	0.00E+00	0.00E+00	See BERA
Fluoranthene	4.95	1.00E+00	5.00E-01	5.00E-01	See BERA	3.04E+00	3.04E+00	See BERA	0.00E+00	0.00E+00	See BERA
Fluorene	4.18	1.00E+00	Regression[a]	3.84E-03	See BERA	9.57E+00	9.57E+00	See BERA	0.00E+00	0.00E+00	See BERA
Naphthalene	3.36	1.00E+00	1.22E+01	1.22E+01	See BERA	4.40E+00	4.40E+00	See BERA	0.00E+00	0.00E+00	See BERA
Phenanthrene	4.55	1.00E+00	Regression[a]	8.47E-01	See BERA	1.72E+00	1.72E+00	See BERA	0.00E+00	0.00E+00	See BERA
High Molecular Weight (HMW) PAHs:											
Benzo(a)anthracene	5.7	1.00E+00	Regression[a]	6.67E-02	See BERA	1.59E+00	1.59E+00	See BERA	0.00E+00	0.00E+00	See BERA
Benzo[A]Pyrene	6.11	1.00E+00	Regression[a]	1.27E-01	See BERA	1.33E+00	1.33E+00	See BERA	0.00E+00	0.00E+00	See BERA
Benzo(b)fluoranthene	6.2	1.00E+00	3.10E-01	3.10E-01	See BERA	2.60E+00	2.60E+00	See BERA	0.00E+00	0.00E+00	See BERA
Benzo(g,h,i)perylene	6.7	1.00E+00	Regression[a]	3.94E-01	See BERA	2.94E+00	2.94E+00	See BERA	0.00E+00	0.00E+00	See BERA
Benzo(k)fluoranthene	6.2	1.00E+00	Regression[a]	1.16E-01	See BERA	2.60E+00	2.60E+00	See BERA	0.00E+00	0.00E+00	See BERA
Chrysene	5.7	1.00E+00	Regression[a]	6.67E-02	See BERA	2.29E+00	2.29E+00	See BERA	0.00E+00	0.00E+00	See BERA
Dibenz(a,h)anthracene	6.69	1.00E+00	1.30E-01	1.30E-01	See BERA	2.31E+00	2.31E+00	See BERA	0.00E+00	0.00E+00	See BERA
Indeno (1,2,3-CD) Pyrene	6.58	1.00E+00	1.10E-01	1.10E-01	See BERA	2.86E+00	2.86E+00	See BERA	0.00E+00	0.00E+00	See BERA
Pyrene	4.88	1.00E+00	7.20E-01	7.20E-01	See BERA	1.75E+00	1.75E+00	See BERA	0.00E+00	0.00E+00	See BERA

Table A-2
Estimated Concentrations in Dietary Items of Terrestrial Receptors
Columbia Falls Aluminum Company
Columbia Falls, Montana

Notes:

Concentrations are placeholders. Please see the Baseline Ecological Risk Assessment (EHS Support, 2019) Appendix H, for additional details, including references.

a, Plant tissue concentrations (mg/kg dry weight) calculated based on regression models, where ln([tissue]) = B0 + B1(ln[soil]). Slopes (B1) and intercepts (B0) are as follows:

Analyte	B0	B1	Data Source
Nickel	-2.223	7.48E-01	Bechtel-Jacobs (1998)
Acenaphthene	-5.562	-8.56E-01	USEPA (2007)
Acenaphthylene	-1.144	7.91E-01	USEPA (2007)
Anthracene	-0.9887	7.78E-01	USEPA (2007)
Benzo(a)anthracene	-2.7078	5.94E-01	USEPA (2007)
Benzo(a)pyrene	-2.0615	9.75E-01	USEPA (2007)
Benzo(g,h,i)perylene	-0.9313	1.18E+00	USEPA (2007)
Benzo(k)fluoranthene	-2.1579	8.60E-01	USEPA (2007)
Chrysene	-2.7078	5.94E-01	USEPA (2007)
Fluorene	-5.562	-8.56E-01	USEPA (2007)
Phenanthrene	-0.1665	6.20E-01	USEPA (2007)

b, Soil invertebrate tissue concentrations (mg/kg dry weight) calculated based on regression models, where ln([tissue]) = B0 + B1(ln[soil]) and slopes (B1) and intercepts (B0) are as follows:

Analyte	B0	B1	Data Source
Aroclor 1254	1.41	1.361	Sample et al. (1998a)

e, Bioaccumulation factor estimated as the product of the soil-plant and ingestion-beef factors reported in Baes et al. (1984)

f, Small mammal tissue concentrations (mg/kg dry weight) calculated based on regression models, where ln([tissue]) = B0 + B1(ln[soil]) and slopes (B1) and intercepts (B0) are as follows:

Analyte	B0	B1	Data Source
Cobalt	-4.4669	1.31E+00	Sample et al. (1998b)
Nickel	-0.2462	4.66E-01	Sample et al. (1998b)

g, Pentachlorophenol concentration in small mammal tissue (mg/kg dry weight) calculated based on regression models, where [tissue] = 0.198 + 0.00452([$diet_{invertebrate}$])

h, USEPA (2005) assumes bioaccumulation of PAHs by birds and mammals is minimal due to rapid metabolism of these compounds after ingestion.

i, Small mammal tissue estimated based on the medial BAF for the general model presented in Sample et al. (1998b)

j, No value was identified in the literature. Soil-to-small mammal BF estimated based on the approach presented in Table 5, consistent with LANL (2017).

EHS Support. 2019. Baseline Ecological Risk Assessment. Columbia Falls Aluminum Company Superfund Site.

BERA, Baseline Ecological Risk Assessment

mg/kg, milligrams per kilogram

Table A-3
Estimated Aquatic Prey Concentrations
Columbia Falls Aluminum Company
Columbia Falls, Montana

Analyte	log K_{ow}	Sediment Concentration (mg/kg, dry weight)	Normalized BSAF (kg OC/kg lipid)[a]	Estimated Concentrations in Dietary Items of Aquatic Receptors (mg/kg, dry weight)		
				Aquatic Life Stage Benthic Invertebrates		
				BSAF[b]	BCF	Estimated Concentration
Metals						
Barium	---	1.00E+01	---	2.82E+00	---	2.82E+01
Selenium	---	1.00E+01	---	3.75E+00	---	3.75E+01
Vanadium	---	1.00E+01	---	2.50E-01	---	2.50E+00
Semi-volatile Organic Compounds (SVOCs) - Polycyclic Aromatic Hydrocarbons (PAHs)						
Low Molecular Weight (LMW) PAHs:						
Acenaphthene	4.01	1.00E+00	7.04E-01	4.58E+00	---	4.58E+00
Acenaphthylene	3.22	1.00E+00	7.54E-01	4.90E+00	---	4.90E+00
Anthracene	4.53	1.00E+00	6.73E-01	4.37E+00	---	4.37E+00
Fluoranthene	5.08	1.00E+00	6.41E-01	4.17E+00	---	4.17E+00
Fluorene	4.21	1.00E+00	6.92E-01	4.50E+00	---	4.50E+00
Naphthalene	3.36	1.00E+00	7.45E-01	4.84E+00	---	4.84E+00
Phenanthrene	4.57	1.00E+00	6.70E-01	4.36E+00	---	4.36E+00
High Molecular Weight (HMW) PAHs:						
Benzo(a)anthracene	6.71	1.00E+00	5.56E-01	3.61E+00	---	3.61E+00
Benzo[A]Pyrene	6.11	1.00E+00	5.86E-01	3.81E+00	---	3.81E+00
Benzo(b)fluoranthene	6.27	1.00E+00	5.78E-01	3.76E+00	---	3.76E+00
Benzo(g,h,i)perylene	6.51	1.00E+00	5.66E-01	3.68E+00	---	3.68E+00
Benzo(k)fluoranthene	6.29	1.00E+00	5.77E-01	3.75E+00	---	3.75E+00
Chrysene	5.71	1.00E+00	6.07E-01	3.94E+00	---	3.94E+00
Dibenz(A,H)Anthracene	6.71	1.00E+00	5.56E-01	3.61E+00	---	3.61E+00

Table A-3
Estimated Aquatic Prey Concentrations
Columbia Falls Aluminum Company
Columbia Falls, Montana

Analyte	log K_{ow}	Sediment Concentration (mg/kg, dry weight)	Normalized BSAF (kg OC/kg lipid)[a]	Estimated Concentrations in Dietary Items of Aquatic Receptors (mg/kg, dry weight)		
				Aquatic Life Stage Benthic Invertebrates		
				BSAF[b]	BCF	Estimated Concentration
Indeno (1,2,3-CD) Pyrene	6.72	1.00E+00	5.55E-01	3.61E+00	---	3.61E+00
Pyrene	4.92	1.00E+00	6.50E-01	4.23E+00	---	4.23E+00

Notes:

Concentrations are placeholders. Please see the Baseline Ecological Risk Assessment (EHS Support, 2019) Appendix H, for additional details, including acronyms and references.
EHS Support. 2019. Baseline Ecological Risk Assessment. Columbia Falls Aluminum Company Superfund Site.

BCF, bioconcentration factor
BSAF, biota-sediment accumulation factor
kg OC / kg lipid,
mg/kg, milligrams per kilogram
a, Normalized BSAF (kg OC / kg lipid) calculated based on K_{ow}, where BSAF = $K_{ow}^{-0.038}$
b, For non-ionic organic constituents, dry weight BSAF calculated from sediment organic carbon and lipid normalized BSAF as follows:

$$BSAF_{dry\ weight} = BSAF_{norm} \times f_{lip;id} \times \frac{1}{f_{oc}}$$

where: $BSAF_{norm}$ = Normalized BSAF (kg OC/kg lipid)
f_{lipid} = Fraction of lipids in prey item expressed on a dry weight basis (0.065, invertebrates; 0.08, fish)

f_{oc} = Fraction of sediment organic carbon expressed on a dry weight basis (0.01 or 1%)

Table A-4
Avian and Mammalian Toxicity Reference Values
Columbia Falls Aluminum Company
Columbia Falls, Montana

Analytes	**Avian Receptors**		**Mammalian Receptors**	
	Chronic TRV_{NOAEL} [a]	**Chronic TRV_{LOAEL} [b]**	**Chronic TRV_{NOAEL} [a]**	**Chronic TRV_{LOAEL} [b]**
	(mg/kg-bw/d)		**(mg/kg-bw/d)**	
Metals				
Barium	73.5	131	51.8	82.7
Cobalt	7.61	20.16	7.33	18.9
Nickel	6.71	18.6	1.7	14.8
Selenium	0.3	0.82	0.143	0.66
Vanadium	0.344	1.7	4.16	9.44
Polychlorinated Biphenyls				
Aroclor 1254	0.18	1.8	0.068	0.68
Polycyclic Aromatic Hydrocarbons (PAHs)				
Total LMW PAHs	16.1	161	65.6	356
Total HMW PAHs	2	20	0.615	38.4

Notes:

Please see the Baseline Ecological Risk Assessment (EHS Support, 2019) Appendix H, for additional details, including acronyms and references.

EHS Support. 2019. Baseline Ecological Risk Assessment. Columbia Falls Aluminum Company Superfund Site. Columbia Falls, Montana. July.

HMW, high molecular weight
LMW, low molecular weight
LOAEL, lowest observed adverse effect level
mg/kg bw/d, milligram per kilogram of body weight per day
NOAEL, no observed adverse effect level
TRV, toxicity reference value

Table A-5
Wildlife PRG Calculation - Meadow Vole
Columbia Falls Aluminum Company
Columbia Falls, Montana

Analyte	Ingestion Rates[a]		Soil-Plant Bioaccumulation Factor (BAF)[b]	NOAEL-Based Soil Benchmark Calculations				LOAEL-Based Soil Benchmark Calculations				HQ_{NOAEL}	HQ_{LOAEL}
	Food Ingestion Rate (FIR) (kg/kg bw/d)	Soil Ingestion Rate (SIR) (kg/kg bw/d)		NOAEL-Based Benchmark Concentration ($C_{soil\text{-}NOAEL}$) (mg/kg, dry weight)[c]	Estimated Soil Plant Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{NOAEL}) (mg/kg bw/d)[d]	Mammalian NOAEL (mg/kg bw/d)[e]	LOAEL-Based Benchmark Concentration ($C_{soil\text{-}LOAEL}$) (mg/kg, dry weight)[c]	Estimated Soil Plant Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{LOAEL}) (mg/kg bw/d)[d]	Mammalian LOAEL (mg/kg bw/d)[e]		
Inorganics - Metals													
Aluminum	0.150	0.00195	8.00E-04	**NC**	---	---	No TRV	**NC**	---	---	No TRV	NA	NA
Antimony	0.150	0.00195	Regression[b]	**8.26E+00**	2.86E-01	5.91E-02	5.90E-02	**4.60E+02**	1.24E+01	2.76E+00	2.76E+00	No TRV	No TRV
Arsenic	0.150	0.00195	3.75E-02	**1.37E+02**	5.14E+00	1.04E+00	1.04E+00	**5.99E+02**	2.25E+01	4.55E+00	4.55E+00	1.00E+00	1.00E+00
Barium	0.150	0.00195	1.56E-01	**2.04E+03**	3.18E+02	5.18E+01	5.18E+01	**3.26E+03**	5.08E+02	8.27E+01	8.27E+01	1.00E+00	1.00E+00
Beryllium	0.150	0.00195	Regression[b]	**1.10E+01**	3.40E+00	5.32E-01	5.32E-01	**1.50E+01**	4.27E+00	6.70E-01	6.70E-01	1.00E+00	1.00E+00
Cadmium	0.150	0.00195	Regression[b]	**3.93E+01**	4.62E+00	7.71E-01	7.70E-01	**1.21E+03**	3.00E+01	6.88E+00	6.87E+00	1.00E+00	1.00E+00
Chromium	0.150	0.00195	4.10E-02	**2.96E+02**	1.21E+01	2.40E+00	2.40E+00	**7.17E+03**	2.94E+02	5.82E+01	5.82E+01	1.00E+00	1.00E+00
Cobalt	0.150	0.00195	7.50E-03	**2.38E+03**	1.79E+01	7.33E+00	7.33E+00	**6.14E+03**	4.60E+01	1.89E+01	1.89E+01	1.00E+00	1.00E+00
Copper	0.150	0.00195	Regression[b]	**7.91E+02**	2.70E+01	5.61E+00	5.60E+00	**3.33E+04**	1.18E+02	8.28E+01	8.27E+01	1.00E+00	1.00E+00
Lead	0.150	0.00195	Regression[b]	**1.28E+03**	1.47E+01	4.70E+00	4.70E+00	**8.37E+04**	1.53E+02	1.87E+02	1.86E+02	1.00E+00	1.00E+00
Manganese	0.150	0.00195	7.90E-02	**3.73E+03**	2.94E+02	5.15E+01	5.15E+01	**1.06E+04**	8.34E+02	1.46E+02	1.46E+02	1.00E+00	1.00E+00
Mercury	0.150	0.00195	Regression[b]	**2.06E+02**	6.71E+00	1.41E+00	1.41E+00	**4.47E+03**	3.58E+01	1.41E+01	1.41E+01	1.00E+00	1.00E+00
Nickel	0.150	0.00195	Regression[b]	**2.91E+02**	7.54E+00	1.70E+00	1.70E+00	**3.70E+03**	5.05E+01	1.48E+01	1.48E+01	1.00E+00	1.00E+00
Selenium	0.150	0.00195	Regression[b]	**1.73E+00**	9.30E-01	1.43E-01	1.43E-01	**6.93E+00**	4.30E+00	6.60E-01	6.60E-01	1.00E+00	1.00E+00
Thallium	0.150	0.00195	4.00E-03	**1.88E+02**	7.52E-01	4.80E-01	4.80E-01	**5.60E+02**	2.24E+00	1.43E+00	1.43E+00	1.00E+00	1.00E+00
Vanadium	0.150	0.00195	4.85E-03	**1.55E+03**	7.52E+00	4.16E+00	4.16E+00	**3.52E+03**	1.71E+01	9.44E+00	9.44E+00	1.00E+00	1.00E+00
Zinc	0.150	0.00195	Regression[b]	**3.65E+03**	4.55E+02	7.55E+01	7.54E+01	**3.34E+04**	1.55E+03	2.98E+02	2.98E+02	1.00E+00	1.00E+00
Inorganics - Other Inorganics													
Cyanide	0.150	0.00195	0.00E+00	**3.52E+04**	0.00E+00	6.87E+01	6.87E+01	**3.52E+05**	0.00E+00	6.87E+02	6.87E+02	NA	NA
Fluoride	0.150	0.00195	6.00E-02	**2.43E+03**	1.46E+02	2.66E+01	2.66E+01	**4.47E+03**	2.68E+02	4.90E+01	4.90E+01	1.00E+00	1.00E+00
Polychlorinated Biphenyls (PCBs)													
Aroclor 1248	0.150	0.00195	1.62E-01	**2.59E+00**	4.19E-01	6.80E-02	6.80E-02	**2.59E+01**	4.19E+00	6.80E-01	6.80E-01	1.00E+00	1.00E+00
Aroclor 1254	0.150	0.00195	8.90E-02	**4.44E+00**	3.95E-01	6.80E-02	6.80E-02	**4.44E+01**	3.95E+00	6.80E-01	6.80E-01	1.00E+00	1.00E+00
Semi-volatile Organic Compounds (SVOCs) - Polycyclic Aromatic Hydrocarbons (PAHs)													
Low Molecular Weight (LMW) PAHs	0.150	0.00195	Regression[b]	**3.13E+04**	2.95E+01	6.56E+01	6.56E+01	**1.77E+05**	6.48E+01	3.56E+02	3.56E+02	1.00E+00	1.00E+00
High Molecular Weight (HMW) PAHs	0.150	0.00195	Regression[b]	**2.45E+01**	3.77E+00	6.15E-01	6.15E-01	**1.89E+03**	2.31E+02	3.84E+01	3.84E+01	1.00E+00	1.00E+00
Semi-volatile Organic Compounds (SVOCs) - Non-PAH SVOCs													
1,2,4,5-Tetrachlorobenzene	0.150	0.00195	8.44E-01	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
2-Chloronaphthalene	0.150	0.00195	1.71E+00	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Biphenyl (Diphenyl)	0.150	0.00195	1.80E+00	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Bis(2-ethylhexyl)phthalate	0.150	0.00195	2.38E-02	**3.31E+03**	7.88E+01	1.83E+01	1.83E+01	**3.31E+04**	7.88E+02	1.83E+02	1.83E+02	1.00E+00	1.00E+00
Butylbenzylphthalate	0.150	0.00195	6.54E-01	**1.59E+03**	1.04E+03	1.59E+02	1.59E+02	**1.59E+04**	1.04E+04	1.59E+03	1.59E+03	1.00E+00	1.00E+00
Dibenzofuran	0.150	0.00195	1.88E+00	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Di-n-butyl phthalate	0.150	0.00195	8.14E-01	**4.43E+03**	3.60E+03	5.50E+02	5.50E+02	**1.47E+04**	1.20E+04	1.83E+03	1.83E+03	1.00E+00	9.99E-01
Di-n-octyl phthalate	0.150	0.00195	2.07E-02	**1.29E+04**	2.66E+02	6.51E+01	6.51E+01	**1.29E+05**	2.66E+03	6.51E+02	6.51E+02	1.00E+00	1.00E+00
Hexachlorobenzene	0.150	0.00195	2.53E-01	**1.77E+02**	4.50E+01	7.10E+00	7.10E+00	**1.77E+03**	4.50E+02	7.10E+01	7.10E+01	1.00E+00	1.00E+00
Hexachlorobutadiene	0.150	0.00195	7.37E-01	**1.78E+03**	1.31E+03	2.00E+02	2.00E+02	**1.78E+04**	1.31E+04	2.00E+03	2.00E+03	No TRV	No TRV
Hexachlorocyclopentadiene	0.150	0.00195	8.03E-01	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Hexachloroethane	0.150	0.00195	1.39E+00	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Pentachlorophenol	0.150	0.00195	5.93E+00	**9.43E+00**	5.59E+01	8.42E+00	8.42E+00	**2.54E+01**	1.51E+02	2.27E+01	2.27E+01	1.00E+00	1.00E+00

Analyte	Ingestion Rates[a]		Soil-Plant Bioaccumulation Factor (BAF)[b]	NOAEL-Based Soil Benchmark Calculations				LOAEL-Based Soil Benchmark Calculations				HQ_{NOAEL}	HQ_{LOAEL}
	Food Ingestion Rate (FIR) (kg/kg bw/d)	Soil Ingestion Rate (SIR) (kg/kg bw/d)		NOAEL-Based Benchmark Concentration ($C_{soil\text{-}NOAEL}$) (mg/kg, dry weight)[c]	Estimated Soil Plant Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{NOAEL}) (mg/kg bw/d)[d]	Mammalian NOAEL (mg/kg bw/d)[e]	LOAEL-Based Benchmark Concentration ($C_{Soil\text{-}LOAEL}$) (mg/kg, dry weight)[c]	Estimated Soil Plant Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{LOAEL}) (mg/kg bw/d)[d]	Mammalian LOAEL (mg/kg bw/d)[e]		
Volatile Organic Compounds (VOCs)													
Methylcyclohexane	0.150	0.00195	2.11E+00	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Dioxin/Furans													
$TEC_{2,3,7,8\text{-TCDD-Mammal}}$	0.150	0.00195	9.41E-02	**3.49E-05**	3.29E-06	5.62E-07	5.62E-07	**2.34E-04**	2.20E-05	3.76E-06	3.76E-06	1.00E+00	1.00E+00

Notes:

Benchmarks (PRGs) presented for all final COPECs. Please see the Baseline Ecological Risk Assessment (EHS Support, 2019) Appendix H, for additional details, including acronyms and references.

a, Ingestion rates expressed as kg/kg bw/d. Diet is assumed to be 100% terrestrial vegetation.

b, Plant tissue concentrations (C_{diet}) (mg/kg dry weight) calculated based on bioaccumulation factors or uptake equations presented in **Table A-2**. Regression models follow the form: ln([tissue]) = B0 + B1(ln[soil]), where slopes (B1) and intercepts (B0) are as follows:

Analyte	B0	B1	Data Source
Antimony	-3.233	0.938	USEPA (2007)
Beryllium	-0.5361	0.7345	USEPA (2007)
Cadmium	-0.475	0.546	Bechtel-Jacobs (1998)
Copper	0.668	0.394	Bechtel-Jacobs (1998)
Lead	-1.328	0.561	Bechtel-Jacobs (1998)
Mercury	0.544	-0.996	Bechtel-Jacobs (1998)
Nickel	-2.223	0.748	Bechtel-Jacobs (1998)
Selenium	-0.677	1.104	Bechtel-Jacobs (1998)
Zinc	1.575	0.554	Bechtel-Jacobs (1998)
LMW PAHs	-1.3205	0.4544	USEPA (2007)
HMW PAHs	-1.7026	0.9469	USEPA (2007)

c, HQ = [(FIR x C_{diet}) + (SIR x C_{soil})] / $TRV_{NOAEL\ or\ LOAEL}$ solved for HQ = 1 where Csoil = Soil benchmark concentration.

d, Estimated daily dose (EDD) calculated as: [(FIR x C_{diet}) + (SIR x C_{soil})]

e, Toxicity reference values (TRVs) were selected as no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) doses presented in **Table A-5**.

NC, Soil benchmark was not calculated due to a lack of TRVs

No TRV, No toxicity reference value was identified.

No area use factor was incorporated into these equations.

2,3,7,8-TCDD, 2,3,7,8-tetrachlorodibenzo dioxin
COPEC, constituent of potential ecological concern
kg/kg bw/d, kilogram per kilogram of body weight per day
mg/kg bw/d, milligram per kilogram of body weight per day
mg/kg, milligram per kilogram
HQ, hazard quotient
NA, not applicable
Bold values, back-calculated values based on wildlife ingestion model to achieve HQs of 1. The LOAEL-based benchmark is selected as the preliminary remediation goal

EHS Support. 2019. Baseline Ecological Risk Assessment. Columbia Falls Aluminum Company Superfund Site. Columbia Falls, Montana. July.

Table A-6
Wildlife PRG Calculation - Short-Tailed Shrew
Columbia Falls Aluminum Company
Columbia Falls, Montana

Analyte	Ingestion Rates[a]		Soil-Invertebrate Bioaccumulation Factor (BAF)[b]	NOAEL-Based Soil Benchmark Calculations				LOAEL-Based Soil Benchmark Calculations				HQ_{NOAEL}	HQ_{LOAEL}
	Food Ingestion Rate (FIR) (kg/kg bw/d)	Soil Ingestion Rate (SIR) (kg/kg bw/d)		NOAEL-Based Benchmark Concentration ($C_{soil\text{-}NOAEL}$) (mg/kg, dry weight)[c]	Estimated Soil Invertebrate Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{NOAEL}) (mg/kg bw/d)[d]	Mammalian NOAEL (mg/kg bw/d)[e]	LOAEL-Based Benchmark Concentration ($C_{Soil\text{-}LOAEL}$) (mg/kg, dry weight)[c]	Estimated Soil Invertebrate Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{LOAEL}) (mg/kg bw/d)[d]	Mammalian LOAEL (mg/kg bw/d)[e]		
Inorganics - Metals													
Aluminum	0.134	0.00147	5.30E-02	**NC**	---	---	No TRV	**NC**	---	---	No TRV	NA	NA
Antimony	0.134	0.00147	1.00E+00	**4.35E-01**	4.35E-01	5.90E-02	5.90E-02	**2.04E+01**	2.04E+01	2.76E+00	2.76E+00	No TRV	No TRV
Arsenic	0.134	0.00147	Regression[b]	**1.08E+02**	6.57E+00	1.04E+00	1.04E+00	**7.46E+02**	2.58E+01	4.55E+00	4.55E+00	1.00E+00	1.00E+00
Barium	0.134	0.00147	9.10E-02	**3.79E+03**	3.45E+02	5.18E+01	5.18E+01	**6.05E+03**	5.51E+02	8.27E+01	8.27E+01	1.00E+00	1.00E+00
Beryllium	0.134	0.00147	4.50E-02	**7.09E+01**	3.19E+00	5.32E-01	5.32E-01	**8.93E+01**	4.02E+00	6.70E-01	6.70E-01	1.00E+00	1.00E+00
Cadmium	0.134	0.00147	Regression[b]	**6.31E-01**	5.74E+00	7.71E-01	7.70E-01	**9.89E+00**	5.12E+01	6.87E+00	6.87E+00	1.00E+00	1.00E+00
Chromium	0.134	0.00147	3.06E-01	**5.65E+01**	1.73E+01	2.40E+00	2.40E+00	**1.37E+03**	4.19E+02	5.82E+01	5.82E+01	1.00E+00	1.00E+00
Cobalt	0.134	0.00147	1.22E-01	**4.11E+02**	5.02E+01	7.33E+00	7.33E+00	**1.06E+03**	1.29E+02	1.89E+01	1.89E+01	1.00E+00	1.00E+00
Copper	0.134	0.00147	5.15E-01	**7.94E+01**	4.09E+01	5.60E+00	5.60E+00	**1.17E+03**	6.04E+02	8.27E+01	8.27E+01	1.00E+00	1.00E+00
Lead	0.134	0.00147	Regression[b]	**1.03E+02**	3.40E+01	4.70E+00	4.70E+00	**9.36E+03**	1.29E+03	1.87E+02	1.86E+02	1.00E+00	1.00E+00
Manganese	0.134	0.00147	Regression[b]	**1.14E+04**	2.60E+02	5.15E+01	5.15E+01	**4.18E+04**	6.31E+02	1.46E+02	1.46E+02	1.00E+00	1.00E+00
Mercury	0.134	0.00147	3.93E+00	**2.67E+00**	1.05E+01	1.41E+00	1.41E+00	**2.67E+01**	1.05E+02	1.41E+01	1.41E+01	1.00E+00	1.00E+00
Nickel	0.134	0.00147	7.78E-01	**1.61E+01**	1.25E+01	1.70E+00	1.70E+00	**1.40E+02**	1.09E+02	1.48E+01	1.48E+01	1.00E+00	1.00E+00
Selenium	0.134	0.00147	Regression[b]	**1.19E+00**	1.05E+00	1.43E-01	1.43E-01	**9.48E+00**	4.82E+00	6.60E-01	6.60E-01	1.00E+00	1.00E+00
Thallium	0.134	0.00147	5.41E-02	**5.50E+01**	2.98E+00	4.80E-01	4.80E-01	**1.64E+02**	8.87E+00	1.43E+00	1.43E+00	1.00E+00	1.00E+00
Vanadium	0.134	0.00147	4.20E-02	**5.86E+02**	2.46E+01	4.16E+00	4.16E+00	**1.33E+03**	5.58E+01	9.44E+00	9.44E+00	1.00E+00	1.00E+00
Zinc	0.134	0.00147	Regression[b]	**3.07E+02**	5.60E+02	7.55E+01	7.54E+01	**1.61E+04**	2.05E+03	2.98E+02	2.98E+02	1.00E+00	1.00E+00
Inorganics - Other Inorganics													
Cyanide	0.134	0.00147	0.00E+00	**4.66E+04**	0.00E+00	6.87E+01	6.87E+01	**4.66E+05**	0.00E+00	6.87E+02	6.87E+02	NA	NA
Fluoride	0.134	0.00147	1.24E-01	**1.47E+03**	1.82E+02	2.66E+01	2.66E+01	**2.71E+03**	3.36E+02	4.90E+01	4.90E+01	1.00E+00	1.00E+00
Polychlorinated Biphenyls (PCBs)													
Aroclor 1248	0.134	0.00147	Regression[b]	**2.15E-01**	5.05E-01	6.80E-02	6.80E-02	**1.17E+00**	5.06E+00	6.80E-01	6.80E-01	1.00E+00	1.00E+00
Aroclor 1254	0.134	0.00147	Regression[b]	**2.15E-01**	5.05E-01	6.80E-02	6.80E-02	**1.17E+00**	5.06E+00	6.80E-01	6.80E-01	1.00E+00	1.00E+00
Semi-volatile Organic Compounds (SVOCs) - Polycyclic Aromatic Hydrocarbons (PAHs)													
Low Molecular Weight (LMW) PAHs	0.134	0.00147	3.04E+00	**1.60E+02**	4.88E+02	6.56E+01	6.56E+01	**8.71E+02**	2.65E+03	3.56E+02	3.56E+02	1.00E+00	1.00E+00
High Molecular Weight (HMW) PAHs	0.134	0.00147	2.60E+00	**1.76E+00**	4.57E+00	6.15E-01	6.15E-01	**1.10E+02**	2.85E+02	3.84E+01	3.84E+01	1.00E+00	1.00E+00
Semi-volatile Organic Compounds (SVOCs) - Non-PAH SVOCs													
1,2,4,5-Tetrachlorobenzene	0.134	0.00147	1.01E+01	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
2-Chloronaphthalene	0.134	0.00147	7.27E+00	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Biphenyl (Diphenyl)	0.134	0.00147	7.10E+00	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Bis(2-ethylhexyl)phthalate	0.134	0.00147	5.44E+01	**2.51E+00**	1.37E+02	1.83E+01	1.83E+01	**2.51E+01**	1.37E+03	1.83E+02	1.83E+02	1.00E+00	1.00E+00
Butylbenzylphthalate	0.134	0.00147	1.14E+01	**1.04E+02**	1.19E+03	1.59E+02	1.59E+02	**1.04E+03**	1.19E+04	1.59E+03	1.59E+03	1.00E+00	1.00E+00
Dibenzofuran	0.134	0.00147	6.96E+00	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Di-n-butyl phthalate	0.134	0.00147	1.03E+01	**3.98E+02**	4.10E+03	5.50E+02	5.50E+02	**1.32E+03**	1.37E+04	1.83E+03	1.83E+03	1.00E+00	1.00E+00
Di-n-octyl phthalate	0.134	0.00147	5.81E+01	**8.36E+00**	4.86E+02	6.51E+01	6.51E+01	**8.36E+01**	4.86E+03	6.51E+02	6.51E+02	1.00E+00	1.00E+00
Hexachlorobenzene	0.134	0.00147	1.79E+01	**2.96E+00**	5.29E+01	7.10E+00	7.10E+00	**2.96E+01**	5.29E+02	7.10E+01	7.10E+01	1.00E+00	1.00E+00
Hexachlorobutadiene	0.134	0.00147	1.08E+01	**1.38E+02**	1.49E+03	2.00E+02	2.00E+02	**1.38E+03**	1.49E+04	2.00E+03	2.00E+03	No TRV	No TRV
Hexachlorocyclopentadiene	0.134	0.00147	1.04E+01	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Hexachloroethane	0.134	0.00147	8.01E+00	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Pentachlorophenol	0.134	0.00147	1.09E+01	**5.76E+00**	6.28E+01	8.42E+00	8.42E+00	**1.55E+01**	1.69E+02	2.27E+01	2.27E+01	1.00E+00	1.00E+00
Volatile Organic Compounds (VOCs)													
Methylcyclohexane	0.134	0.00147	6.59E+00	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Dioxin/Furans													
$TEC_{2,3,7,8\text{-}TCDD\text{-}Mammal}$	0.134	0.00147	Regression[b]	**1.42E-06**	4.18E-06	5.62E-07	5.62E-07	**7.08E-06**	2.80E-05	3.76E-06	3.76E-06	1.00E+00	1.00E+00

EHS Support

Notes:

Benchmarks (PRGs) presented for all final COPECs. Please see the Baseline Ecological Risk Assessment (EHS Support, 2019) Appendix H, for additional details, including acronyms and references.
a, Ingestion rates expressed as kg/kg bw/d based on receptor-specific parameters presented in **Table A-1**. Diet is assumed to be 100% soil invertebrates.

b, Soil invertebrate concentrations (C_{diet}) (mg/kg dry weight) calculated based on bioaccumulation factors or uptake equations presented in **Table A-2**. Regression models follow the form: ln([tissue]) = B0 + B1(ln[soil]), where slopes (B1) and intercepts (B0) are as follows:

Analyte	B0	B1	Data Source
Arsenic	-1.421	0.706	Sample et al. (1999)
Cadmium	2.114	0.795	Sample et al. (1999)
Lead	-0.218	0.807	Sample et al. (1999)
Manganese	-0.809	0.682	Sample et al. (1999)
Selenium	-0.075	0.733	Sample et al. (1999)
Zinc	4.449	0.328	Sample et al. (1999)
2,3,7,8-TCDD	3.533	1.182	Sample et al. (1998a)
Aroclor 1254	1.41	1.361	Sample et al. (1998a)

c, HQ = [(FIR x C_{diet}) + (SIR x C_{soil})] / $TRV_{NOAEL\ or\ LOAEL}$ solved for HQ = 1 where Csoil = Soil benchmark concentration.
d, Estimated daily dose (EDD) calculated as: [(FIR x C_{diet}) + (SIR x C_{soil})]
e, Toxicity reference values (TRVs) were selected as no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) doses presented in **Table A-5**.
NC, Soil benchmark was not calculated due to a lack of TRVs
No TRV, No toxicity reference value was identified.
No area use factor was incorporated into these equations.

2,3,7,8-TCDD, 2,3,7,8-tetrachlorodibenzo dioxin
COPEC, constituent of potential ecological concern
kg/kg bw/d, kilogram per kilogram of body weight per day
mg/kg bw/d, milligram per kilogram of body weight per day
mg/kg, milligram per kilogram
HQ, hazard quotient
NA, not applicable
Bold values, back-calculated values based on wildlife ingestion model to achieve HQs of 1. The LOAEL-based benchmark is selected as the preliminary remediation goal.
EHS Support. 2019. Baseline Ecological Risk Assessment. Columbia Falls Aluminum Company Superfund Site. Columbia Falls, Montana. July.

Table A-7
Wildlife PRG Calculation - American Woodcock
Columbia Falls Aluminum Company
Columbia Falls, Montana

Analyte	Ingestion Rates[a]		Soil-Invertebrate Bioaccumulation Factor (BAF)[b]	Soil-Plant Bioaccumulation Factor (BAF)[b]	NOAEL-Based Soil Benchmark Calculations					LOAEL-Based Soil Benchmark Calculations			
	Food Ingestion Rate (FIR) (kg/kg bw/d)	Soil Ingestion Rate (SIR) (kg/kg bw/d)			NOAEL-Based Benchmark Concentration ($C_{soil\text{-}NOAEL}$) (mg/kg, dry weight)[c]	Estimated Soil Invertebrate Concentration (C_{dieEW})[b]	Estimated Plant Concentration (C_{dietP})[b]	Estimated Daily Dose (EDD_{NOAEL}) (mg/kg bw/d)[d]	Avian NOAEL (mg/kg bw/d)[e]	LOAEL-Based Benchmark Concentration ($C_{Soil\text{-}LOAEL}$) (mg/kg, dry weight)[c]	Estimated Soil Invertebrate Concentration (C_{diet})[b]	Estimated Plant Concentration (C_{dietP})[b]	Estimated Daily Dose (EDD_{LOAEL}) (mg/kg bw/d)[d]
Inorganics - Metals													
Aluminum	0.119	0.00895	5.30E-02	8.00E-04	**NC**	---	---	---	1.10E+02	**NC**	---	---	---
Antimony	0.119	0.00895	1.00E+00	Regression[b]	**NC**	---	---	---	No TRV	**NC**	---	---	---
Arsenic	0.119	0.00895	Regression[b]	3.75E-02	**1.46E+02**	8.13E+00	5.46E+00	2.24E+00	2.24E+00	**3.19E+02**	1.41E+01	1.20E+01	4.51E+00
Barium	0.119	0.00895	9.10E-02	1.56E-01	**3.57E+03**	3.25E+02	5.57E+02	7.35E+01	7.35E+01	**6.36E+03**	5.79E+02	9.93E+02	1.31E+02
Beryllium	0.119	0.00895	4.50E-02	Regression[b]	**NC**	---	---	---	No TRV	**NC**	---	---	---
Cadmium	0.119	0.00895	Regression[b]	Regression[b]	**1.84E+00**	1.34E+01	8.67E-01	1.47E+00	1.47E+00	**1.15E+01**	5.79E+01	2.36E+00	6.35E+00
Chromium	0.119	0.00895	3.06E-01	4.10E-02	**6.29E+01**	1.92E+01	2.58E+00	2.66E+00	2.66E+00	**3.69E+02**	1.13E+02	1.51E+01	1.56E+01
Cobalt	0.119	0.00895	1.22E-01	7.50E-03	**3.44E+02**	4.19E+01	2.58E+00	7.61E+00	7.61E+00	**9.11E+02**	1.11E+02	6.83E+00	2.02E+01
Copper	0.119	0.00895	5.15E-01	Regression[b]	**6.12E+01**	3.15E+01	9.86E+00	4.05E+00	4.05E+00	**5.37E+02**	2.77E+02	2.32E+01	3.48E+01
Lead	0.119	0.00895	Regression[b]	Regression[b]	**2.99E+01**	1.25E+01	1.78E+00	1.63E+00	1.63E+00	**1.48E+03**	2.90E+02	1.59E+01	4.46E+01
Manganese	0.119	0.00895	Regression[b]	7.90E-02	**1.47E+04**	3.10E+02	1.16E+03	1.79E+02	1.79E+02	**3.24E+04**	5.30E+02	2.56E+03	3.77E+02
Mercury	0.119	0.00895	3.93E+00	Regression[b]	**1.03E+00**	4.06E+00	3.76E-01	4.50E-01	4.50E-01	**2.10E+00**	8.24E+00	5.52E-01	9.10E-01
Nickel	0.119	0.00895	7.78E-01	Regression[b]	**7.22E+01**	5.62E+01	2.66E+00	6.71E+00	6.71E+00	**2.00E+02**	1.56E+02	5.71E+00	1.86E+01
Selenium	0.119	0.00895	Regression[b]	Regression[b]	**3.28E+00**	2.22E+00	1.89E+00	2.90E-01	2.90E-01	**1.20E+01**	5.75E+00	7.93E+00	8.20E-01
Thallium	0.119	0.00895	5.41E-02	4.00E-03	**2.36E+01**	1.28E+00	9.46E-02	3.50E-01	3.50E-01	**2.36E+02**	1.28E+01	9.46E-01	3.50E+00
Vanadium	0.119	0.00895	4.20E-02	4.85E-03	**2.54E+01**	1.07E+00	1.23E-01	3.44E-01	3.44E-01	**1.26E+02**	5.28E+00	6.10E-01	1.70E+00
Zinc	0.119	0.00895	Regression[b]	Regression[b]	**3.32E+02**	5.74E+02	1.20E+02	6.61E+01	6.61E+01	**3.54E+03**	1.25E+03	4.47E+02	1.71E+02
Inorganics - Other Inorganics													
Cyanide	0.119	0.00895	0.00E+00	0.00E+00	**4.66E+04**	0.00E+00	0.00E+00	4.17E+02	4.00E-02	**4.66E+05**	0.00E+00	0.00E+00	4.17E+03
Fluoride	0.119	0.00895	1.24E-01	6.00E-02	**5.31E+02**	6.58E+01	3.19E+01	1.22E+01	1.22E+01	**5.31E+03**	6.58E+02	3.19E+02	1.22E+02
Polychlorinated Biphenyls (PCBs)													
Aroclor 1248	0.119	0.00895	Regression[b]	1.62E-01	**5.07E-01**	1.62E+00	8.20E-02	1.80E-01	1.80E-01	**2.78E+00**	1.65E+01	4.50E-01	1.80E+00
Aroclor 1254	0.119	0.00895	Regression[b]	8.90E-02	**5.08E-01**	1.63E+00	4.52E-02	1.80E-01	1.80E-01	**2.78E+00**	1.65E+01	2.48E-01	1.80E+00
Semi-volatile Organic Compounds (SVOCs) - Polycyclic Aromatic Hydrocarbons (PAHs)													
Low Molecular Weight (LMW) PAHs	0.119	0.00895	3.04E+00	Regression[b]	**4.79E+01**	1.46E+02	1.55E+00	1.61E+01	1.61E+01	**4.80E+02**	1.46E+03	4.41E+00	1.61E+02
High Molecular Weight (HMW) PAHs	0.119	0.00895	2.60E+00	Regression[b]	**6.89E+00**	1.79E+01	1.13E+00	2.00E+00	2.00E+00	**6.90E+01**	1.79E+02	1.00E+01	2.00E+01
Semi-volatile Organic Compounds (SVOCs) - Non-PAH SVOCs													
1,2,4,5-Tetrachlorobenzene	0.119	0.00895	1.01E+01	8.44E-01	**NC**	---	---	---	No TRV	**NC**	---	---	---
2-Chloronaphthalene	0.119	0.00895	7.27E+00	1.71E+00	**NC**	---	---	---	No TRV	**NC**	---	---	---
Biphenyl (Diphenyl)	0.119	0.00895	7.10E+00	1.80E+00	**NC**	---	---	---	No TRV	**NC**	---	---	---
Bis(2-ethylhexyl)phthalate	0.119	0.00895	5.44E+01	2.38E-02	**1.88E-01**	1.02E+01	4.47E-03	1.10E+00	1.10E+00	**1.88E+00**	1.02E+02	4.47E-02	1.10E+01
Butylbenzylphthalate	0.119	0.00895	1.14E+01	6.54E-01	**8.84E-02**	1.01E+00	5.78E-02	1.10E-01	1.10E-01	**8.84E-01**	1.01E+01	5.78E-01	1.10E+00
Dibenzofuran	0.119	0.00895	6.96E+00	1.88E+00	**NC**	---	---	---	No TRV	**NC**	---	---	---
Di-n-butyl phthalate	0.119	0.00895	1.03E+01	8.14E-01	**9.77E-02**	1.01E+00	7.95E-02	1.10E-01	1.10E-01	**9.77E-01**	1.01E+01	7.95E-01	1.10E+00
Di-n-octyl phthalate	0.119	0.00895	5.81E+01	2.07E-02	**1.76E-02**	1.02E+00	3.65E-04	1.10E-01	1.10E-01	**1.76E-01**	1.02E+01	3.65E-03	1.10E+00
Hexachlorobenzene	0.119	0.00895	1.79E+01	2.53E-01	**2.59E+00**	4.63E+01	6.56E-01	5.00E+00	5.00E+00	**2.59E+01**	4.63E+02	6.56E+00	5.00E+01
Hexachlorobutadiene	0.119	0.00895	1.08E+01	7.37E-01	**1.38E+02**	1.49E+03	1.02E+02	1.63E+02	No TRV	**1.38E+03**	1.49E+04	1.02E+03	1.63E+03
Hexachlorocyclopentadiene	0.119	0.00895	1.04E+01	8.03E-01	**NC**	---	---	---	No TRV	**NC**	---	---	---
Hexachloroethane	0.119	0.00895	8.01E+00	1.39E+00	**NC**	---	---	---	No TRV	**NC**	---	---	---
Pentachlorophenol	0.119	0.00895	1.09E+01	5.93E+00	**5.38E+00**	5.87E+01	3.19E+01	6.73E+00	6.73E+00	**4.16E+01**	4.53E+02	2.47E+02	5.20E+01
Volatile Organic Compounds (VOCs)													
Methylcyclohexane	0.119	0.00895	6.59E+00	2.11E+00	**NC**	---	---	---	No TRV	**NC**	---	---	---
Dioxin/Furans													
$TEC_{2,3,7,8\text{-}TCDD\text{-}Avian}$	0.119	0.00895	Regression[b]	9.41E-02	**4.39E-06**	1.59E-05	4.13E-07	1.75E-06	1.75E-06	**3.10E-05**	1.60E-04	2.91E-06	1.75E-05

Table A-7
Wildlife PRG Calculation - American Woodcock
Columbia Falls Aluminum Company
Columbia Falls, Montana

Notes:

Benchmarks (PRGs) presented for all final COPECs. Please see the Baseline Ecological Risk Assessment (EHS Support, 2019) Appendix H, for additional details, including acronyms and references.

a, Ingestion rates expressed as kg/kg bw/d based on receptor-specific parameters presented in **Table A-1**. Diet is assumed to consist of 90% terrestrial invertebrates and 10% terrestrial vegetation.

b, Soil invertebrate and plant concentrations (C_{dietI} and C_{dietP}) (mg/kg dry weight) calculated based on bioaccumulation factors or uptake equations presented in **Table A-2**. Regression models follow the form: ln([tissue]) = B0 + B1(ln[soil]), where slopes (B1) and intercepts (B0) are as follows:

Analyte	B0	B1	Data Source
Arsenic	-1.421	0.706	Sample et al. (1999)
Cadmium	2.114	0.795	Sample et al. (1999)
Lead	-0.218	0.807	Sample et al. (1999)
Manganese	-0.809	0.682	Sample et al. (1999)
Selenium	-0.075	0.733	Sample et al. (1999)
Zinc	4.449	0.328	Sample et al. (1999)
2,3,7,8-TCDD	3.533	1.182	Sample et al. (1998a)
Aroclor 1254	1.41	1.361	Sample et al. (1998a)

Plant tissue concentrations (C_{diet}) (mg/kg dry weight) calculated based on bioaccumation factors or uptake equations presented in **Table A-2**. Regression models follow the form: ln([tissue]) = B0 + B1(ln[soil]), where slopes (B1) and intercepts (B0) are as follows:

Analyte	B0	B1	Data Source
Antimony	-3.233	0.938	USEPA (2007)
Beryllium	-0.5361	0.7345	USEPA (2007)
Cadmium	-0.475	0.546	Bechtel-Jacobs (1998)
Copper	0.668	0.394	Bechtel-Jacobs (1998)
Lead	-1.328	0.561	Bechtel-Jacobs (1998)
Mercury	0.544	-0.996	Bechtel-Jacobs (1998)
Nickel	-2.223	0.748	Bechtel-Jacobs (1998)
Selenium	-0.677	1.104	Bechtel-Jacobs (1998)
Zinc	1.575	0.554	Bechtel-Jacobs (1998)
LMW PAHs	-1.3205	0.4544	USEPA (2007)
HMW PAHs	-1.7026	0.9469	USEPA (2007)

c, HQ = [(FIR x C_{diet}) + (SIR x C_{soil})] / $TRV_{NOAEL\ or\ LOAEL}$ solved for HQ = 1 where Csoil = Soil benchmark concentration.

d, Estimated daily dose (EDD) calculated as: [(FIR x C_{diet}) + (SIR x C_{soil})]

e, Toxicity reference values (TRVs) were selected as no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) doses presented in **Table A-5**.

NC, Soil benchmark was not calculated due to a lack of TRVs

No TRV, No toxicity reference value was identified.

No area use factor was incorporated into these equations.

2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo dioxin

COPEC = constituent of potential ecological concern

kg/kg bw/d = kilogram per kilogram of body weight per day

mg/kg bw/d = milligram per kilogram of body weight per day

mg/kg = milligram per kilogram

HQ = hazard quotient

NA = not applicable

Bold values = back-calculated values based on wildlife ingestion model to achieve HQs of 1. The LOAEL-based benchmark is selected as the preliminary remediation goal.

EHS Support. 2019. Baseline Ecological Risk Assessment. Columbia Falls Aluminum Company Superfund Site. Columbia Falls, Montana. July.

Table A-8
Wildlife PRG Calculation - Yellow-Billed Cuckoo
Columbia Falls Aluminum Company
Columbia Falls, Montana

Analyte	Ingestion Rates[a]		Soil-Invertebrate Bioaccumulation Factor (BAF)[b]	NOAEL-Based Soil Benchmark Calculations			
	Food Ingestion Rate (FIR) (kg/kg bw/d)	Soil Ingestion Rate (SIR) (kg/kg bw/d)		NOAEL-Based Benchmark Concentration ($C_{soil\text{-}NOAEL}$) (mg/kg, dry weight)[c]	Estimated Soil Invertebrate Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{NOAEL}) (mg/kg bw/d)[d]	Avian NOAEL (mg/kg bw/d)[e]
Inorganics - Metals							
Aluminum	0.156	0	5.30E-02	**NC**	---	---	1.10E+02
Antimony	0.156	0	1.00E+00	**NC**	---	---	No TRV
Arsenic	0.156	0	Regression[b]	**3.26E+02**	1.44E+01	2.24E+00	2.24E+00
Barium	0.156	0	9.10E-02	**5.18E+03**	4.71E+02	7.35E+01	7.35E+01
Beryllium	0.156	0	4.50E-02	**NC**	---	---	No TRV
Cadmium	0.156	0	Regression[b]	**1.18E+00**	9.42E+00	1.47E+00	1.47E+00
Chromium	0.156	0	3.06E-01	**5.57E+01**	1.71E+01	2.66E+00	2.66E+00
Cobalt	0.156	0	1.22E-01	**4.00E+02**	4.88E+01	7.61E+00	7.61E+00
Copper	0.156	0	5.15E-01	**5.04E+01**	2.60E+01	4.05E+00	4.05E+00
Lead	0.156	0	Regression[b]	**2.40E+01**	1.04E+01	1.63E+00	1.63E+00
Manganese	0.156	0	Regression[b]	**1.00E+05**	1.15E+03	1.79E+02	1.79E+02
Mercury	0.156	0	3.93E+00	**7.34E-01**	2.88E+00	4.50E-01	4.50E-01
Nickel	0.156	0	7.78E-01	**5.53E+01**	4.30E+01	6.71E+00	6.71E+00
Selenium	0.156	0	Regression[b]	**2.58E+00**	1.86E+00	2.90E-01	2.90E-01
Thallium	0.156	0	5.41E-02	**4.15E+01**	2.24E+00	3.50E-01	3.50E-01
Vanadium	0.156	0	4.20E-02	**5.25E+01**	2.21E+00	3.44E-01	3.44E-01
Zinc	0.156	0	Regression[b]	**1.31E+02**	4.24E+02	6.61E+01	6.61E+01
Inorganics - Other Inorganics							
Cyanide	0.156	0	0.00E+00	**4.66E+04**	0.00E+00	0.00E+00	4.00E-02
Fluoride	0.156	0	1.24E-01	**6.31E+02**	7.82E+01	1.22E+01	1.22E+01
Polychlorinated Biphenyls (PCBs)							
Aroclor 1248	0.156	0	Regression[b]	**3.94E-01**	1.15E+00	1.80E-01	1.80E-01
Aroclor 1254	0.156	0	Regression[b]	**3.94E-01**	1.15E+00	1.80E-01	1.80E-01
Semi-volatile Organic Compounds (SVOCs) - Polycyclic Aromatic Hydrocarbons (PAHs)							
Low Molecular Weight (LMW) PAHs	0.156	0	3.04E+00	**3.39E+01**	1.03E+02	1.61E+01	1.61E+01
High Molecular Weight (HMW) PAHs	0.156	0	2.60E+00	**4.93E+00**	1.28E+01	2.00E+00	2.00E+00
Semi-volatile Organic Compounds (SVOCs) - Non-PAH SVOCs							
1,2,4,5-Tetrachlorobenzene	0.156	0	1.01E+01	**NC**	---	---	No TRV
2-Chloronaphthalene	0.156	0	7.27E+00	**NC**	---	---	No TRV
Biphenyl (Diphenyl)	0.156	0	7.10E+00	**NC**	---	---	No TRV
Bis(2-ethylhexyl)phthalate	0.156	0	5.44E+01	**1.30E-01**	7.05E+00	1.10E+00	1.10E+00
Butylbenzylphthalate	0.156	0	1.14E+01	**6.17E-02**	7.05E-01	1.10E-01	1.10E-01
Dibenzofuran	0.156	0	6.96E+00	**NC**	---	---	No TRV
Di-n-butyl phthalate	0.156	0	1.03E+01	**6.84E-02**	7.05E-01	1.10E-01	1.10E-01
Di-n-octyl phthalate	0.156	0	5.81E+01	**1.21E-02**	7.05E-01	1.10E-01	1.10E-01
Hexachlorobenzene	0.156	0	1.79E+01	**1.79E+00**	3.21E+01	5.00E+00	5.00E+00
Hexachlorobutadiene	0.156	0	1.08E+01	**1.38E+02**	1.49E+03	2.33E+02	No TRV
Hexachlorocyclopentadiene	0.156	0	1.04E+01	**NC**	---	---	No TRV
Hexachloroethane	0.156	0	8.01E+00	**NC**	---	---	No TRV
Pentachlorophenol	0.156	0	1.09E+01	**3.96E+00**	4.31E+01	6.73E+00	6.73E+00
Volatile Organic Compounds (VOCs)							
Methylcyclohexane	0.156	0	6.59E+00	**NC**	---	---	No TRV
Dioxin/Furans							
$TEC_{2,3,7,8\text{-}TCDD\text{-}Avian}$	0.156	0	Regression[b]	**3.27E-06**	1.12E-05	1.75E-06	1.75E-06

Notes:

Benchmarks (PRGs) presented for all final COPECs. Please see the Baseline Ecological Risk Assessment (EHS Support, 2019) Appendix H, for additional details, including acronyms and re

a, Ingestion rates expressed as kg/kg bw/d based on receptor-specific parameters presented in **Table A-1**. Diet is assumed to consist of 100% terrestrial invertebrates.

b, Soil invertebrate concentrations (C_{diet}) (mg/kg dry weight) calculated based on bioaccumulation factors or uptake equations presented in **Table A-2**. Regression models follow the for

Analyte	B0	B1	Data Source
Arsenic	-1.421	0.706	Sample et al. (1999)
Cadmium	2.114	0.795	Sample et al. (1999)
Lead	-0.218	0.807	Sample et al. (1999)
Manganese	-0.809	0.682	Sample et al. (1999)
Selenium	-0.075	0.733	Sample et al. (1999)
Zinc	4.449	0.328	Sample et al. (1999)
2,3,7,8-TCDD	3.533	1.182	Sample et al. (1998a)
Aroclor 1254	1.41	1.361	Sample et al. (1998a)

c, HQ = [(FIR x C_{diet}) + (SIR x C_{soil})] / $TRV_{NOAEL\ or\ LOAEL}$ solved for HQ = 1 where Csoil = Soil benchmark concentration.

d, Estimated daily dose (EDD) calculated as: [(FIR x C_{diet}) + (SIR x C_{soil})]

e, Toxicity reference values (TRVs) were selected as no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) doses presented in **Table A-5**.

NC, Soil benchmark was not calculated due to a lack of TRVs

No TRV, No toxicity reference value was identified.

Table A-9
Wildlife PRG Calculation - American Dipper
Columbia Falls Aluminum Company
Columbia Falls, Montana

Analyte	Ingestion Rates[a]		Sed-Invertebrate Bioaccumulation Factor (BAF)[b]	NOAEL-Based Sediment Benchmark Calculations				LOAEL-Based Sediment Benchmark Calculations			
	Food Ingestion Rate (FIR) (kg/kg bw/d)	Sed Ingestion Rate (SIR) (kg/kg bw/d)		NOAEL-Based Benchmark Concentration ($C_{sed\text{-}NOAEL}$) (mg/kg, dry weight)[c]	Estimated Benthic Invertebrate Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{NOAEL}) (mg/kg bw/d)[d]	Avian NOAEL (mg/kg bw/d)[e]	LOAEL-Based Benchmark Concentration ($C_{sed\text{-}LOAEL}$) (mg/kg, dry weight)[c]	Estimated Benthic Invertebrate Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{LOAEL}) (mg/kg bw/d)[d]	Avian LOAEL (mg/kg bw/d)[e]
Inorganics - Metals											
Aluminum	0.167	0.003	NC	**NC**	---	---	1.10E+02	**NC**	---	---	1.10E+03
Antimony	0.167	0.003	5.75E-01	**NC**	---	---	No TRV	**NC**	---	---	No TRV
Arsenic	0.167	0.003	3.73E-01	**3.43E+01**	1.28E+01	2.24E+00	2.24E+00	**6.91E+01**	2.58E+01	4.51E+00	4.51E+00
Barium	0.167	0.003	2.82E+00	**1.55E+02**	4.37E+02	7.35E+01	7.35E+01	**2.76E+02**	7.79E+02	1.31E+02	1.31E+02
Beryllium	0.167	0.003	1.67E-01	**NC**	---	---	No TRV	**NC**	---	---	No TRV
Cadmium	0.167	0.003	4.59E-01	**1.85E+01**	8.47E+00	1.47E+00	1.47E+00	**7.97E+01**	3.66E+01	6.35E+00	6.35E+00
Chromium	0.167	0.003	8.30E-02	**1.58E+02**	1.31E+01	2.66E+00	2.66E+00	**9.25E+02**	7.68E+01	1.56E+01	1.56E+01
Cobalt	0.167	0.003	NC	**NC**	---	---	7.61E+00	**NC**	---	---	2.02E+01
Copper	0.167	0.003	6.61E-01	**3.57E+01**	2.36E+01	4.05E+00	4.05E+00	**3.07E+02**	2.03E+02	3.48E+01	3.48E+01
Lead	0.167	0.003	8.00E-02	**9.96E+01**	7.97E+00	1.63E+00	1.63E+00	**2.73E+03**	2.18E+02	4.46E+01	4.46E+01
Manganese	0.167	0.003	NC	**NC**	---	---	1.79E+02	**NC**	---	---	3.77E+02
Mercury	0.167	0.003	NC	**NC**	---	---	4.50E-01	**NC**	---	---	9.10E-01
Nickel	0.167	0.003	1.34E-01	**2.64E+02**	3.54E+01	6.71E+00	6.71E+00	**7.33E+02**	9.82E+01	1.86E+01	1.86E+01
Selenium	0.167	0.003	3.75E+00	**4.61E-01**	1.73E+00	2.90E-01	2.90E-01	**1.30E+00**	4.89E+00	8.20E-01	8.20E-01
Thallium	0.167	0.003	2.00E-02	**5.52E+01**	1.10E+00	3.50E-01	3.50E-01	**5.52E+02**	1.10E+01	3.50E+00	3.50E+00
Vanadium	0.167	0.003	2.50E-01	**7.69E+00**	1.92E+00	3.44E-01	3.44E-01	**3.80E+01**	9.50E+00	1.70E+00	1.70E+00
Zinc	0.167	0.003	8.40E-01	**4.61E+02**	3.88E+02	6.61E+01	6.61E+01	**1.19E+03**	1.00E+03	1.71E+02	1.71E+02
Inorganics - Other Inorganics											
Cyanide	0.167	0.003	NC	**NC**	---	---	4.00E-02	**4.66E+05**	---	---	4.00E-01
Fluoride	0.167	0.003	NC	**NC**	---	---	1.22E+01	**2.71E+03**	---	---	1.22E+02
Polychlorinated Biphenyls (PCBs)											
Aroclor 1248	0.167	0.003	NC	**NC**	---	---	1.80E-01	**NC**	---	---	1.80E+00
Aroclor 1254	0.167	0.003	NC	**NC**	---	---	1.80E-01	**NC**	---	---	1.80E+00
Semi-volatile Organic Compounds (SVOCs) - Polycyclic Aromatic Hydrocarbons (PAHs)											
Low Molecular Weight (LMW) PAHs	0.167	0.003	4.90E+00	**1.96E+01**	9.61E+01	1.61E+01	1.61E+01	**1.96E+02**	9.61E+02	1.61E+02	1.61E+02
High Molecular Weight (HMW) PAHs	0.167	0.003	4.23E+00	**2.82E+00**	1.19E+01	2.00E+00	2.00E+00	**2.82E+01**	1.19E+02	2.00E+01	2.00E+01
Semi-volatile Organic Compounds (SVOCs) - Non-PAH SVOCs											
1,2,4,5-Tetrachlorobenzene	0.167	0.003	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV
2-Chloronaphthalene	0.167	0.003	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV
Biphenyl (Diphenyl)	0.167	0.003	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV
Bis(2-ethylhexyl)phthalate	0.167	0.003	NC	**NC**	---	---	1.10E+00	**NC**	---	---	1.10E+01
Butylbenzylphthalate	0.167	0.003	NC	**NC**	---	---	1.10E-01	**NC**	---	---	1.10E+00
Dibenzofuran	0.167	0.003	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV
Di-n-butyl phthalate	0.167	0.003	NC	**NC**	---	---	1.10E-01	**NC**	---	---	1.10E+00
Di-n-octyl phthalate	0.167	0.003	NC	**NC**	---	---	1.10E-01	**NC**	---	---	1.10E+00
Hexachlorobenzene	0.167	0.003	NC	**NC**	---	---	5.00E+00	**NC**	---	---	5.00E+01
Hexachlorobutadiene	0.167	0.003	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV
Hexachlorocyclopentadiene	0.167	0.003	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV
Hexachloroethane	0.167	0.003	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV
Pentachlorophenol	0.167	0.003	NC	**NC**	---	---	6.73E+00	**NC**	---	---	5.20E+01
Volatile Organic Compounds (VOCs)											
Methylcyclohexane	0.167	0.003	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV

Table A-9
Wildlife PRG Calculation - American Dipper
Columbia Falls Aluminum Company
Columbia Falls, Montana

Analyte	Ingestion Rates[a]		Sed-Invertebrate Bioaccumulation Factor (BAF)[b]	NOAEL-Based Sediment Benchmark Calculations				LOAEL-Based Sediment Benchmark Calculations			
	Food Ingestion Rate (FIR) (kg/kg bw/d)	Sed Ingestion Rate (SIR) (kg/kg bw/d)		NOAEL-Based Benchmark Concentration ($C_{sed\text{-}NOAEL}$) (mg/kg, dry weight)[c]	Estimated Benthic Invertebrate Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{NOAEL}) (mg/kg bw/d)[d]	Avian NOAEL (mg/kg bw/d)[e]	LOAEL-Based Benchmark Concentration ($C_{sed\text{-}LOAEL}$) (mg/kg, dry weight)[c]	Estimated Benthic Invertebrate Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{LOAEL}) (mg/kg bw/d)[d]	Avian LOAEL (mg/kg bw/d)[e]
Dioxin/Furans											
$TEC_{2,3,7,8\text{-}TCDD\text{-}Mammal}$	0.167	0.003	NC	**NC**	---	---	1.75E-06	**NC**	---	---	1.75E-05

Notes:

Benchmarks (PRGs) presented for all final COPECs. Please see the Baseline Ecological Risk Assessment (EHS Support, 2019) Appendix H, for additional details, including acronyms and references.
a, Ingestion rates expressed as kg/kg bw/d based on receptor-specific parameters presented in **Table A-1**. Diet is assumed to be 100% benthic invertebrates.
b, Sediment invertebrate concentrations (C_{diet}) (mg/kg dry weight) calculated based on bioaccumulation factors or uptake equations presented in **Table A-4**.
The highest bioaccumulation factor for individual LMW (acenaphthylene = 4.9) and HMW (pyrene = 4.23) constituents used for LMW and HMW PAHs.
c, HQ = [(FIR x C_{diet}) + (SIR x C_{sed})] / $TRV_{NOAEL\ or\ LOAEL}$ solved for HQ = 1 where C_{sed} = Sediment benchmark concentration.
d, Estimated daily dose (EDD) calculated as: [(FIR x C_{diet}) + (SIR x C_{soil})]
e, Toxicity reference values (TRVs) were selected as no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) doses presented in **Table A-5**.
NC, Sediment benchmark was not calculated due to a lack of TRVs, or because constituent was not a chemical of potential concern in sediment.
No TRV, No toxicity reference value was identified.
No area use factor was incorporated into these equations.
COPEC, constituent of potential ecological concern
kg/kg bw/d, kilogram per kilogram of body weight per day
mg/kg bw/d, milligram per kilogram of body weight per day
mg/kg, milligram per kilogram
HQ, hazard quotient
NA, not applicable
Bold values = back-calculated values based on wildlife ingestion model to achieve HQs of 1. The LOAEL-based benchmark is selected as the preliminary remediation goal.

Table A-10
Wildlife PRG Calculation - Belted Kingfisher
Columbia Falls Aluminum Company
Columbia Falls, Montana

Analyte	Ingestion Rates[a]		Sed-Invertebrate Bioaccumulation Factor (BAF)[b]	NOAEL-Based Sediment Benchmark Calculations				LOAEL-Based Sediment Benchmark Calculations				HQ_{NOAEL}	HQ_{LOAEL}
	Food Ingestion Rate (FIR) (kg/kg bw/d)	Sed Ingestion Rate (SIR) (kg/kg bw/d)		NOAEL-Based Benchmark Concentration ($C_{sed\text{-}NOAEL}$) (mg/kg, dry weight)[c]	Estimated Benthic Invertebrate Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{NOAEL}) (mg/kg bw/d)[d]	Avian NOAEL (mg/kg bw/d)[e]	LOAEL-Based Benchmark Concentration ($C_{sed\text{-}LOAEL}$) (mg/kg, dry weight)[c]	Estimated Benthic Invertebrate Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{LOAEL}) (mg/kg bw/d)[d]	Avian LOAEL (mg/kg bw/d)[e]		
Inorganics - Metals													
Aluminum	0.155	0.000	NC	**NC**	---	---	1.10E+02	**NC**	---	---	1.10E+03	NA	NA
Antimony	0.155	0.000	5.75E-01	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Arsenic	0.155	0.000	3.73E-01	**3.87E+02**	1.45E+02	2.24E+00	2.24E+00	**7.80E+01**	2.91E+01	4.51E+00	4.51E+00	1.00E+00	1.00E+00
Barium	0.155	0.000	2.82E+00	**1.68E+03**	4.74E+03	7.35E+01	7.35E+01	**3.00E+02**	8.45E+02	1.31E+02	1.31E+02	1.00E+00	1.00E+00
Beryllium	0.155	0.000	1.67E-01	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Cadmium	0.155	0.000	4.59E-01	**2.07E+02**	9.48E+01	1.47E+00	1.47E+00	**8.93E+01**	4.10E+01	6.35E+00	6.35E+00	1.00E+00	1.00E+00
Chromium	0.155	0.000	8.30E-02	**2.07E+03**	1.72E+02	2.66E+00	2.66E+00	**1.21E+03**	1.01E+02	1.56E+01	1.56E+01	1.00E+00	1.00E+00
Cobalt	0.155	0.000	NC	**NC**	---	---	7.61E+00	**NC**	---	---	2.02E+01	NA	NA
Copper	0.155	0.000	6.61E-01	**3.95E+02**	2.61E+02	4.05E+00	4.05E+00	**3.40E+02**	2.25E+02	3.48E+01	3.48E+01	1.00E+00	1.00E+00
Lead	0.155	0.000	8.00E-02	**1.31E+03**	1.05E+02	1.63E+00	1.63E+00	**3.60E+03**	2.88E+02	4.46E+01	4.46E+01	1.00E+00	1.00E+00
Manganese	0.155	0.000	NC	**NC**	---	---	1.79E+02	**NC**	---	---	3.77E+02	NA	NA
Mercury	0.155	0.000	NC	**NC**	---	---	4.50E-01	**NC**	---	---	9.10E-01	NA	NA
Nickel	0.155	0.000	1.34E-01	**3.23E+03**	4.33E+02	6.71E+00	6.71E+00	**8.96E+02**	1.20E+02	1.86E+01	1.86E+01	1.00E+00	1.00E+00
Selenium	0.155	0.000	3.75E+00	**4.99E+00**	1.87E+01	2.90E-01	2.90E-01	**1.41E+00**	5.29E+00	8.20E-01	8.20E-01	1.00E+00	1.00E+00
Thallium	0.155	0.000	2.00E-02	**1.13E+03**	2.26E+01	3.50E-01	3.50E-01	**1.13E+03**	2.26E+01	3.50E+00	3.50E+00	1.00E+00	1.00E+00
Vanadium	0.155	0.000	2.50E-01	**8.88E+01**	2.22E+01	3.44E-01	3.44E-01	**4.39E+01**	1.10E+01	1.70E+00	1.70E+00	1.00E+00	1.00E+00
Zinc	0.155	0.000	8.40E-01	**5.08E+03**	4.26E+03	6.61E+01	6.61E+01	**2.43E+03**	2.04E+03	3.16E+02	1.71E+02	1.00E+00	1.85E+00
Inorganics - Other Inorganics													
Cyanide	0.155	0.000	NC	**NC**	---	---	4.00E-02	**4.66E+05**	---	---	4.00E-01	NA	NA
Fluoride	0.155	0.000	NC	**NC**	---	---	1.22E+01	**2.71E+03**	---	---	1.22E+02	NA	NA
Polychlorinated Biphenyls (PCBs)													
Aroclor 1248	0.155	0.000	NC	**NC**	---	---	1.80E-01	**NC**	---	---	1.80E+00	NA	NA
Aroclor 1254	0.155	0.000	NC	**NC**	---	---	1.80E-01	**NC**	---	---	1.80E+00	NA	NA
Semi-volatile Organic Compounds (SVOCs) - Polycyclic Aromatic Hydrocarbons (PAHs)													
Low Molecular Weight (LMW) PAHs	0.155	0.000	4.90E+00	**2.12E+02**	1.04E+03	1.61E+01	1.61E+01	**2.12E+02**	1.04E+03	1.61E+02	1.61E+02	1.00E+00	1.00E+00
High Molecular Weight (HMW) PAHs	0.155	0.000	4.23E+00	**3.05E+01**	1.29E+02	2.00E+00	2.00E+00	**3.05E+01**	1.29E+02	2.00E+01	2.00E+01	1.00E+00	1.00E+00
Semi-volatile Organic Compounds (SVOCs) - Non-PAH SVOCs													
1,2,4,5-Tetrachlorobenzene	0.155	0.000	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
2-Chloronaphthalene	0.155	0.000	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Biphenyl (Diphenyl)	0.155	0.000	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Bis(2-ethylhexyl)phthalate	0.155	0.000	NC	**NC**	---	---	1.10E+00	**NC**	---	---	1.10E+01	NA	NA
Butylbenzylphthalate	0.155	0.000	NC	**NC**	---	---	1.10E-01	**NC**	---	---	1.10E+00	NA	NA
Dibenzofuran	0.155	0.000	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Di-n-butyl phthalate	0.155	0.000	NC	**NC**	---	---	1.10E-01	**NC**	---	---	1.10E+00	NA	NA
Di-n-octyl phthalate	0.155	0.000	NC	**NC**	---	---	1.10E-01	**NC**	---	---	1.10E+00	NA	NA
Hexachlorobenzene	0.155	0.000	NC	**NC**	---	---	5.00E+00	**NC**	---	---	5.00E+01	NA	NA
Hexachlorobutadiene	0.155	0.000	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Hexachlorocyclopentadiene	0.155	0.000	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Hexachloroethane	0.155	0.000	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV
Pentachlorophenol	0.155	0.000	NC	**NC**	---	---	6.73E+00	**NC**	---	---	5.20E+01	NA	NA
Volatile Organic Compounds (VOCs)													
Methylcyclohexane	0.155	0.000	NC	**NC**	---	---	No TRV	**NC**	---	---	No TRV	No TRV	No TRV

Table A-10
Wildlife PRG Calculation - Belted Kingfisher
Columbia Falls Aluminum Company
Columbia Falls, Montana

Analyte	Ingestion Rates[a]		Sed-Invertebrate Bioaccumulation Factor (BAF)[b]	NOAEL-Based Sediment Benchmark Calculations				LOAEL-Based Sediment Benchmark Calculations				HQ_{NOAEL}	HQ_{LOAEL}
	Food Ingestion Rate (FIR) (kg/kg bw/d)	Sed Ingestion Rate (SIR) (kg/kg bw/d)		NOAEL-Based Benchmark Concentration ($C_{sed-NOAEL}$) (mg/kg, dry weight)[c]	Estimated Benthic Invertebrate Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{NOAEL}) (mg/kg bw/d)[d]	Avian NOAEL (mg/kg bw/d)[e]	LOAEL-Based Benchmark Concentration ($C_{sed-LOAEL}$) (mg/kg, dry weight)[c]	Estimated Benthic Invertebrate Concentration (C_{diet})[b]	Estimated Daily Dose (EDD_{LOAEL}) (mg/kg bw/d)[d]	Avian LOAEL (mg/kg bw/d)[e]		
Dioxin/Furans													
$TEC_{2,3,7,8\text{-TCDD-Mammal}}$	0.155	0.000	NC	**NC**	---	---	1.75E-06	**NC**	---	---	1.75E-05	NA	NA

Notes:

Benchmarks (PRGs) presented for all final COPECs. Please see the Baseline Ecological Risk Assessment (EHS Support, 2019) Appendix H, for additional details, including acronyms and references.
a, Ingestion rates expressed as kg/kg bw/d based on receptor-specific parameters presented in **Table A-1**. Diet is assumed to be 10% benthic invertebrates and 90% fish.
b, Sediment invertebrate concentrations (C_{diet}) (mg/kg dry weight) calculated based on bioaccumulation factors or uptake equations presented in **Table A-4**.
The highest bioaccumulation factor for individual LMW (acenaphthylene = 4.9) and HMW (pyrene = 4.23) constituents used for LMW and HMW PAHs.
c, HQ = [(FIR x C_{diet}) + (SIR x C_{sed})] / $TRV_{NOAEL\ or\ LOAEL}$ solved for HQ = 1 where Csed = Sediment benchmark concentration.
d, Estimated daily dose (EDD) calculated as: [(FIR x C_{diet}) + (SIR x C_{soil})]
e, Toxicity reference values (TRVs) were selected as no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) doses presented in **Table A-5**.
NC, Sediment benchmark was not calculated due to a lack of TRVs, or because constituent was not a chemical of potential concern in sediment.
No TRV, No toxicity reference value was identified.
No area use factor was incorporated into these equations.
COPEC, constituent of potential ecological concern
kg/kg bw/d, kilogram per kilogram of body weight per day
mg/kg bw/d, milligram per kilogram of body weight per day
mg/kg, milligram per kilogram
HQ, hazard quotient
NA, not applicable
Bold values, back-calculated values based on wildlife ingestion model to achieve HQs of 1. The LOAEL-based benchmark is selected as the preliminary remediation goal.

Attachment B Technical Basis for the Development of a Preliminary Remediation Goal (PRG) for Cyanide in Benthic Habitats Based on Aqueous Exposure to Free Cyanide in Porewater

MEMO

To: Andrew Baris, Roux Environmental Engineering and Geology, D.P.C.

From: Gary Long, EHS Support

CC: Laura Jensen, Roux Environmental Engineering and Geology, D.P.C.
Crystal Stowell, Roux Environmental Engineering and Geology, D.P.C.

Date: March 16, 2020

Re: Technical Basis for the Development of a Preliminary Remediation Goal (PRG) for Cyanide in Benthic Habitats Based on Aqueous Exposure to Free Cyanide in Porewater
Former Columbia Falls Aluminum Company Aluminum Reduction Facility,
Columbia Falls, Montana

Introduction

This memorandum presents the technical rationale for the development of a preliminary remediation goal (PRG) for cyanide in benthic habitats based on aqueous exposure to free cyanide in porewater as part of the Draft Feasibility Study Work Plan (FSWP) being completed on behalf of the Columbia Falls Aluminum Company, LLC (CFAC) for the Former CFAC Aluminum Reduction Facility in Columbia Falls, Montana (Site).

A conference call was held with the U.S. Environmental Protection Agency (EPA) and the Montana Department of Environmental Quality (MDEQ) on February 13, 2020 to discuss draft ecological risk-based preliminary remediation goals (Draft EcoPRGs) presented in the *Development of Preliminary Remediation Goals for Ecological Risk Drivers at the Former Columbia Falls Aluminum Company Aluminum Reduction Facility, Columbia Falls, Montana* (October 18, 2019), submitted as Appendix B of the Draft FSWP prepared by Roux Environmental Engineering and Geology, D.P.C. (Roux; December 4, 2019). A key issue discussed during the conference call was determining the appropriate basis for developing a PRG for the protection of benthic organisms inhabiting sediments where groundwater containing cyanide and other constituents of potential ecological concern (COPECs) discharges through sediments into overlying surface water. The Baseline Ecological Risk Assessment (BERA) completed for the Site indicated the potential for adverse ecological effects associated with exposure to cyanide in surface water, sediment, and porewater in the Backwater Seep Sampling Area (BSSA), the Flathead River Riparian Area Channel (Riparian Area Channel), and the South Percolation Ponds (SPP) exposure areas of the Site (EHS Support, 2019).

This memorandum presents the technical basis for the use of a porewater-based free cyanide PRG for the protection of benthic organisms in exposure areas where groundwater containing cyanide discharges through sediments into surface water at the Site. The following sections present the conceptual site model (CSM) for cyanide exposure to benthic habitats at the Site and summarize key elements of cyanide behavior and exposure in benthic habitats, including cyanide fate and transport, bioavailability, and toxicity, that support the development of a porewater-based PRG for benthic habitats receiving groundwater discharge.

Conceptual Site Model for Cyanide Exposure in CFAC Benthic Habitats

The CSM developed through multiple phases of the Remedial Investigation at the Site indicates that groundwater discharge is the source of cyanide to sediments, porewater, and surface water in the BSSA, Riparian Area Channel, and SPP (Roux, 2020; EHS Support, 2019). The following section summarizes the understanding of cyanide sources, fate and transport characteristics, and exposure to benthic organisms in benthic habitats at CFAC.

Cyanide is a by-product of the aluminum reduction process that is formed within the smelting pot liner under high temperatures through the reaction of carbon in the cathode and sidewalls of the pot liner and available nitrogen (Wong-Chong et al., 2006). Through this process, cyanide accumulates within the pot liner during its operational lifespan. Once the liner has reached its operational lifespan and is removed from the pot lines, it is considered spent pot liner (SPL). SPL at CFAC was disposed of in on-Site landfills from 1955 to 1990. Due to the soluble cyanide fraction of SPL, particularly sodium cyanide (NaCN), on-Site landfills, specifically the West Landfill, the Wet Scrubber Sludge Pond, and the Center Landfill, were identified as the primary sources of cyanide in groundwater at the Site (Roux, 2019; Roux, 2020).

The migration of cyanide in groundwater from on-Site source areas follows the southerly groundwater flow patterns to the Flathead River (Roux, 2020). Groundwater and surface water elevation data indicate that groundwater discharges from the upper hydrogeologic unit through sediment (porewater) into surface water in the Flathead River (Roux, 2020). The discharge of cyanide (and fluoride) in groundwater to the Flathead River adjacent to the Site was historically a permitted discharge under the Site Montana Pollution Discharge Elimination System (MPDES) permit (# MT-0030066) from May 1994 through April 2019.

The BERA identified the potential for adverse effects associated with exposure to cyanide in sediments, porewater, and surface water of the BSSA, Riparian Area Channel, and SPP where groundwater discharge through sediments to surface water was identified (EHS Support, 2019). Porewater samples collected in the BSSA contained free cyanide concentrations ranging from 3.6 to 62.4 µg/L, exceeding acute (22 µg/L) and chronic (5.2 µg/L) National Recommended Water Quality Criteria (NRWQC) in three of six samples (EHS Support, 2019). Total cyanide concentrations in the BSSA ranged from 38.8 µg/L to 491 µg/L, exceeding Montana Department of Environmental Quality Circular 7 (DEQ-7) acute (22 µg/L) and chronic (5.2 µg/L) aquatic life standards for total cyanide in all six samples (EHS Support, 2019). Total cyanide concentrations in sediment samples from the BSSA ranged from 0.35 mg/kg to 8.3 mg/kg; free cyanide concentrations were below detection limits for all five sediment samples analyzed from the BSSA (EHS Support, 2019).

In the Riparian Area Channel, porewater concentrations of free cyanide ranged from 2.4 µg/L to 38.7 µg/L, exceeding acute NRWQC in three of six samples and the chronic NRWQC in four of six samples. Total cyanide concentrations in porewater ranged from 52.7 µg/L to 429 µg/L, exceeding DEQ-7 acute and chronic aquatic life standards for total cyanide in all six samples. Total cyanide concentrations in sediment samples from the Riparian Area Channel ranged from 0.27 mg/kg to 1.7 mg/kg; free cyanide was below detection limits in the only sediment sample analyzed in the Riparian Area Channel (EHS Support, 2019).

In the South Percolation Pond, free cyanide concentrations in all six porewater samples were below the quantitation limit of 1.5 µg/L. Total cyanide was detected in four of six porewater samples at concentrations ranging from 11 µg/L to 129 µg/L, exceeding DEQ-7 acute and chronic aquatic life standards for total cyanide in three of six samples. Total cyanide concentrations in sediment samples from the South Percolation Pond ranged from 0.14 mg/kg to 8.5 mg/kg; free cyanide was detected at 0.89 mg/kg in the only sediment sample analyzed for free cyanide in the South Percolation Pond (EHS Support, 2019).

The Draft FSWP identified cyanide as a constituent of concern (COC) based on the CSM and the risks to benthic organisms identified in the BERA. As presented in the section below, free cyanide, the bioavailable and toxic form of cyanide, is not expected to persist in the sediment matrix due to its high solubility and rapid degradation. However, continued cyanide inputs from shallow groundwater result in ongoing chronic exposure conditions in benthic habitats and overlying surface water in the BSSA, Riparian Area Channel, and SPP. Therefore, the reduction of cyanide concentrations in groundwater inputs is a critical component of reducing exposure to benthic and aquatic receptors in the BSSA, Riparian Area Channel, and SPP. Based on the high solubility of free cyanide and its limited persistence in the sediment matrix, the Draft FSWP (Appendix B) identified the control of groundwater inputs of cyanide as the approach to address potential exposure to cyanide in sediments, porewater, and surface water for benthic invertebrates. The following sections discuss the fate and transport, bioavailability, and toxicity of cyanide in benthic habitats and provide the basis for the use of a porewater-based PRG for free cyanide for the protection of benthic organisms.

Cyanide Exposure in Benthic Habitats

The following sections describe the fate and transport characteristics of cyanide in aquatic environments and summarize available information relating to the bioavailability and toxicity of cyanide to aquatic organisms.

Fate and Transport Characteristics

Cyanide is a general term that refers to several compounds that contain a carbon-nitrogen functional group where the two atoms are bound together with a triple bond. Cyanide occurs in multiple forms in the environment. Aqueous forms of cyanide in the aquatic environment are broadly categorized into four classes: free cyanide ($HCN + CN^-$), metal-cyanide complexes, cyanate/thiocyanate species, and organocyanide compounds (Ghosh et al., 2006). HCN is the dominant free CN species in water under environmentally relevant conditions (ECCC, 2018). Metal-cyanide complexes may be further divided into weak metal-cyanide complexes and strong metal-cyanide complexes.

The dissociation of metal-cyanide complexes into free cyanide is dependent on pH, temperature, and reduction-oxidation potential. Weak acid dissociable (WAD) complexes with certain transition metals

(Cu, Ag, Zn, Cd, Ni, and Hg) dissociate under weak acid pH (approximately 4.5); metal-cyanide complexes with other transition metals (Au, Fe, Pt, Pd, and Co) are highly resistant to dissociation and only dissociate under strong acid conditions (pH approximately 1-2) and high temperatures (100 °C). Several metal-cyanide complexes are known to be photochemically reactive. In the presence of ultraviolet (UV) light, the photolysis of ferrocyanide and ferricyanide complexes results in the formation of free cyanide, as HCN. The rate of photochemical dissociation is dependent on pH, free cyanide concentration in solution, UV intensity, temperature, turbidity, and water column depth (Ghosh et al., 2006).

Free cyanide ($HCN + CN^-$) formed through photodegradation or other mechanisms does not persist in aquatic environments because rapid biodegradation occurs in the water column and sediments or volatilization occurs within the water column. Free cyanide is highly soluble and expected to remain in solution in the aquatic environment until it is degraded or volatilized. Free cyanide can be oxidized to form cyanate (-CNO) or react with sulfur to form thiocyanate (-SCN), which are relatively nontoxic in comparison with free cyanide (Ghosh et al., 2006). Free cyanide does not bioaccumulate in aquatic organisms (Lanno and Menzie, 2006).

Total cyanide concentrations reported in sediment can include hydrogen cyanide (HCN), cyanide ion (CN^-), simple cyanides (e.g., KCN, NaCN), and metallo- and organo-cyanide complexes. However, free cyanide does not partition to mineral sediment and only partitions weakly to sediment organic carbon (Dzombak et al., 2006; Lanno and Menzie, 2006). The bioavailability and toxicity of the limited free cyanide that partitions weakly to sediment organic carbon is reduced relative to aqueous-phase free cyanide. Low levels of free cyanide in sediment are readily degraded by microbial processes and do not persist in biologically active sediments (Gensemer et al., 2007).

Bioavailability and Toxicity

The primary mode of cyanide toxicity is disruption of cellular respiration, specifically histotoxic hypoxia, which is the inability of cells to take up oxygen. In the aquatic environment, there is strong scientific consensus that free cyanide ($HCN + CN^-$) is the bioavailable and toxic form of cyanide to aquatic receptors (Young et al., 2006; Gensemer et al., 2006; Lanno and Menzie, 2006; WDNR, 2003). While cyanide may exist in a variety of metallocyanide or organic complexes in the aquatic environment, the toxicity of these complexes is largely a function of their dissociation to free cyanide (Gensemer et al., 2006). Cyanide bound to metals such as iron, copper, or nickel is much less toxic to freshwater organisms than free cyanide. With the exception of silver-cyanide complexes, toxicity observed in tests using metallocyanide complexes was not due to these complex ions or total cyanide, but rather was due to the concentration of free cyanide (HCN) and to the dissociated metallic ions (Gensemer et al., 2006). WDNR (2003) states that total cyanide determinations are not useful measures of either water or sediment quality because most complexed cyanides are relatively nontoxic. Collectively, these studies indicate that cyanide toxicity is best expressed as a function of free cyanide rather than total cyanide (Gensemer et al., 2006).

Due to its low persistence in the aquatic environment, toxic responses to free cyanide are primarily associated with acute exposure scenarios as a result of spills or releases. However, chronic exposure to free cyanide in surface waters and benthic habitat is an important consideration where, as described in the CSM presented above for CFAC, groundwater discharge provides a continued and sustained source of cyanide to benthic (sediment and porewater) and aquatic (surface water) exposure media (Lanno and Menzie, 2006).

Acute and chronic water quality standards for cyanide are established in the NRWQC and DEQ-7 for the protection of aquatic life, including aquatic organisms inhabiting the water column and benthic organism inhabiting sediments. NRWQC aquatic life criteria for cyanide were derived based on exposure to free cyanide, based on the scientific consensus that free cyanide is the bioavailable and toxic form. DEQ-7 aquatic life criteria are based on total cyanide; however, DEQ-7 criteria for total cyanide are based on the free cyanide criteria presented in the NRWQC. Basing the DEQ-7 criteria on total cyanide criteria using free cyanide toxicity endpoints conservatively accounts for the potential dissociation of cyanide complexes into free cyanide within the water column.

While the NRWQC and DEQ-7 standards are protective of general aquatic life, available data indicate that macroinvertebrates, such as aquatic insects that are likely present within (infaunal benthic organisms) or upon (epifaunal benthic organism) sediments within the BSSA, Riparian Area Channel, or SPP, are less sensitive to cyanide than organisms that may be exposed in the water column. Of the 27 aquatic taxa that have been evaluated for acute toxicity to cyanide, all 12 of the benthic test species evaluated ranked among the 14 least sensitive test organisms, indicating that benthic organisms are relatively insensitive to cyanide toxicity (Gensemer et al., 2007; Gensemer et al., 2006). The relative insensitivity of benthic organisms to free cyanide compared to pelagic organisms indicates that the NRWQC and DEQ-7 aquatic life criteria are adequately protective and may be overprotective of exposure to porewater in benthic habitats.

Reviews of cyanide toxicity in the aquatic environment indicate that exposure from sediment is relatively minor compared to exposure from water, and that exposures are greatest for receptors that are immersed in water (Gensemer et al., 2006; Lanno and Menzie, 2006; Gensemer et al., 2007). Given the limited importance of the bulk sediment exposure pathway, ecotoxicity data based on total cyanide exposure to bulk sediment are limited and the available endpoints are considered to be a poor indicator of toxicity (ECCC, 2018; WDNR, 2003). A scientific review of cyanide ecotoxicology and evaluation of ambient water quality criteria concluded that sediment-based cyanide criterion did not appear to be warranted due to the relative insensitivity of benthic organisms to cyanide exposure and the low persistence of free cyanide in sediment (Gensemer et al., 2007). As a result, there are few available toxicological benchmarks for cyanide based on exposure to bulk sediment, which are considered to have low confidence in predicting cyanide toxicity to benthic invertebrates.

Cyanide PRG Development for Benthic Habitats

This section presents the technical basis for the development of a porewater based free cyanide PRG for the protection of benthic organisms based on the CSM for cyanide exposure in benthic habitats at CFAC and the review of cyanide fate and transport, bioavailability, and toxicity presented in the previous sections.

Technical Basis

The mitigation of continued groundwater inputs of cyanide to the BSSA, Riparian Area Channel, and SPP is critical to reducing free cyanide exposure to benthic (sediment and porewater) and pelagic (surface water) organisms. Once groundwater inputs of cyanide are reduced, free cyanide formed through the dissociation of residual metal-cyanide complexes in sediment is not likely to persist in the aquatic environment due to degradation as described above. With reduced groundwater inputs, free cyanide concentrations will decline coincident with reduced input from upgradient groundwater, as well as due to degradation in benthic (porewater) and aquatic (surface water) habitats, thereby leading to natural recovery. The natural recovery of benthic and aquatic habitats following the reduction of groundwater inputs may be monitored through measurements of free cyanide in porewater and surface water, respectively.

Free cyanide measurements in porewater are the most appropriate endpoints to evaluate exposure and monitor recovery in benthic habitats due to the high solubility of free cyanide and the consensus that free cyanide is the bioavailable and toxic form. The establishment of an EcoPRG for free cyanide exposure to porewater based on the NRWQC acute and chronic aquatic life criteria of 22 µg free CN/L and 5.2 µg free CN/L, respectively, would be protective of benthic organisms given the relative insensitivity of benthic invertebrates to cyanide exposure as compared to water column organisms. Further, establishing the EcoPRG on the basis of the free cyanide NRWQC in porewater is considered to be protective, given that UV-mediated dissociation of cyanide complexes into free cyanide is limited in sediments by the lack of light penetration below the sediment-surface water interface. However, further refinement of the porewater EcoPRG for free cyanide based on toxicity endpoints including only benthic test organisms may be warranted given the observed differences in toxic sensitivity to cyanide between benthic and water column test organisms.

As discussed in the previous section, bulk sediment is not a reliable endpoint to evaluate or monitor exposure and recovery because ecotoxicity data based on total cyanide exposure to bulk sediment are insufficient and are considered to be a poor indicator of toxicity (ECCC, 2018; WDNR, 2003; Gensemer et al., 2007). Given that aqueous exposure to free cyanide is the most relevant exposure medium, the Wisconsin Department of Natural Resources (WDNR) Consensus-Based Sediment Quality Guidelines indicate that the free form of cyanide present in the porewater is more relatable to the toxicity of benthic organisms than the total cyanide measured in the solid (sediment) phase (WDNR, 2003).

Regulatory Precedent

Consistent with the bioavailability, toxicity, and fate and transport characteristics described above for free cyanide, there is little precedent for the remediation of cyanide in sediment based on bulk sediment concentrations. A review of U.S. regulatory actions for cyanide in sediment under CERCLA and RCRA indicates that cyanide is seldom a contaminant of focus in sediment remediation efforts because free cyanide is readily biodegradable, and because cyanide species have low bioaccumulation potential (Nackles et al., 2006). Consistent with the review by Nackles et al. (2006), a preliminary review of EPA Records of Decision (RODs) conducted in preparation of this memorandum did not identify ecological risk-based sediment remedial action objectives (RAOs) based on cyanide measurements in bulk sediment.

Summary

This memorandum presents the technical basis for establishing an EcoPRG for free cyanide exposure to porewater based on the NRWQC acute and chronic aquatic life criteria of 22 µg free CN/L and 5.2 µg free CN/L, respectively for the protection of benthic habitats in the BSSA, Riparian Area Channel, and SPP. Free cyanide measurements in porewater are the most appropriate endpoints to evaluate exposure and monitor recovery in benthic habitats due to the high solubility of free cyanide and the consensus that free cyanide is the bioavailable and toxic form. Importantly, metal cyanide complexes (specifically iron cyanide) will not dissociate in response to UV light as light is not expected to penetrate below the sediment surface water interface to a significant degree and thus, total CN to free CN via photolysis is minimal and other cyanide complexes have been shown to be non-toxic to benthic organisms (Gensemer et al., 2006). Bulk sediment is not a reliable endpoint to establish an EcoPRG for cyanide for benthic habitats because ecotoxicity data based on total cyanide exposure to bulk sediment are insufficient and are considered to be a poor indicator of toxicity.

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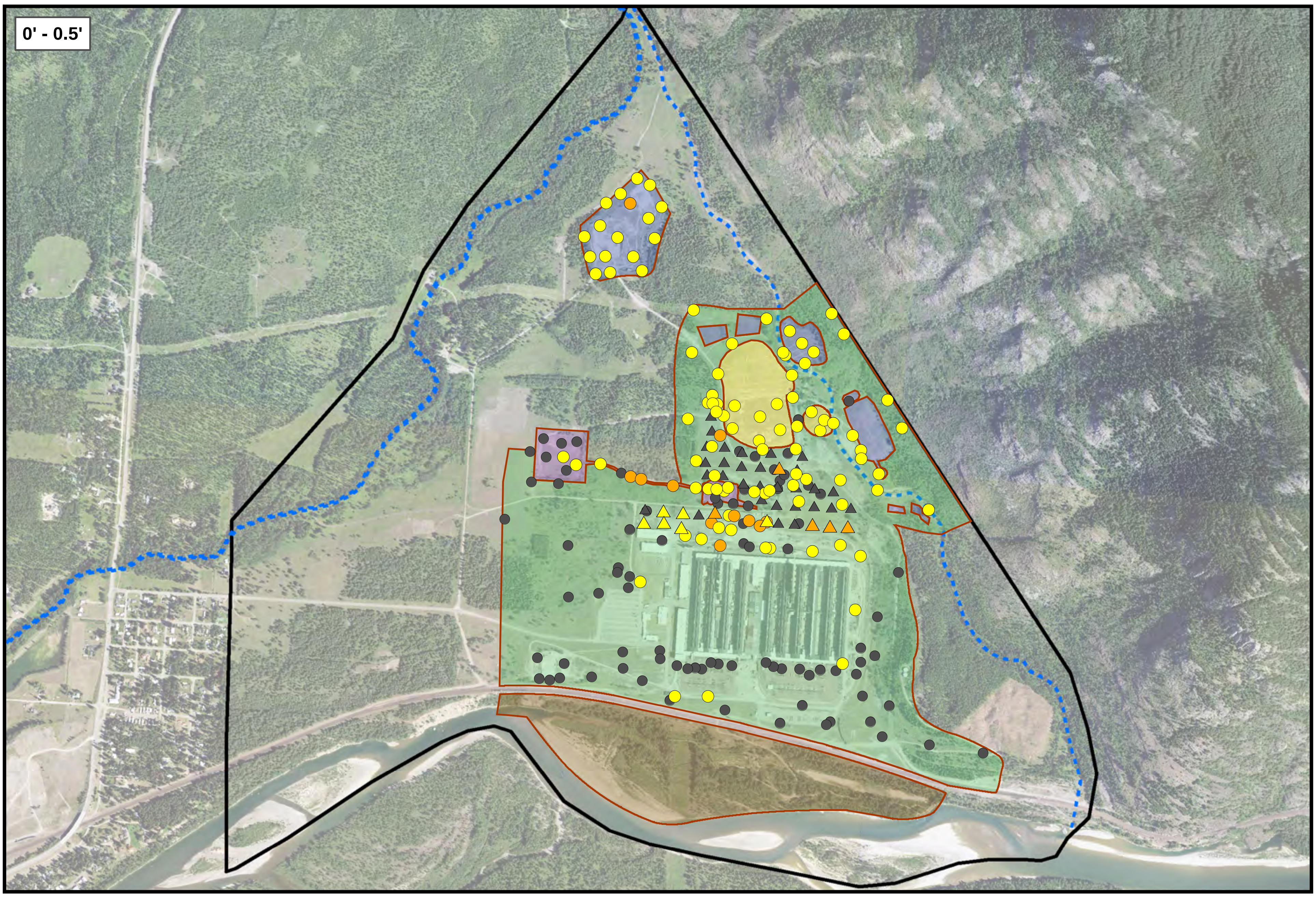
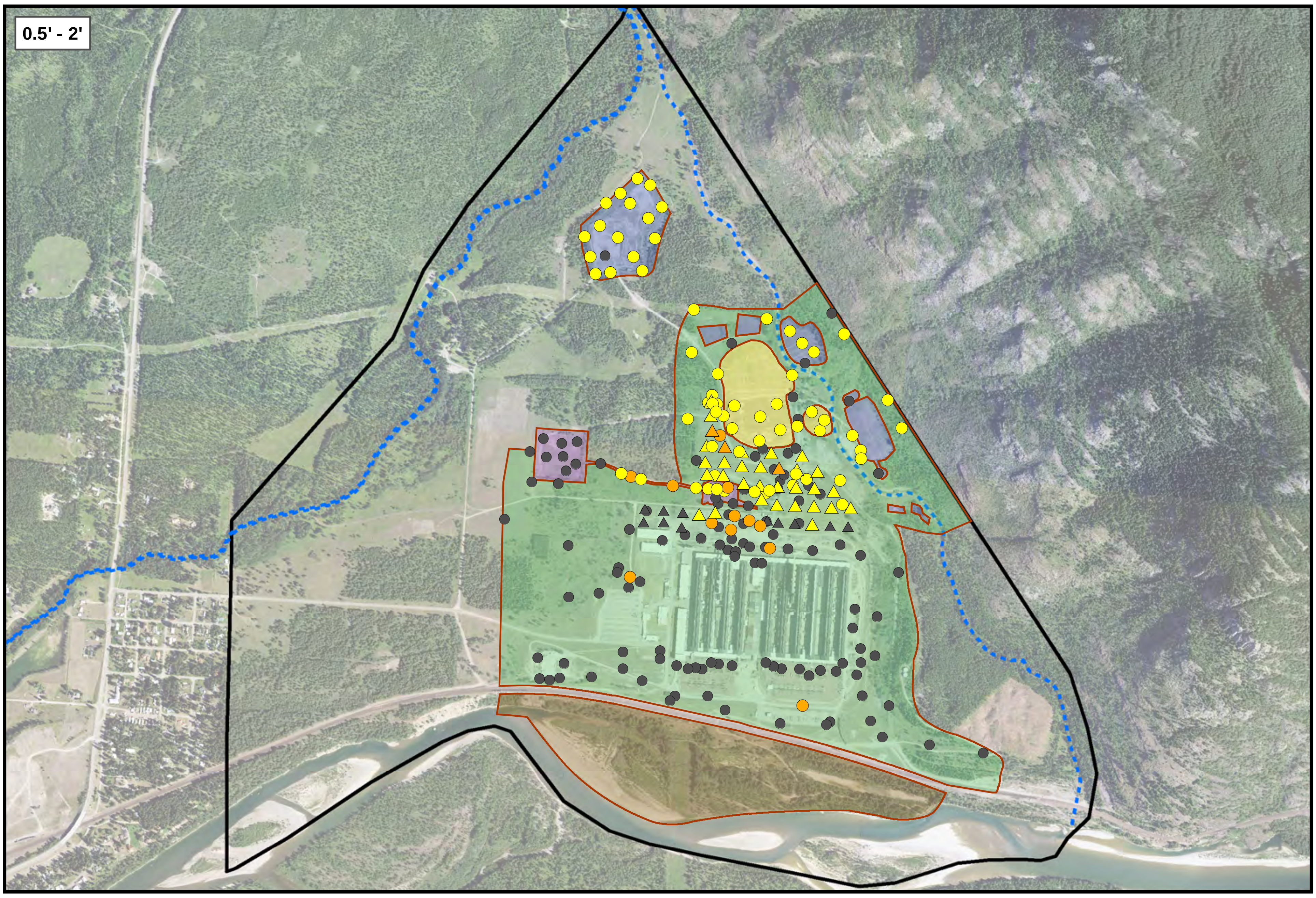
APPENDIX C

Human Health PRG Comparison – Soil Thematic Maps

1. Exceedances of Human Health PRGs in Soil Samples
2. Concentrations of Arsenic in Soil Samples – Human Health PRG Comparison
3. Concentrations of Benzo[A]Anthracene in Soil Samples – Human Health PRG Comparison
4. Concentrations of Benzo[A]Pyrene in Soil Samples – Human Health PRG Comparison
5. Concentrations of Benzo[B]Fluoranthene in Soil Samples – Human Health PRG Comparison
6. Concentrations of Dibenz[A,H]Anthracene in Soil Samples – Human Health PRG Comparison
7. Concentrations of Indeno[1,2,3-C,D]Pyrene in Soil Samples – Human Health PRG Comparison

V:\GIS\PROJECTS\2476Y\0001Y\256\C1. EXCEEDANCE_HH_SOIL.MXD





LEGEND - EA 1, 2, 3, 4, & ISM GRID AREA

SO	ISM	
●	▲	LOCATION WITH NO EXCEEDANCES
● (yellow)	▲ (yellow)	LOCATION WITH ONE OR MORE EXCEEDANCES OF A 10^{-6} TR PRG, BUT NO EXCEEDANCE OF ANY 10^{-5} TR PRG
● (orange)	▲ (orange)	LOCATION WITH ONE OR MORE EXCEEDANCES OF A 10^{-5} TR PRG

N

0 1,500'

Title:

EXCEEDANCES OF HUMAN HEALTH PRGS IN SOIL SAMPLES

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/16/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	C1
Project Mgr: L.J.	Project: 2476.0001Y008	
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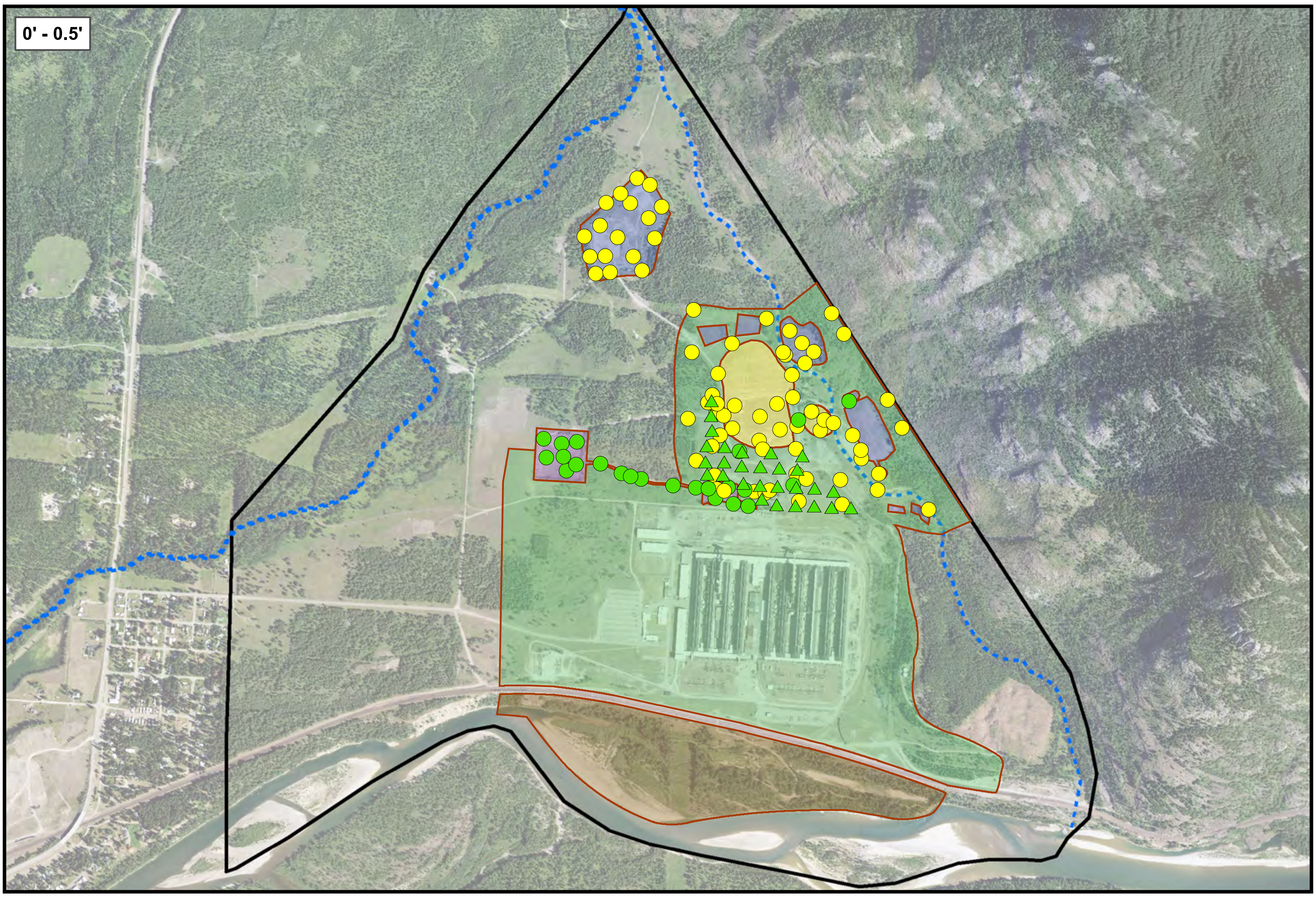
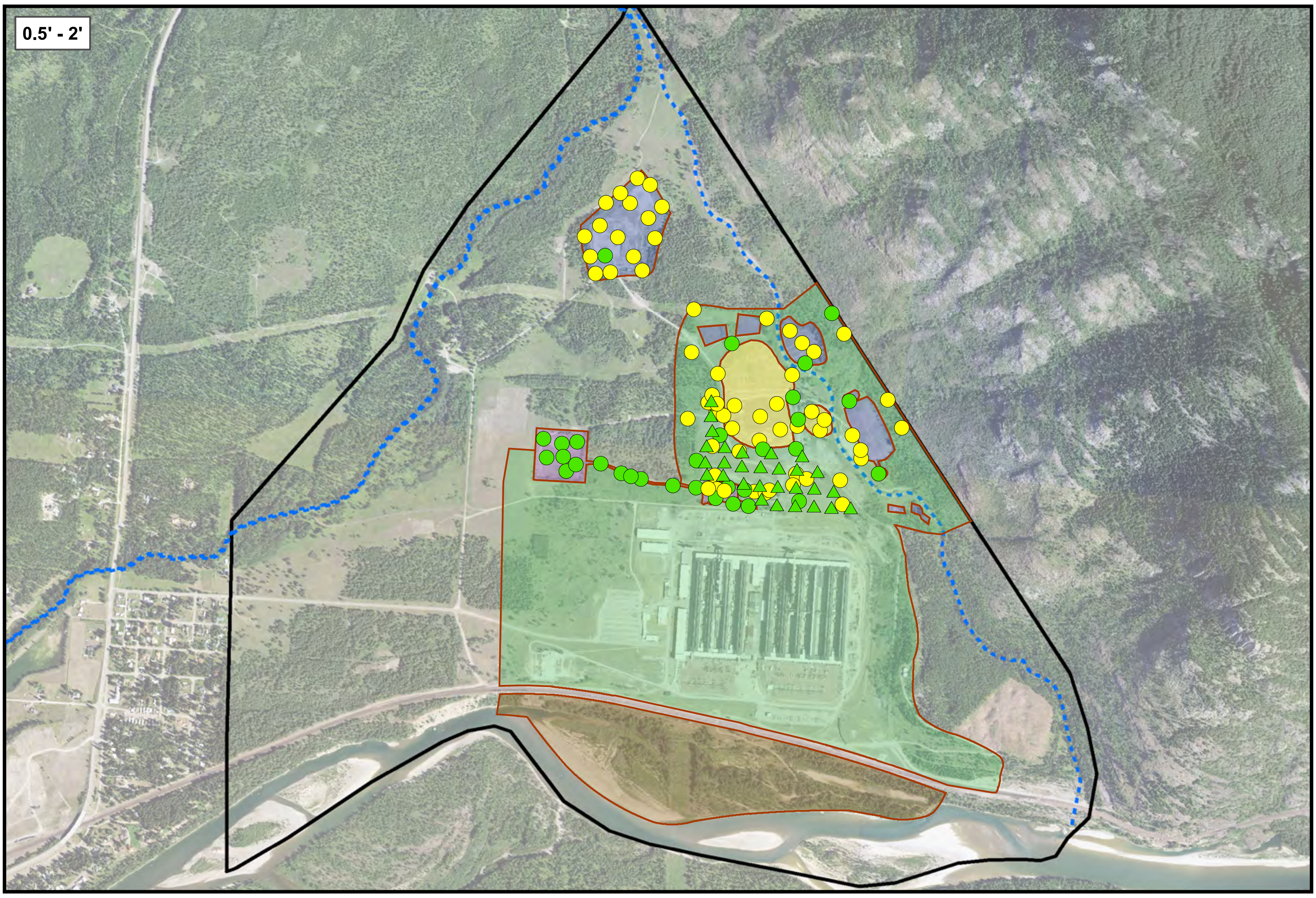




CONCENTRATION LEGEND - EA 2, 3, 4, & ISM GRID AREA

SO	ISM	
● (blue)	▲ (blue)	ANALYTE NOT DETECTED
● (green)	▲ (green)	LESS THAN 10^{-6} TR PRG
● (yellow)	▲ (yellow)	GREATER THAN 10^{-6} TR PRG, LESS THAN 10^{-5} TR PRG
● (orange)	▲ (orange)	GREATER THAN 10^{-5} TR PRG

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

PRG LEGEND BY EXPOSURE AREA

TR PRG	EA 2	EA 3, 4
10^{-6}	20	4
10^{-5}	200	40

N

0 1,500'

Title:

CONCENTRATIONS OF ARSENIC IN SOIL SAMPLES – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

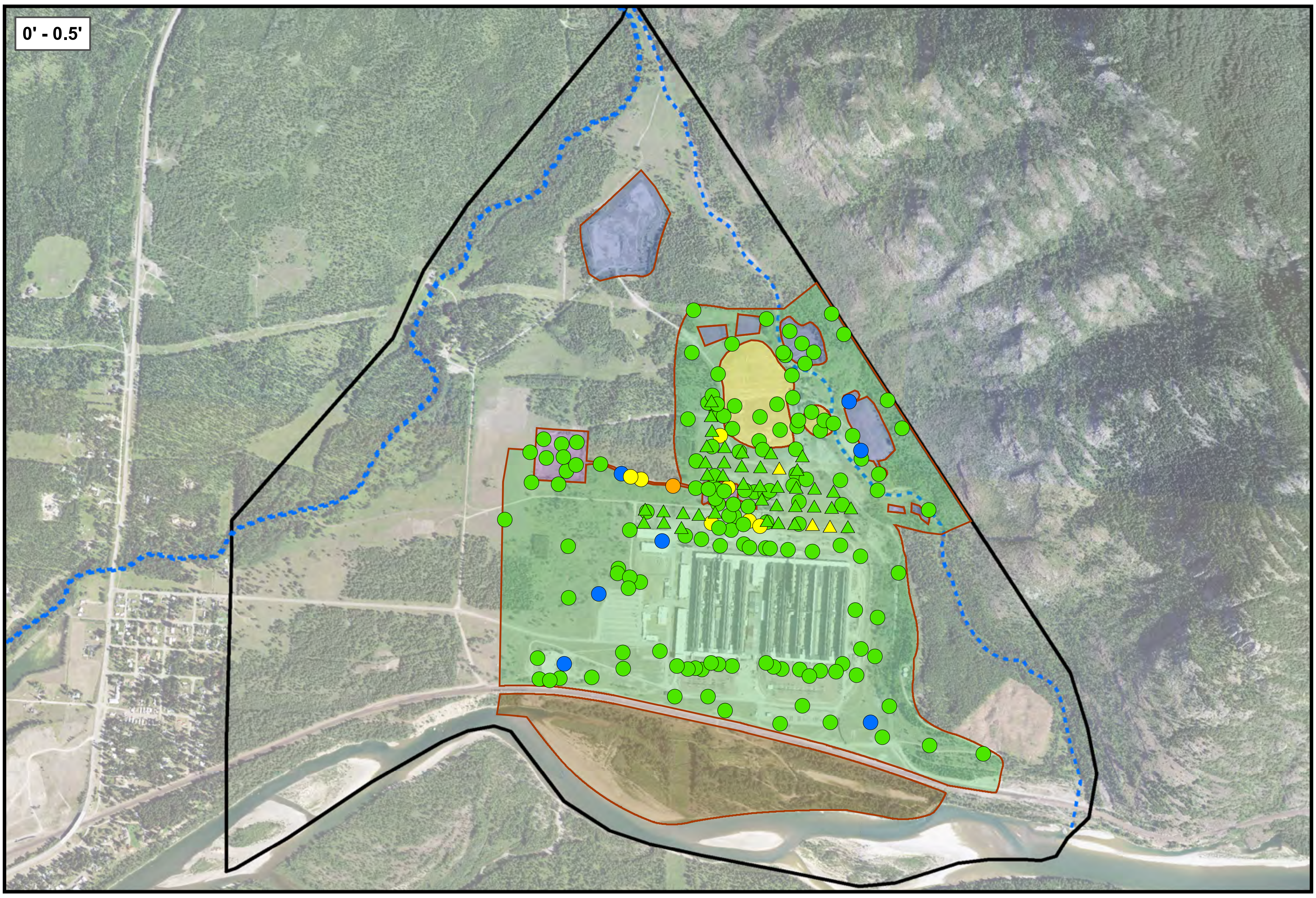
Prepared for:

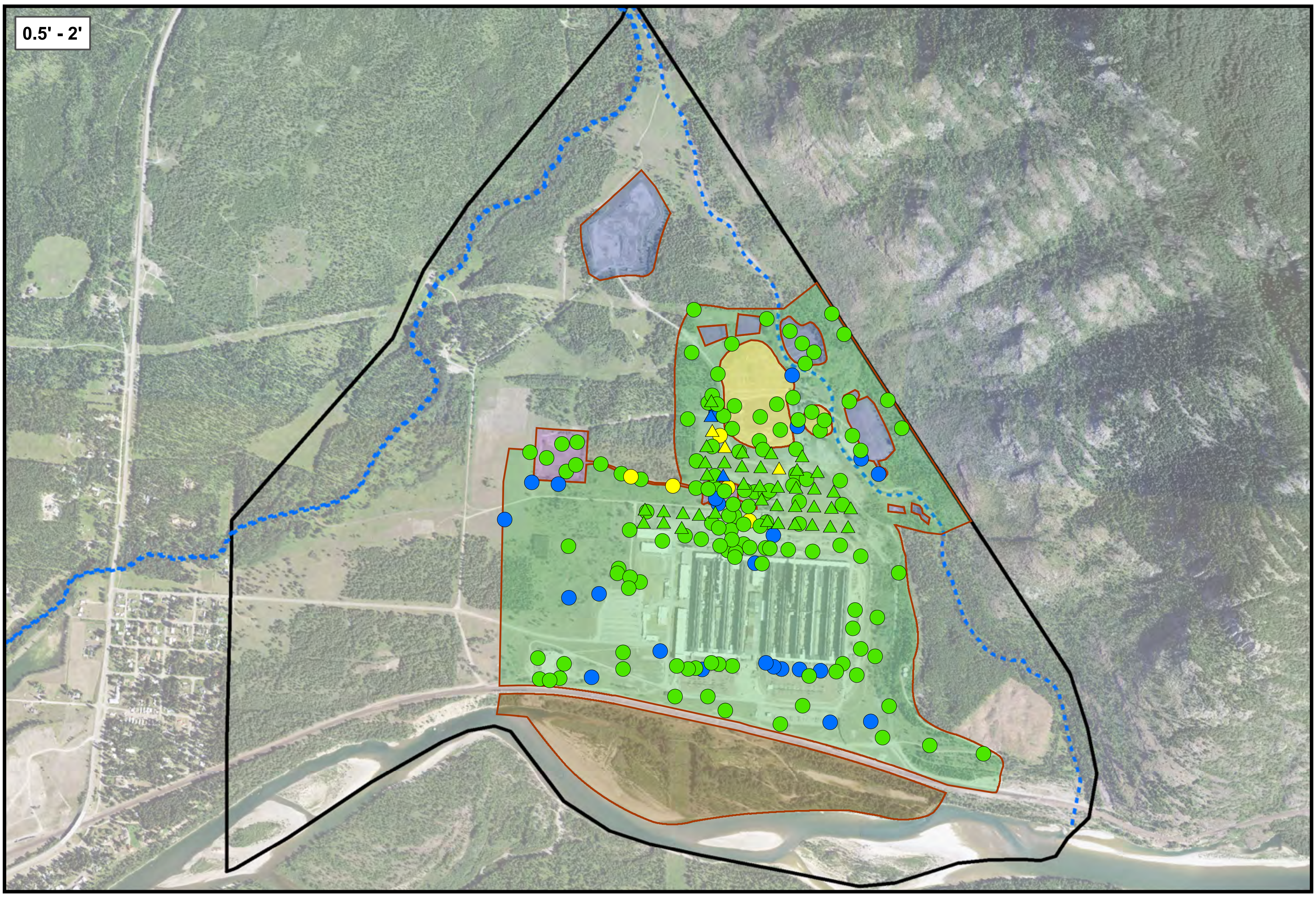
COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/16/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	C2
Project Mgr: L.J.	Project: 2476.0001Y008	
File: C2. Soil_HH_Arsenic.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\C3. SOIL_HH_BENZO(A)ANTHRACENE.MXD





CONCENTRATION LEGEND - EA 1, 2, 3, & ISM GRID AREA

SO	ISM	
● (blue)	▲ (blue)	ANALYTE NOT DETECTED
● (green)	▲ (green)	LESS THAN 10^{-6} TR PRG
● (yellow)	▲ (yellow)	GREATER THAN 10^{-6} TR PRG, LESS THAN 10^{-5} TR PRG
● (orange)	▲ (orange)	GREATER THAN 10^{-5} TR PRG

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

PRG LEGEND BY EXPOSURE AREA

TR PRG	EA 2	EA 1, 3
10^{-6}	140	28
10^{-5}	1,400	280

N

0 1,500'

Title:

CONCENTRATIONS OF BENZO[A]ANTHRACENE IN SOIL SAMPLES – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

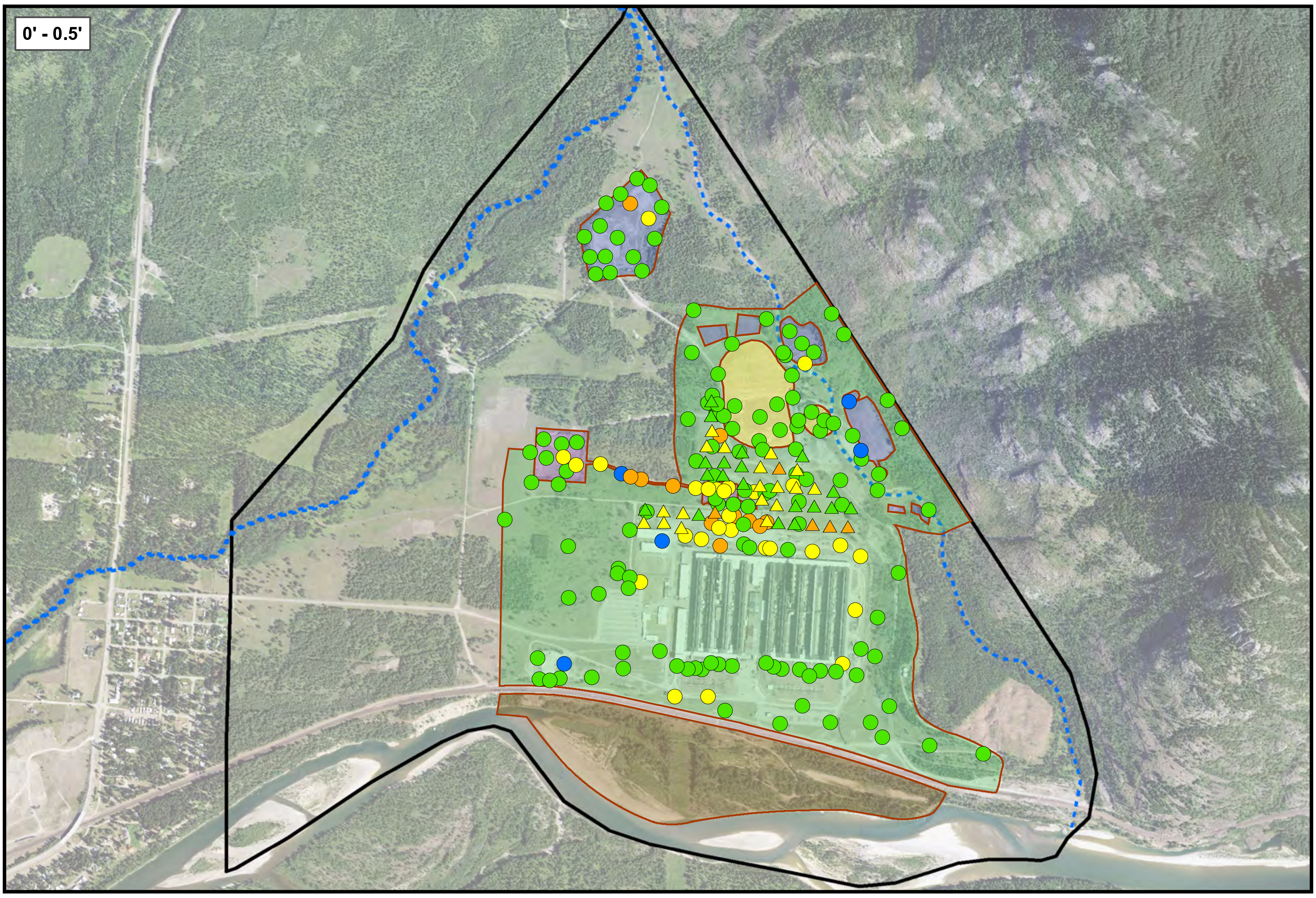
Prepared for:

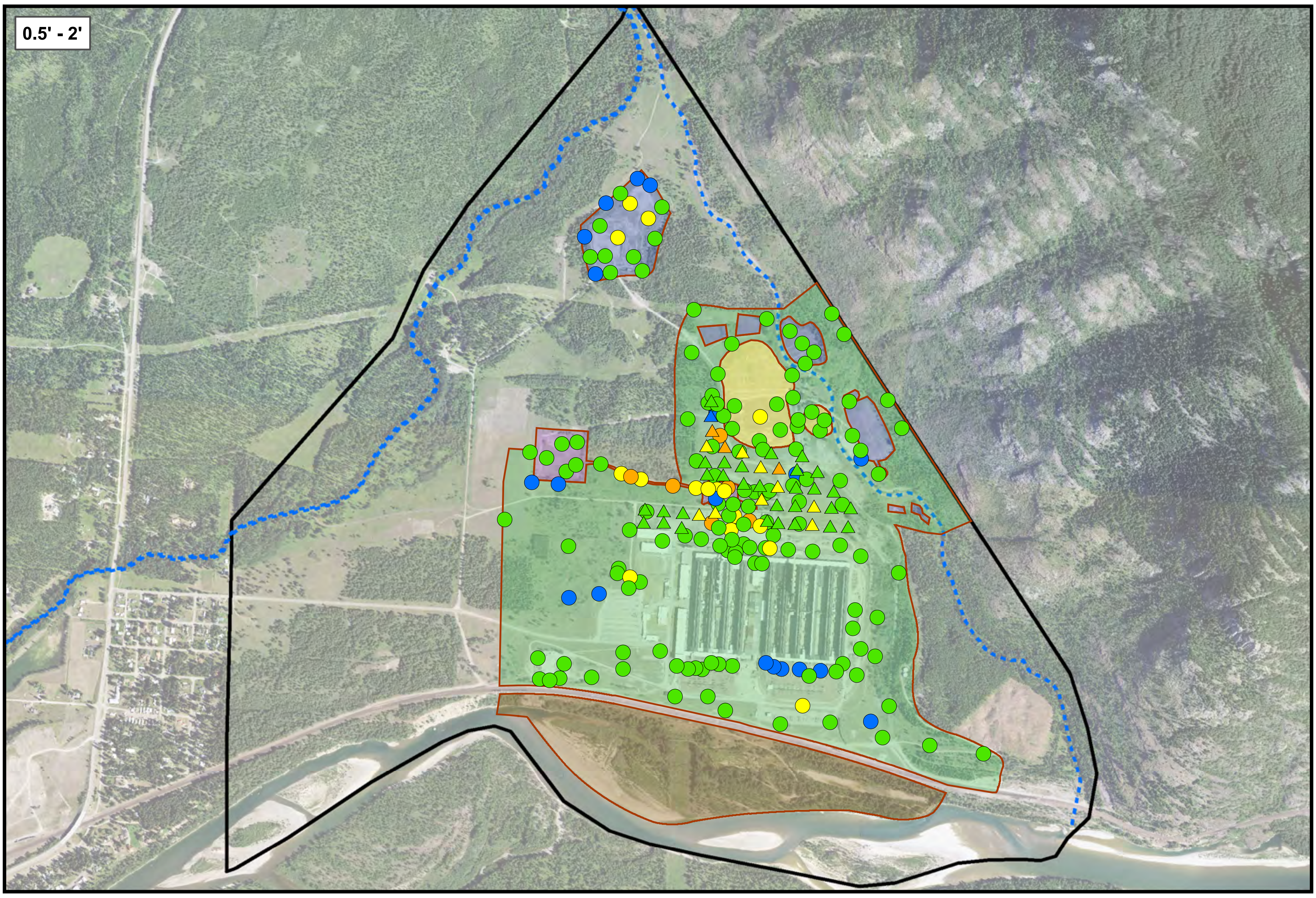
COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 02/26/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	C3
Project Mgr: L.J.	Project: 2476.0001Y008	
File: C3. Soil_HH_Benzo(A)Anthracene.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\C4. SOIL_HH_BENZO[A]PYRENE.MXD





CONCENTRATION LEGEND - EA 1, 2, 3, 4, & ISM GRID AREA

SO	ISM	
●	▲	ANALYTE NOT DETECTED
●	▲	LESS THAN 10^{-6} TR PRG
●	▲	GREATER THAN 10^{-6} TR PRG, LESS THAN 10^{-5} TR PRG
●	▲	GREATER THAN 10^{-5} TR PRG

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

PRG LEGEND BY EXPOSURE AREA

TR PRG	EA 1	EA 2	EA 3, 4
10^{-6}	2.8	14	2.8
10^{-5}	20	140	28

N

0 1,500'

Title:

CONCENTRATIONS OF BENZO[A]PYRENE IN SOIL SAMPLES – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

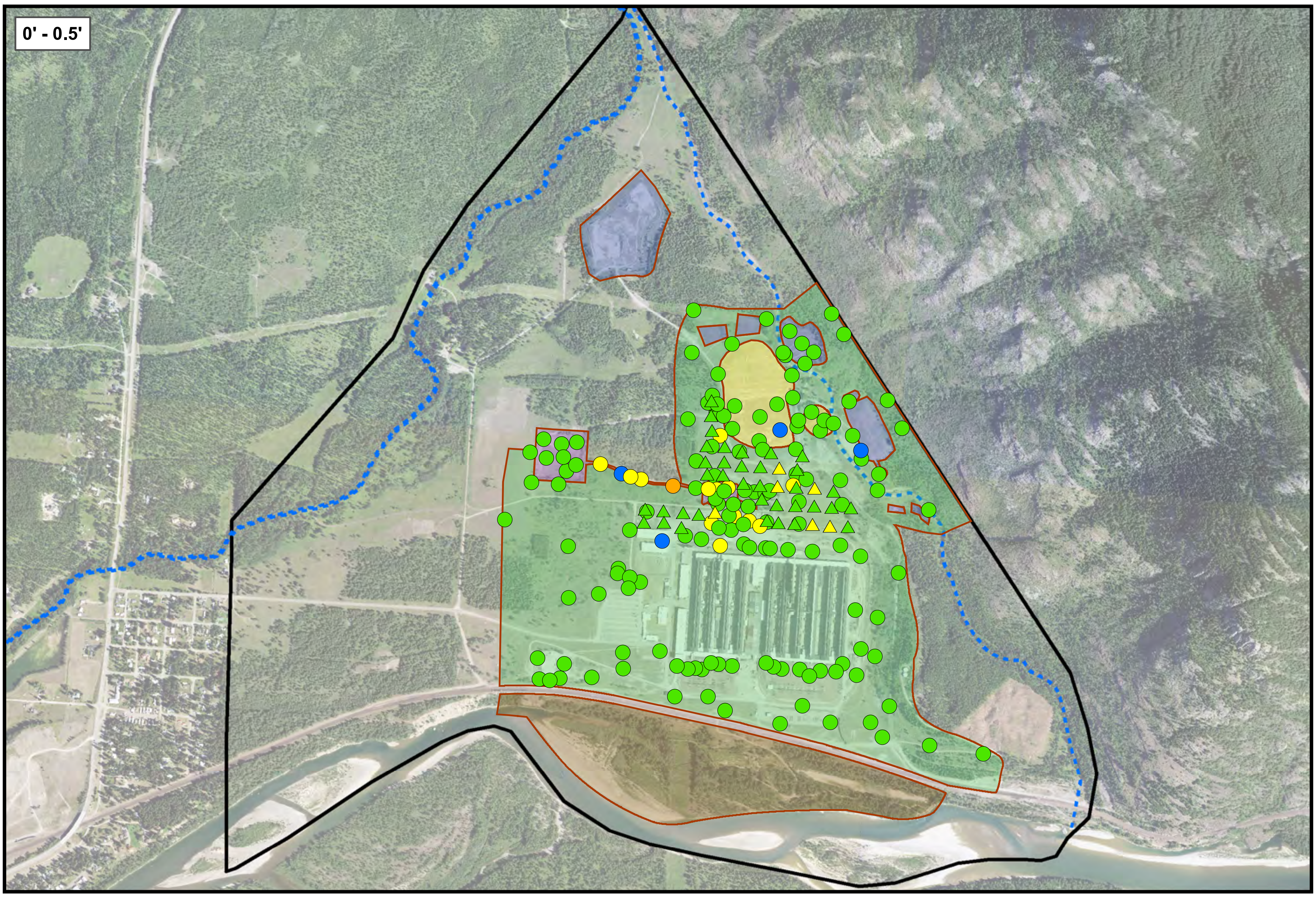
Prepared for:

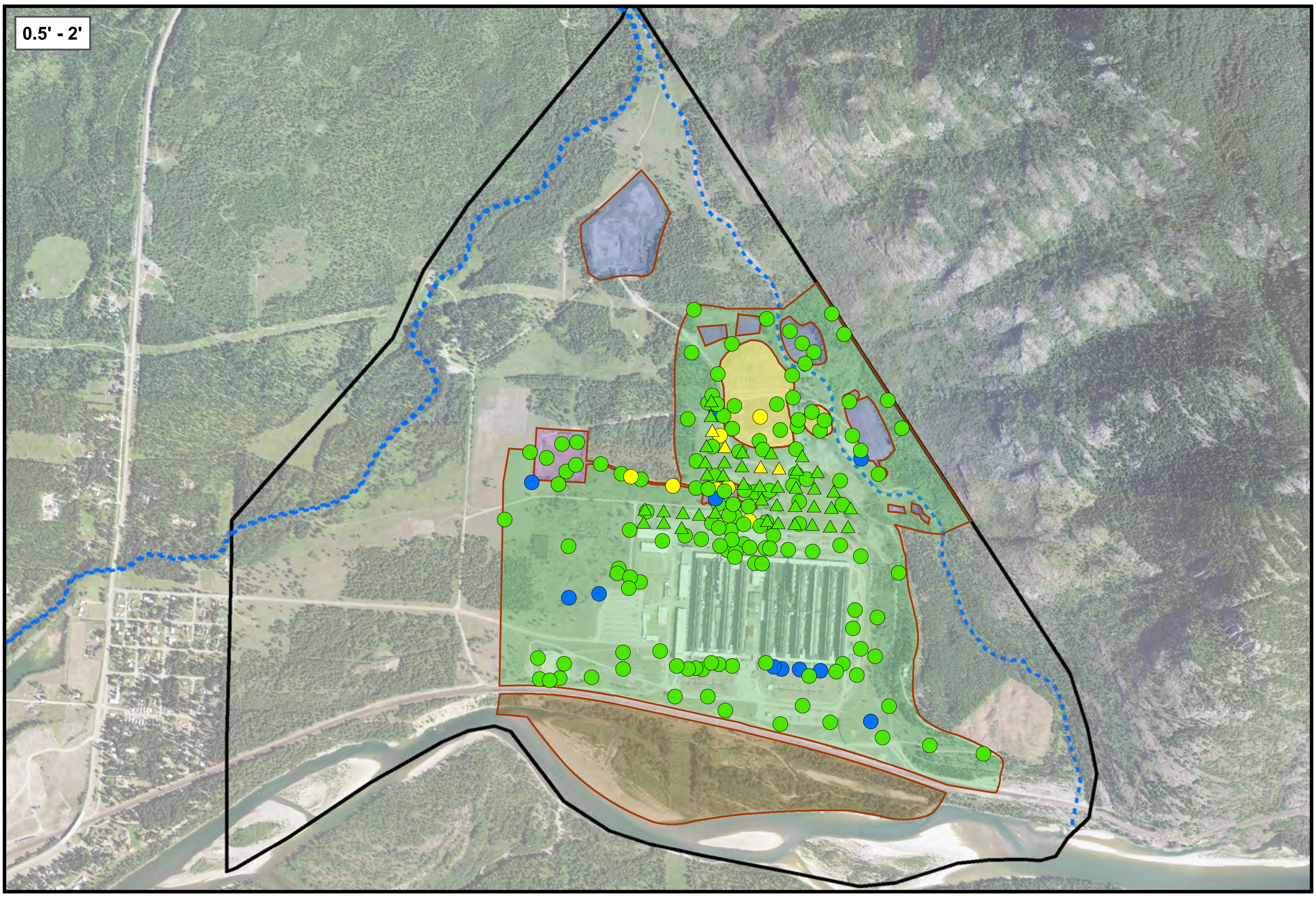
COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 02/26/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	C4
Project Mgr: L.J.	Project: 2476.0001Y008	
File: C4. Soil_HH_Benzo[A]Pyrene.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\C5. SOIL_HH_BENZO[B]FLUORANTHENE.MXD





CONCENTRATION LEGEND - EA 1, 2, 3, & ISM GRID AREA

SO	ISM	
● (blue)	▲ (blue)	ANALYTE NOT DETECTED
● (green)	▲ (green)	LESS THAN 10^{-6} TR PRG
● (yellow)	▲ (yellow)	GREATER THAN 10^{-6} TR PRG, LESS THAN 10^{-5} TR PRG
● (orange)	▲ (orange)	GREATER THAN 10^{-5} TR PRG

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

PRG LEGEND BY EXPOSURE AREA

TR PRG	EA 2	EA 1, 3
10^{-6}	140	28
10^{-5}	1,400	280

N

0 1,500'

Title:

CONCENTRATIONS OF BENZO[B]FLUORANTHENE IN SOIL SAMPLES – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 02/26/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	C5
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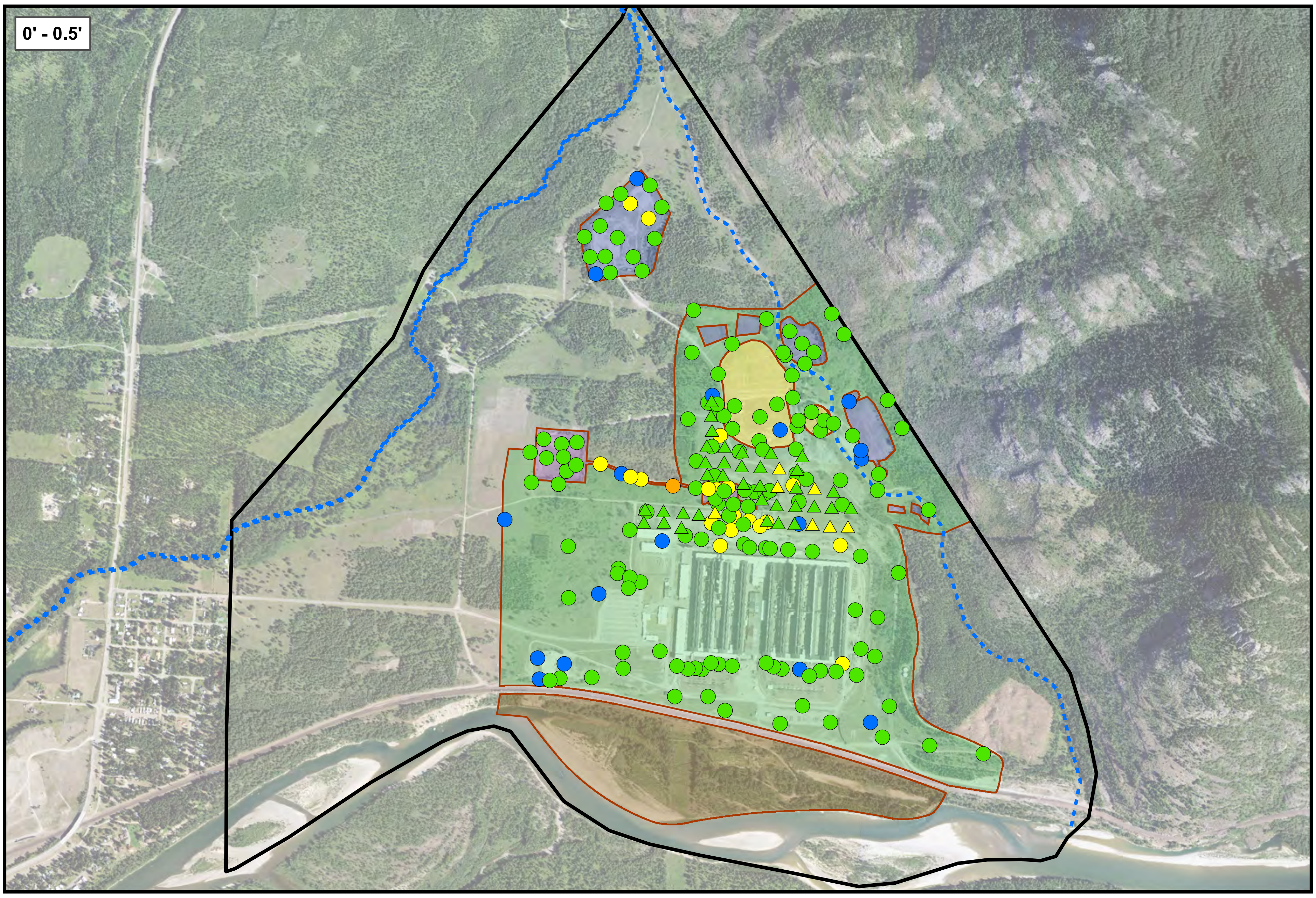
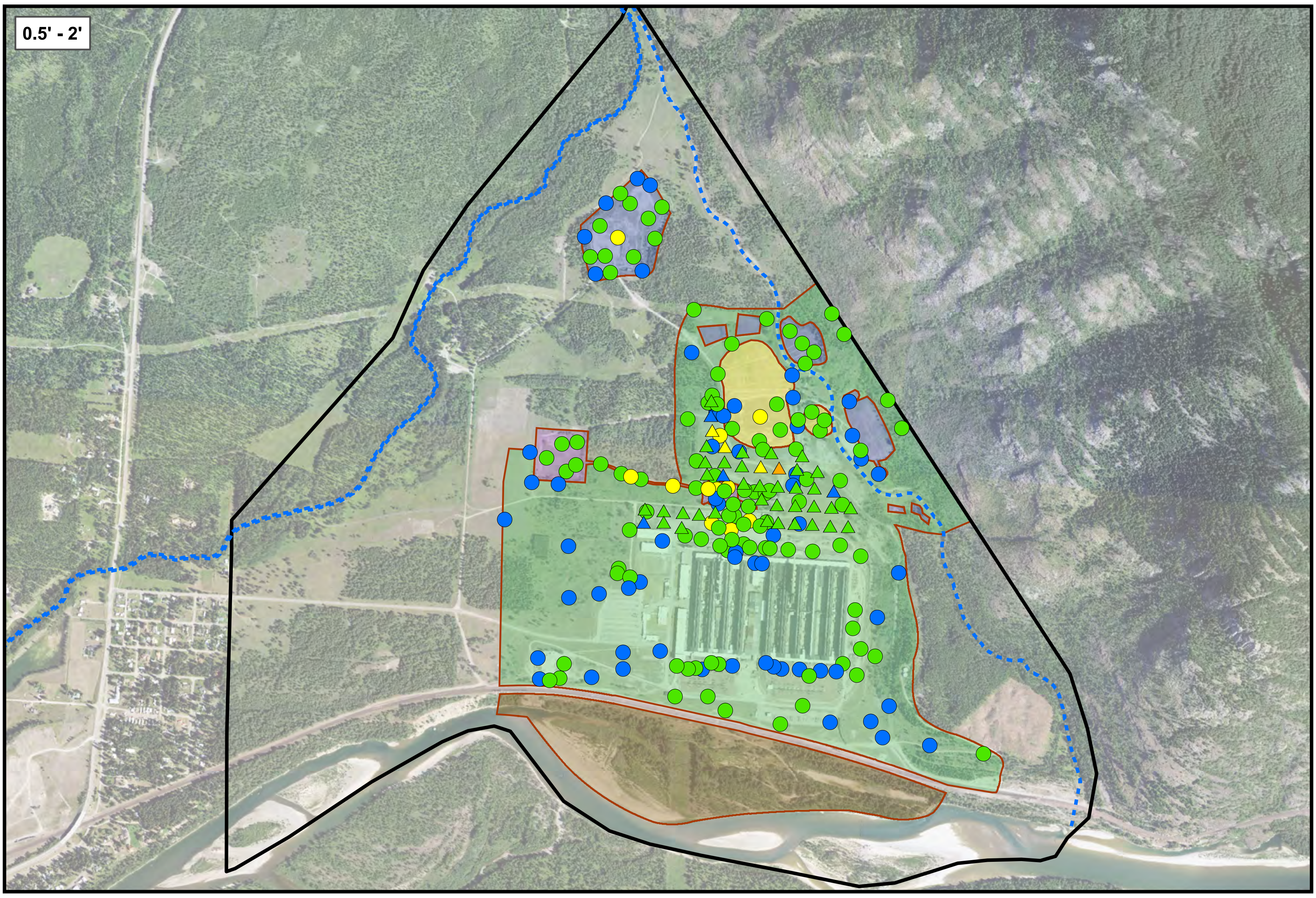
File: C5. Soil_HH_Benzo[B]Fluoranthene.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\C6. SOIL_HH_DIBENZ[A,H]ANTHRACENE.MXD





CONCENTRATION LEGEND - EA 1, 2, 3, 4, & ISM GRID AREA

SO	ISM	
● (blue)	▲ (blue)	ANALYTE NOT DETECTED
● (green)	▲ (green)	LESS THAN 10^{-6} TR PRG
● (yellow)	▲ (yellow)	GREATER THAN 10^{-6} TR PRG, LESS THAN 10^{-5} TR PRG
● (orange)	▲ (orange)	GREATER THAN 10^{-5} TR PRG

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

PRG LEGEND BY EXPOSURE AREA

TR PRG	EA 2	EA 1, 3, 4
10^{-6}	14	2.8
10^{-5}	140	28

N

0 1,500'

Title:

CONCENTRATIONS OF DIBENZ[A,H]ANTHRACENE IN SOIL SAMPLES – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 02/26/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	
Project Mgr: L.J.	Project: 2476.0001Y008	C6
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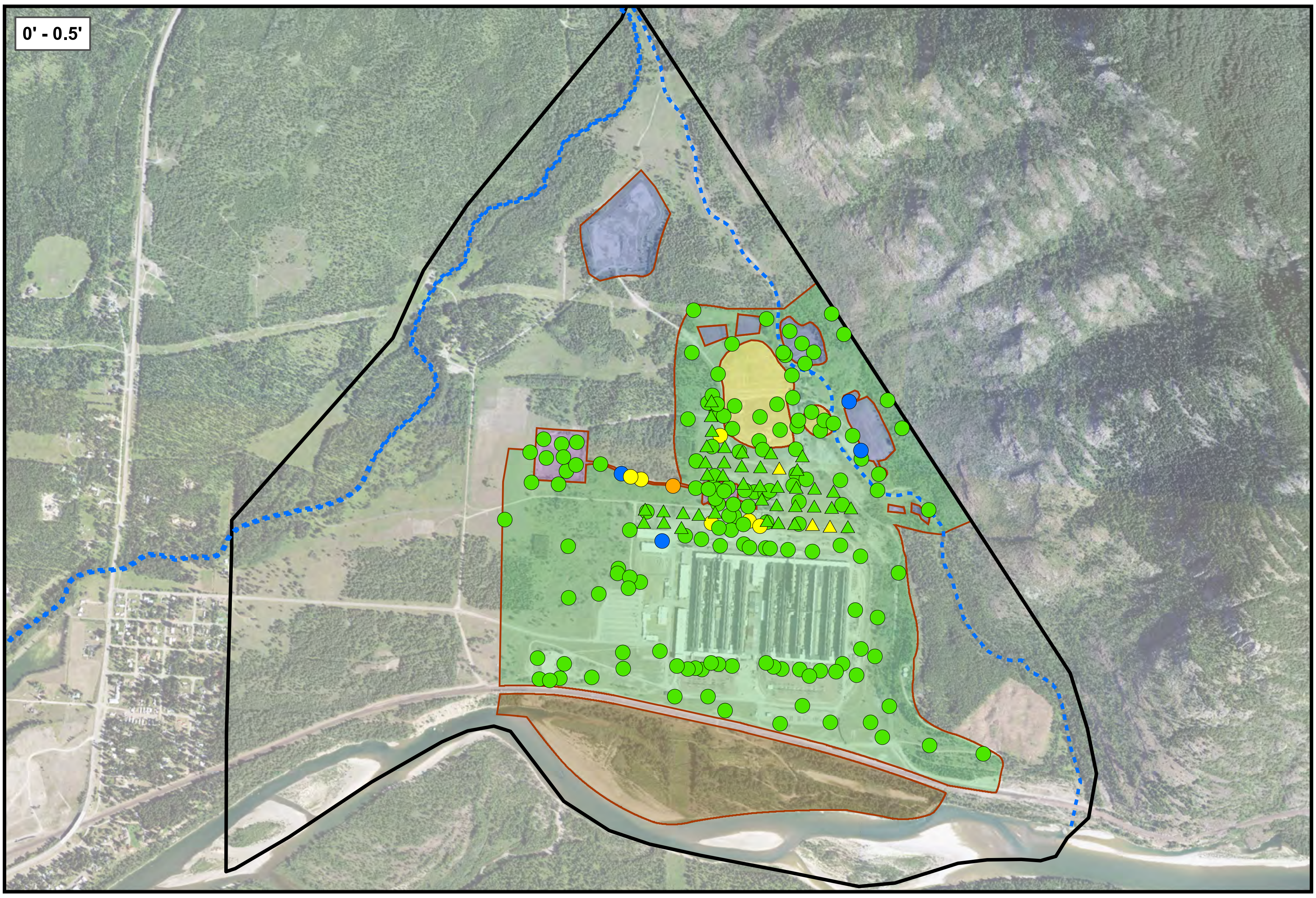
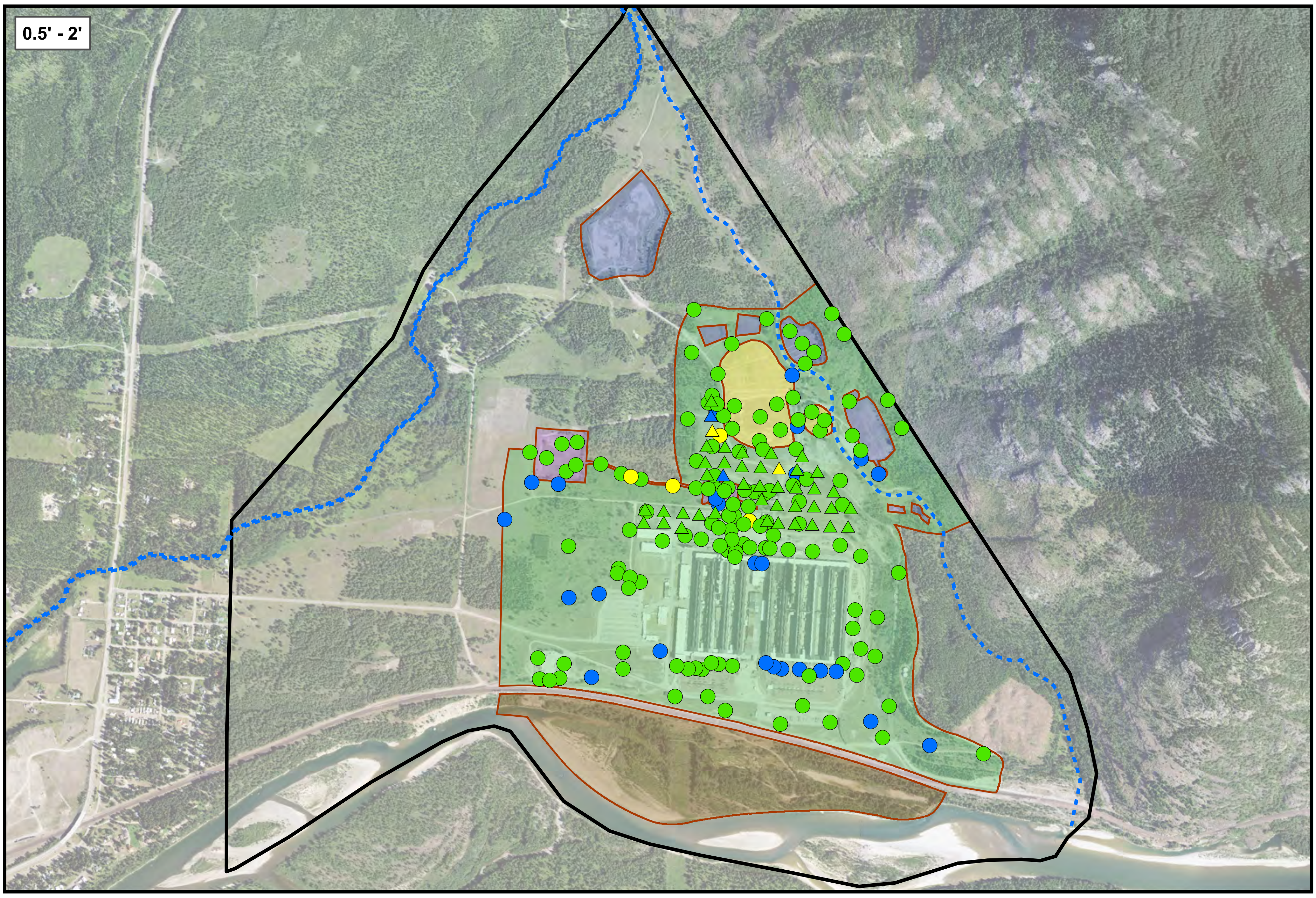
V:\GIS\PROJECTS\2476Y\0001Y\256\C7. SOIL_HH_INDENO(1,2,3-C,D)PYRENE.MXD





CONCENTRATION LEGEND - EA 1, 2, 3, & ISM GRID AREA

SO	ISM	
● (blue)	▲ (blue)	ANALYTE NOT DETECTED
● (green)	▲ (green)	LESS THAN 10^{-6} TR PRG
● (yellow)	▲ (yellow)	GREATER THAN 10^{-6} TR PRG, LESS THAN 10^{-5} TR PRG
● (orange)	▲ (orange)	GREATER THAN 10^{-5} TR PRG

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

PRG LEGEND BY EXPOSURE AREA

TR PRG	EA 2	EA 1, 3
10^{-6}	140	28
10^{-5}	1,400	280

N

0 1,500'

Title:

CONCENTRATIONS OF INDENO[1,2,3-C,D]PYRENE IN SOIL SAMPLES – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

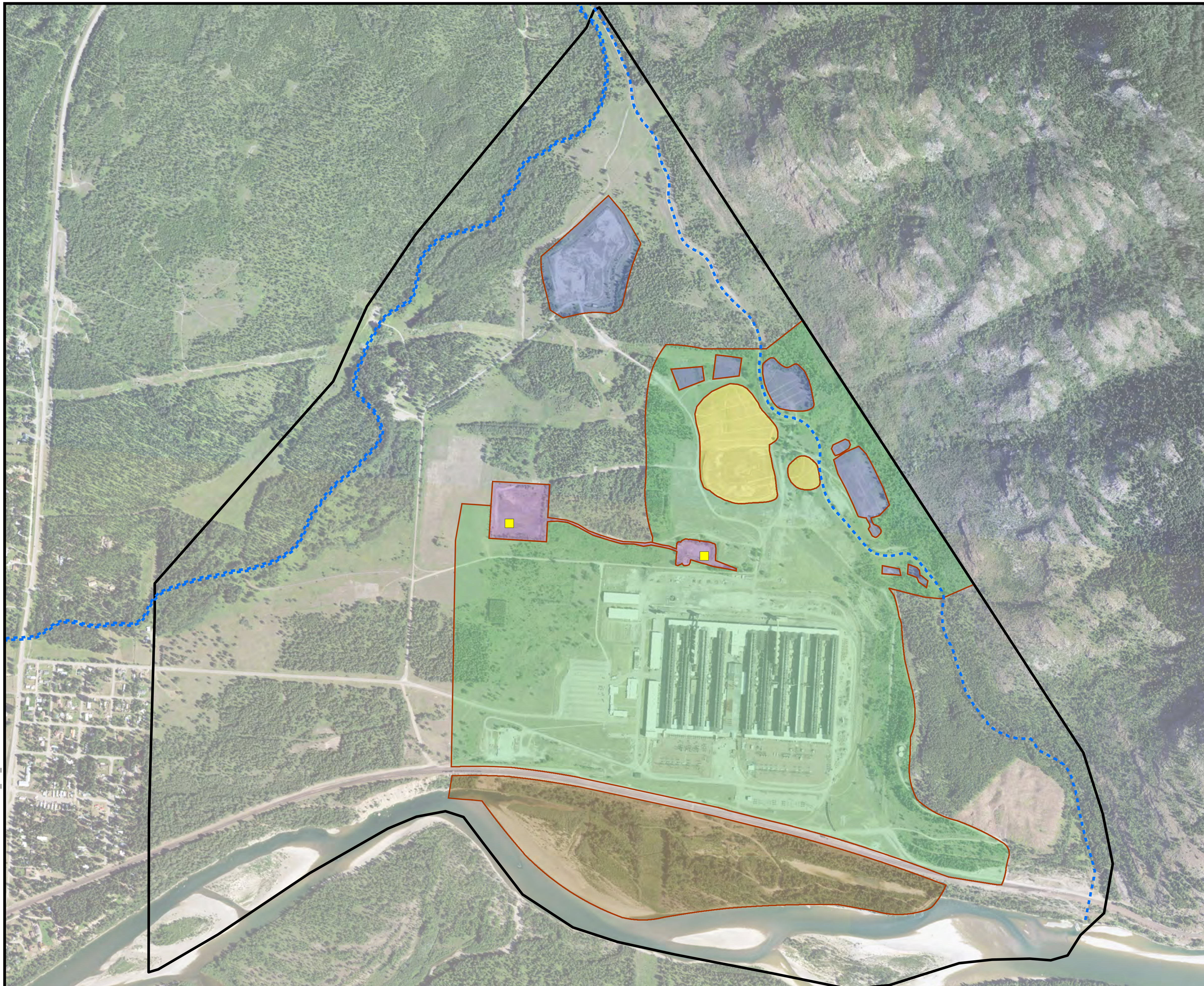
ROUX

Compiled by: C.S.	Date: 02/26/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	C7
Project Mgr: L.J.	Project: 2476.0001Y008	
File: C7. Soil_HH_Indeno(1,2,3-C,D)Pyrene.mxd		

APPENDIX D

Human Health PRG Comparison – Sediment Thematic Maps

1. Exceedances of Human Health PRGs in Sediment Samples
2. Concentrations of Arsenic in Sediment – Human Health PRG Comparison
3. Concentrations of Benzo[A]Pyrene in Sediment – Human Health PRG Comparison
4. Concentrations of Benzo[B]Fluoranthene in Sediment – Human Health PRG Comparison
5. Concentrations of Dibenz[A,H]Anthracene in Sediment – Human Health PRG Comparison
6. Concentrations of Indeno[1,2,3-C,D]Pyrene in Sediment – Human Health PRG Comparison



LEGEND - EA 2

- LOCATION WITH NO EXCEEDANCES
- LOCATION WITH ONE OR MORE EXCEEDANCES OF A 10^{-6} TR PRG, BUT NO EXCEEDANCE OF ANY 10^{-5} TR PRG
- LOCATION WITH ONE OR MORE EXCEEDANCES OF A 10^{-5} TR PRG

1,000 0 1,000'

Title:

EXCEEDANCES OF HUMAN HEALTH PRGS IN SEDIMENT SAMPLES

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

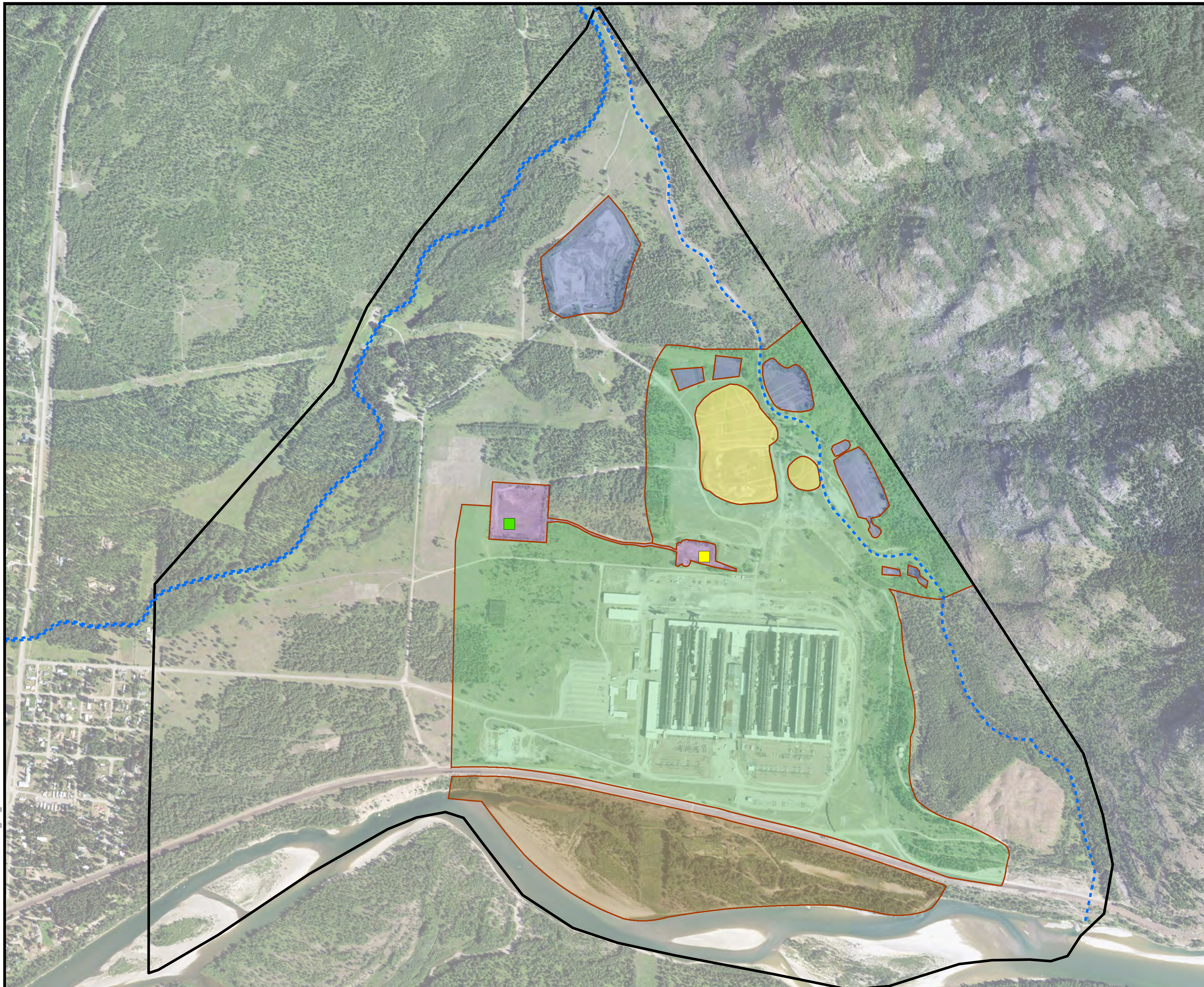
Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 02/26/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	D1
Project Mgr: L.J.	Project: 2476.0001Y008	
File: D1. Exceedance_HH_Sed.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\D1. EXCEEDANCE_HH_SED.MXD



N

CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED (blue)
- LESS THAN 10^{-6} TR PRG (green)
- GREATER THAN 10^{-6} TR PRG, LESS THAN 10^{-5} TR PRG (yellow)
- GREATER THAN 10^{-5} TR PRG (orange)

PRG LEGEND BY EXPOSURE AREA

TR PRG	EA 2
10^{-6}	20
10^{-5}	200

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

1,000 0 1,000'

Title:

CONCENTRATIONS OF ARSENIC IN SEDIMENT – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

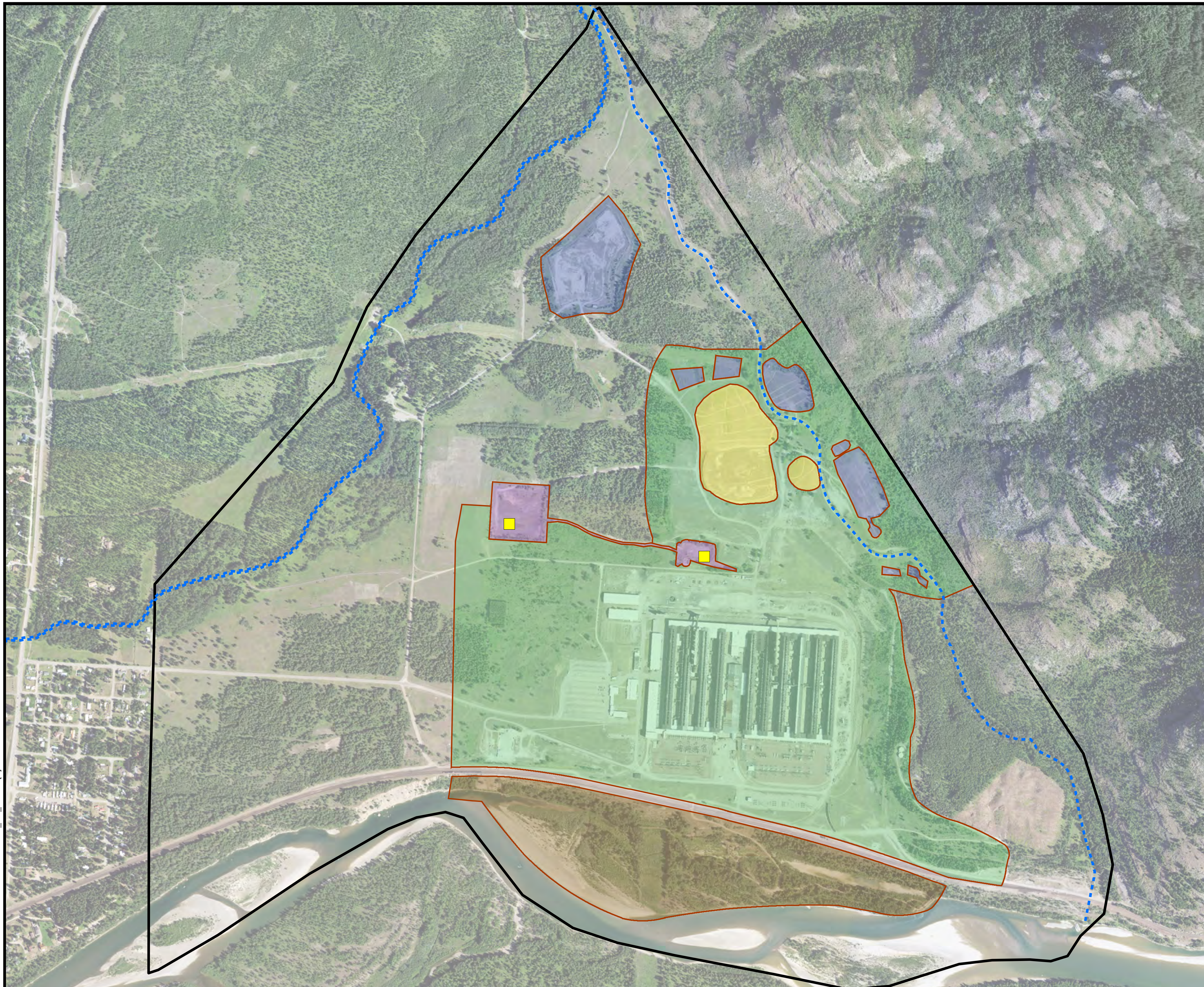
Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 02/26/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	D2
Project Mgr: L.J.	Project: 2476.0001Y008	
File: D2. Sed_HH_Arsenic.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\D2. SED_HH_ARSENIC.MXD



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CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- LESS THAN 10^{-6} TR PRG
- GREATER THAN 10^{-6} TR PRG, LESS THAN 10^{-5} TR PRG
- GREATER THAN 10^{-5} TR PRG

PRG LEGEND BY EXPOSURE AREA

TR PRG	EA 2
10^{-6}	14
10^{-5}	140

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

1,000 0 1,000'

Title:

CONCENTRATIONS OF BENZO[A]PYRENE IN SEDIMENT – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

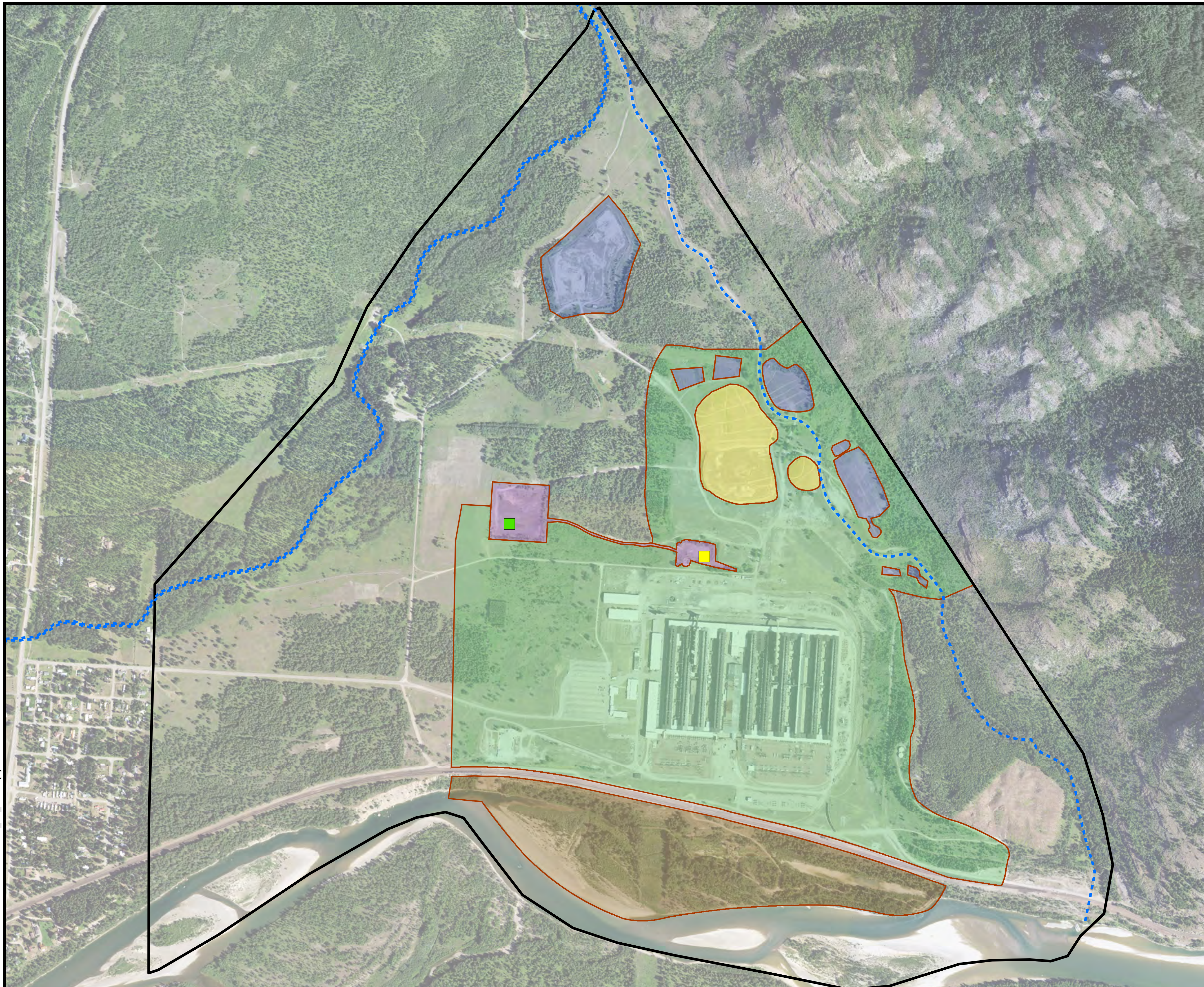
Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 02/26/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	D3
Project Mgr: L.J.	Project: 2476.0001Y008	
File: D3. Sed_HH_Benzo[A]Pyrene.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\D3. SED_HH_BENZO[A]PYRENE.MXD



N

CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- LESS THAN 10^{-6} TR PRG
- GREATER THAN 10^{-6} TR PRG, LESS THAN 10^{-5} TR PRG
- GREATER THAN 10^{-5} TR PRG

PRG LEGEND BY EXPOSURE AREA

TR PRG	EA 2
10^{-6}	140
10^{-5}	1,400

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

1,000 0 1,000'

Title:

CONCENTRATIONS OF BENZO[B]FLUORANTHENE IN SEDIMENT – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

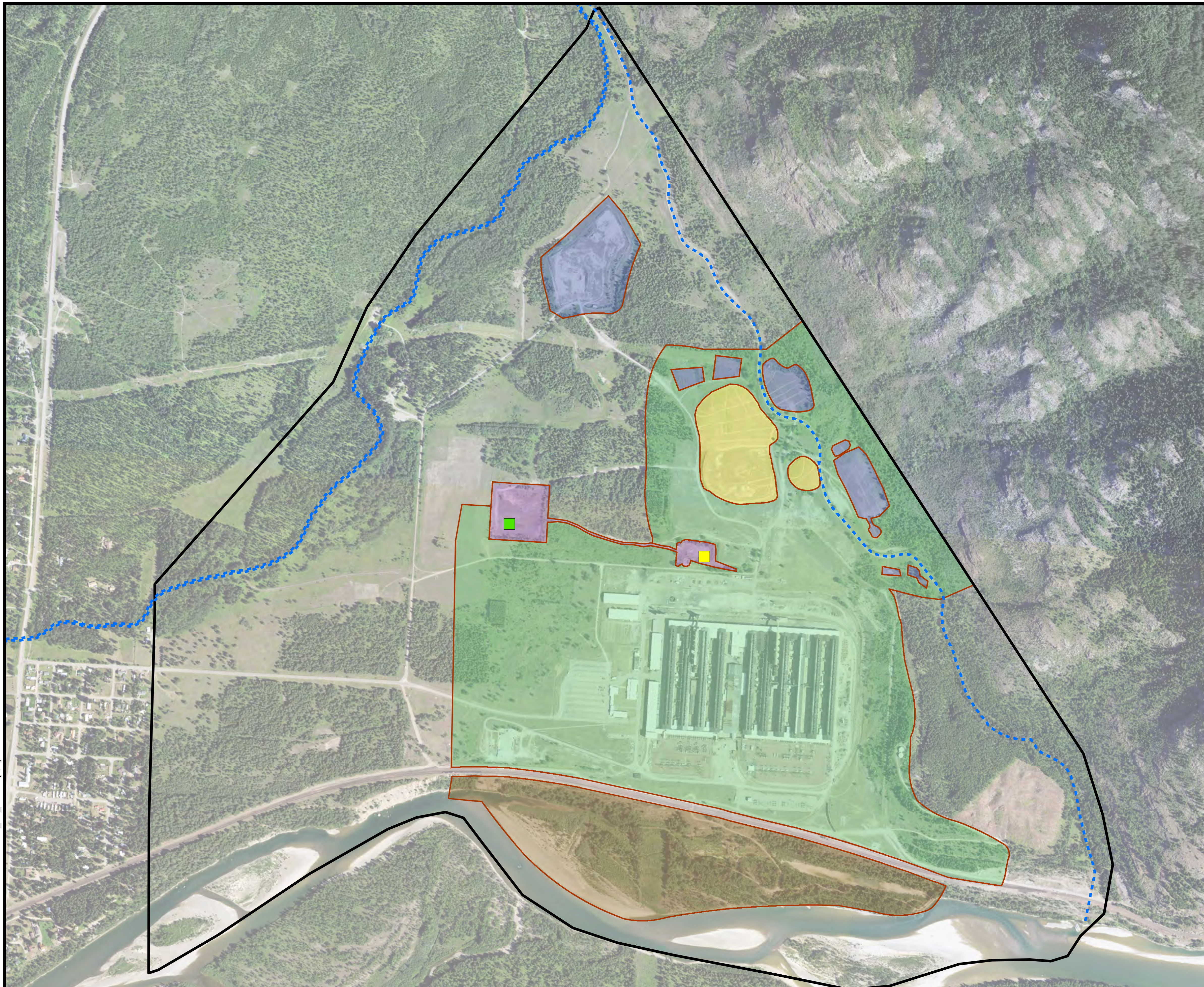
Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 02/26/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	D4
Project Mgr: L.J.	Project: 2476.0001Y008	
File: D4. Sed_HH_Benzo[B]Fluoranthene.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\D4. SED_HH_BENZO[B]FLUORANTHENE.MXD



CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- LESS THAN 10^{-6} TR PRG
- GREATER THAN 10^{-6} TR PRG, LESS THAN 10^{-5} TR PRG
- GREATER THAN 10^{-5} TR PRG

PRG LEGEND BY EXPOSURE AREA

TR PRG	EA 2
10^{-6}	14
10^{-5}	140

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

1,000 0 1,000'

Title:

CONCENTRATIONS OF DIBENZ[A,H]ANTHRACENE IN SEDIMENT – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

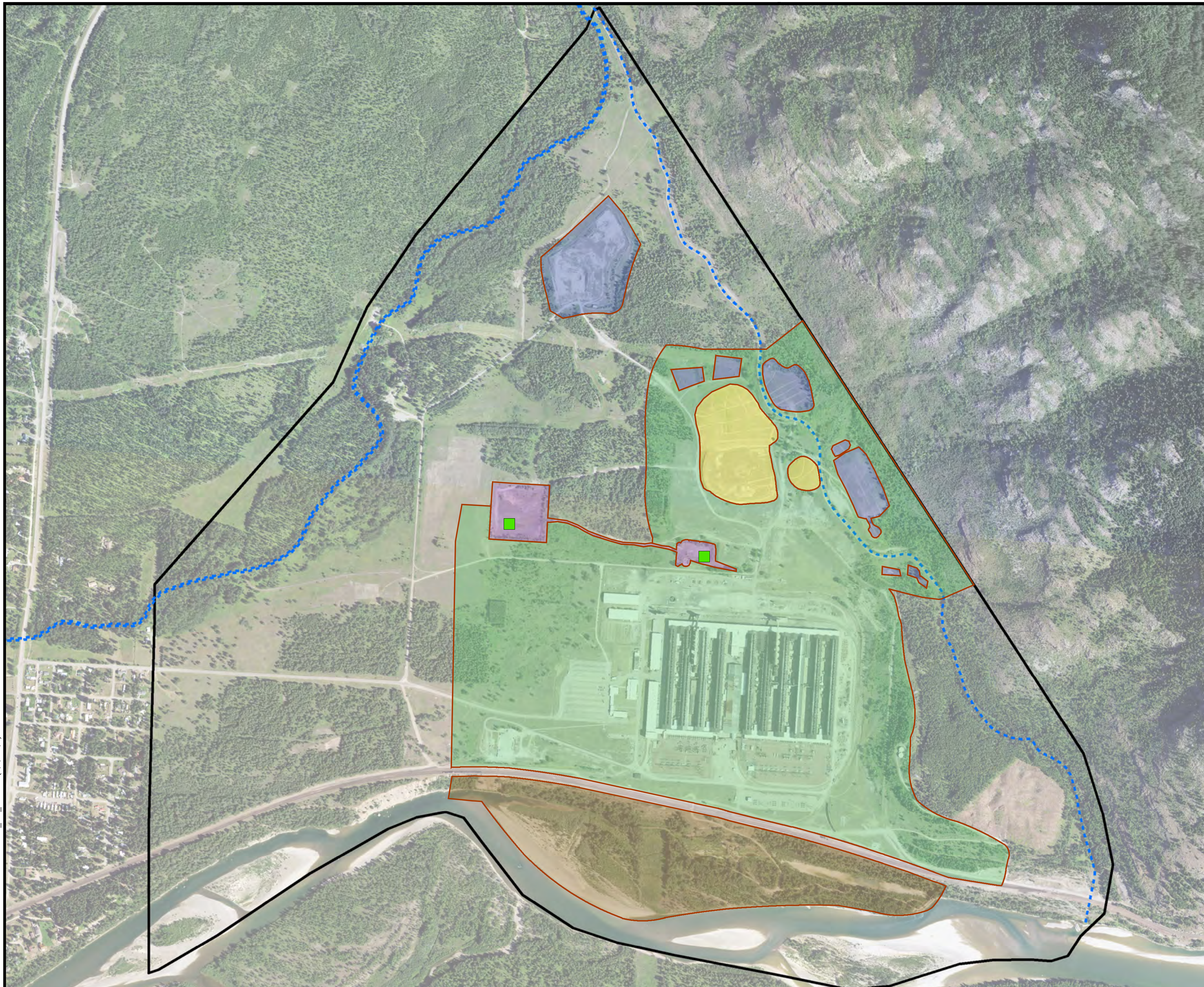
Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 02/26/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	D5
Project Mgr: L.J.	Project: 2476.0001Y008	
File: D5. Sed_HH_Dibenz[A,H]Anthracene.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\D5. SED_HH_DIBENZ[A,H]ANTHRACENE.MXD



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CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- LESS THAN 10^{-6} TR PRG
- GREATER THAN 10^{-6} TR PRG, LESS THAN 10^{-5} TR PRG
- GREATER THAN 10^{-5} TR PRG

PRG LEGEND BY EXPOSURE AREA

TR PRG	EA 2
10^{-6}	140
10^{-5}	1,400

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

1,000 0 1,000'

Title:

CONCENTRATIONS OF INDENO[1,2,3-C,D]PYRENE IN SEDIMENT – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

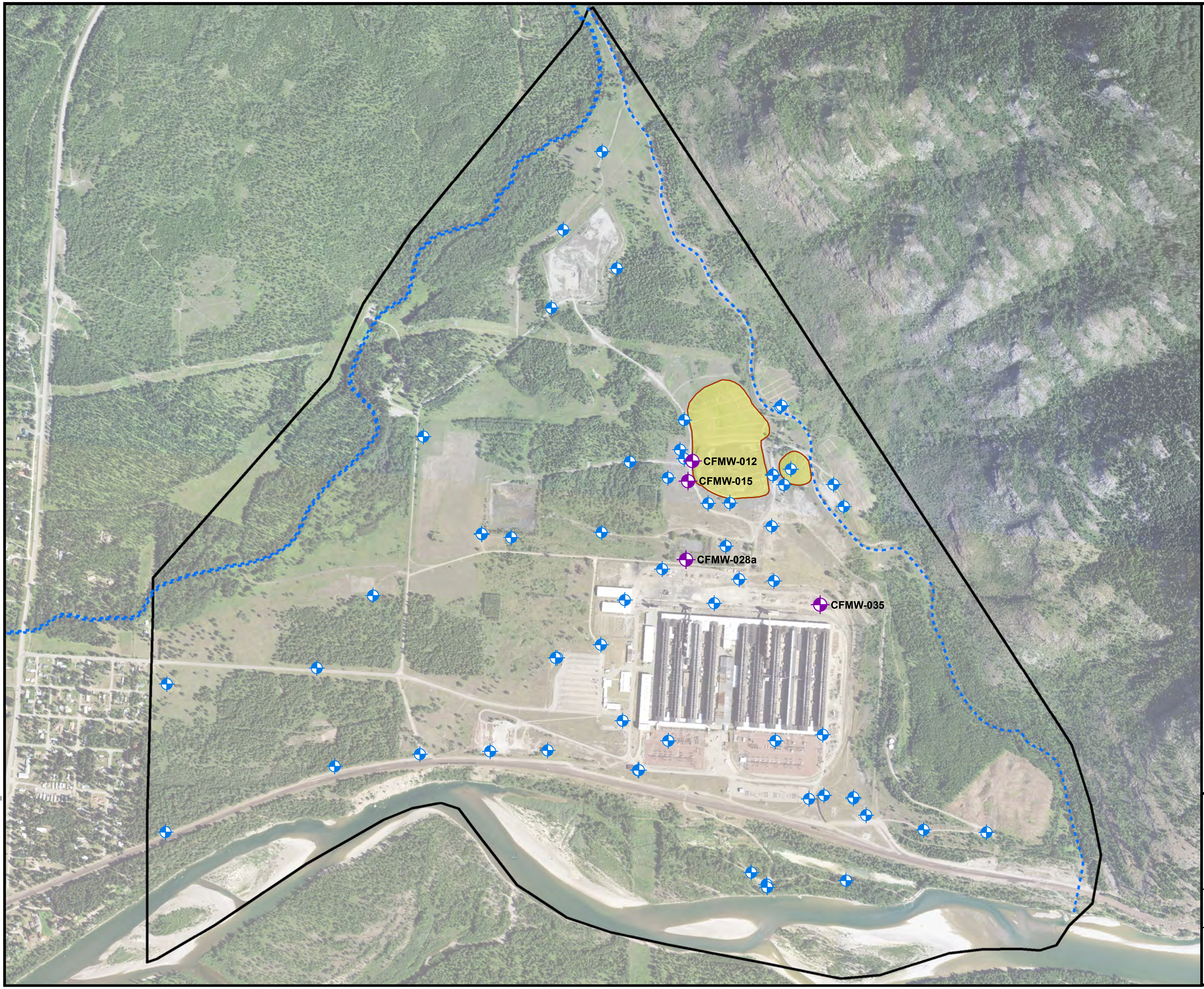
Compiled by: C.S.	Date: 02/26/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	D6
Project Mgr: L.J.	Project: 2476.0001Y008	
File: D6. Sed_HH_Indeno(1,2,3-C,D)Pyrene.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\D6. SED_HH_INDENO(1,2,3-C,D)PYRENE.MXD

APPENDIX E

Human Health PRG Comparison – Groundwater Contour Maps

1. Concentrations of Arsenic in Upper Hydrogeologic Unit Groundwater – Human Health PRG Comparison
2. Concentrations of Total Cyanide in Upper Hydrogeologic Unit Groundwater – Human Health PRG Comparison
3. Concentrations of Fluoride in Upper Hydrogeologic Unit Groundwater – Human Health PRG Comparison



Title:

CONCENTRATIONS OF ARSENIC IN UPPER HYDROGEOLOGIC UNIT GROUNDWATER – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 02/24/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	E1
Project Mgr: L.J.	Project: 2476.0001Y008	
File: E1. Arsenic_GW.mxd		

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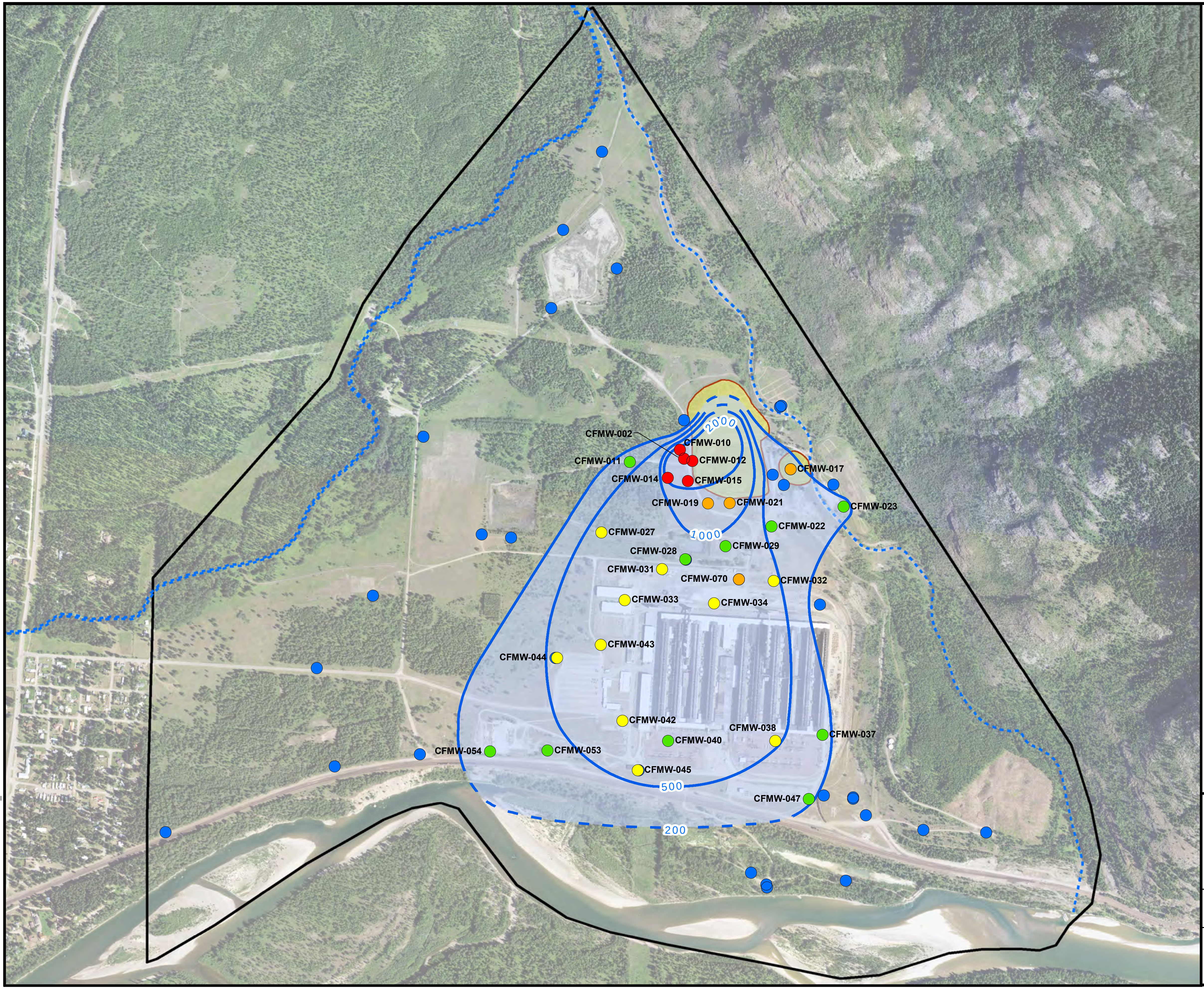

LEGEND

- LANDFILLS DECISION UNIT1
- APPROXIMATE EXTENT OF DETECTED CONCENTRATIONS GREATER THAN DEQ-7 GROUNDWATER HUMAN HEALTH STANDARDS
- 200 APPROXIMATE EXTENT OF DENOTED CONCENTRATION (DASHED WHERE INFERRED)
- CREEK FEATURES
- SITE BOUNDARY

CONCENTRATION LEGEND

- <200
- 200 - 500
- 500 - 1,000
- 1,000 - 2,000
- >2,000

NOTE

EPA RISK BASED SCREENING LEVEL DRINKING WATER MCL AND DEQ-7 GROUNDWATER HUMAN HEALTH STANDARD FOR TOTAL CYANIDE IS 200 µG/L

1,000 0 1,000'

Title:

CONCENTRATIONS OF TOTAL CYANIDE IN UPPER HYDROGEOLOGIC UNIT GROUNDWATER – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/11/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	E2
Project Mgr: L.J.	Project: 2476.0001Y008	
File: E2. Cyanide_GW.mxd		

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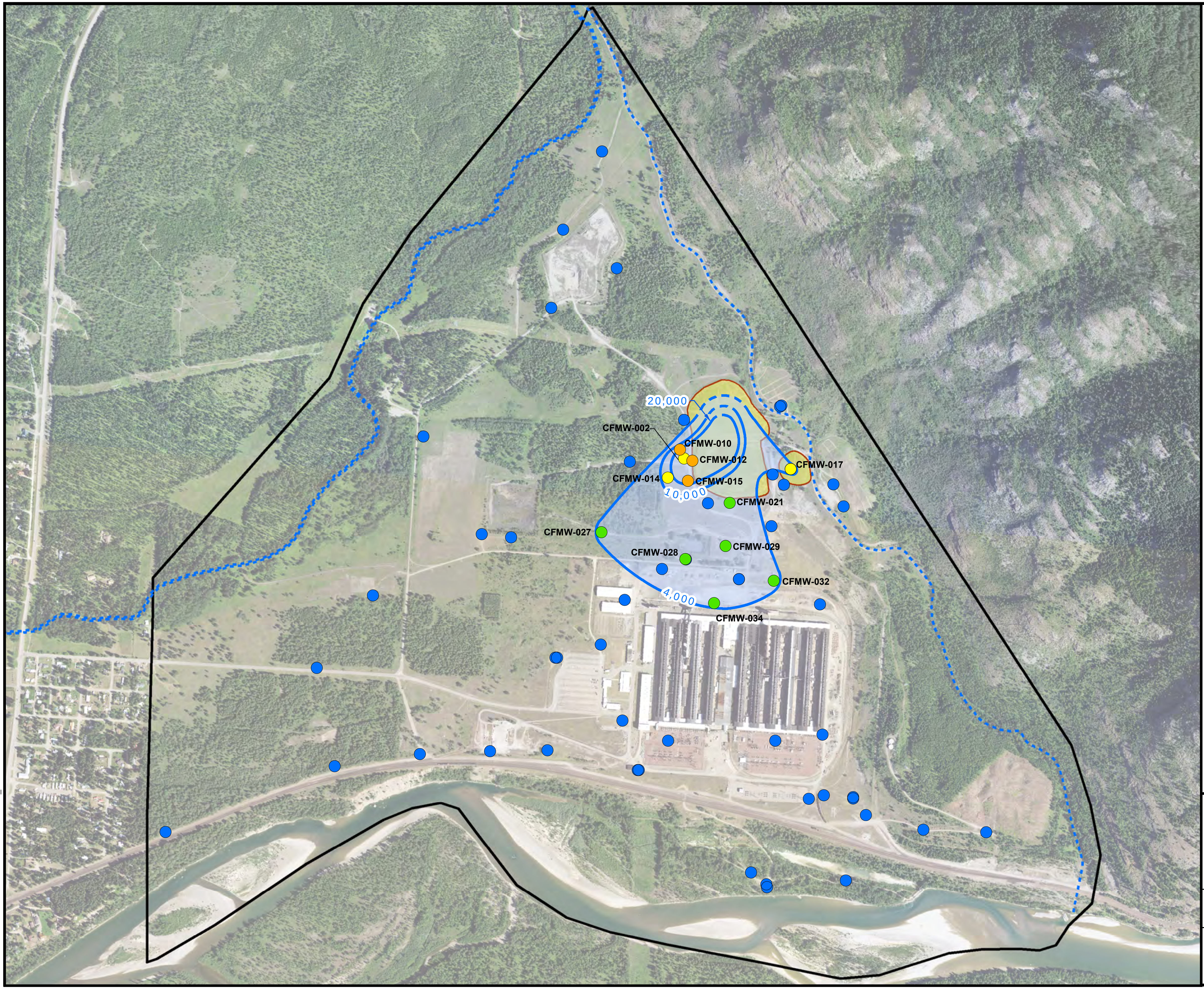


LEGEND

LANDFILLS DECISION UNIT1

APPROXIMATE EXTENT OF DETECTED CONCENTRATIONS GREATER THAN DEQ-7 GROUNDWATER HUMAN HEALTH STANDARDS

4,000 APPROXIMATE EXTENT OF DENOTED CONCENTRATION (DASHED WHERE INFERRED)

CREEK FEATURES

SITE BOUNDARY

CONCENTRATION LEGEND

<4,000

4,000 - 10,000

10,000 - 20,000

>20,000

NOTE

EPA RISK BASED SCREENING LEVEL DRINKING WATER MCL AND DEQ-7 GROUNDWATER HUMAN HEALTH STANDARD FOR FLUORIDE IS 4,000 µG/L

1,000 0 1,000'

Title:

CONCENTRATIONS OF FLUORIDE IN UPPER HYDROGEOLOGIC UNIT GROUNDWATER – HUMAN HEALTH PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

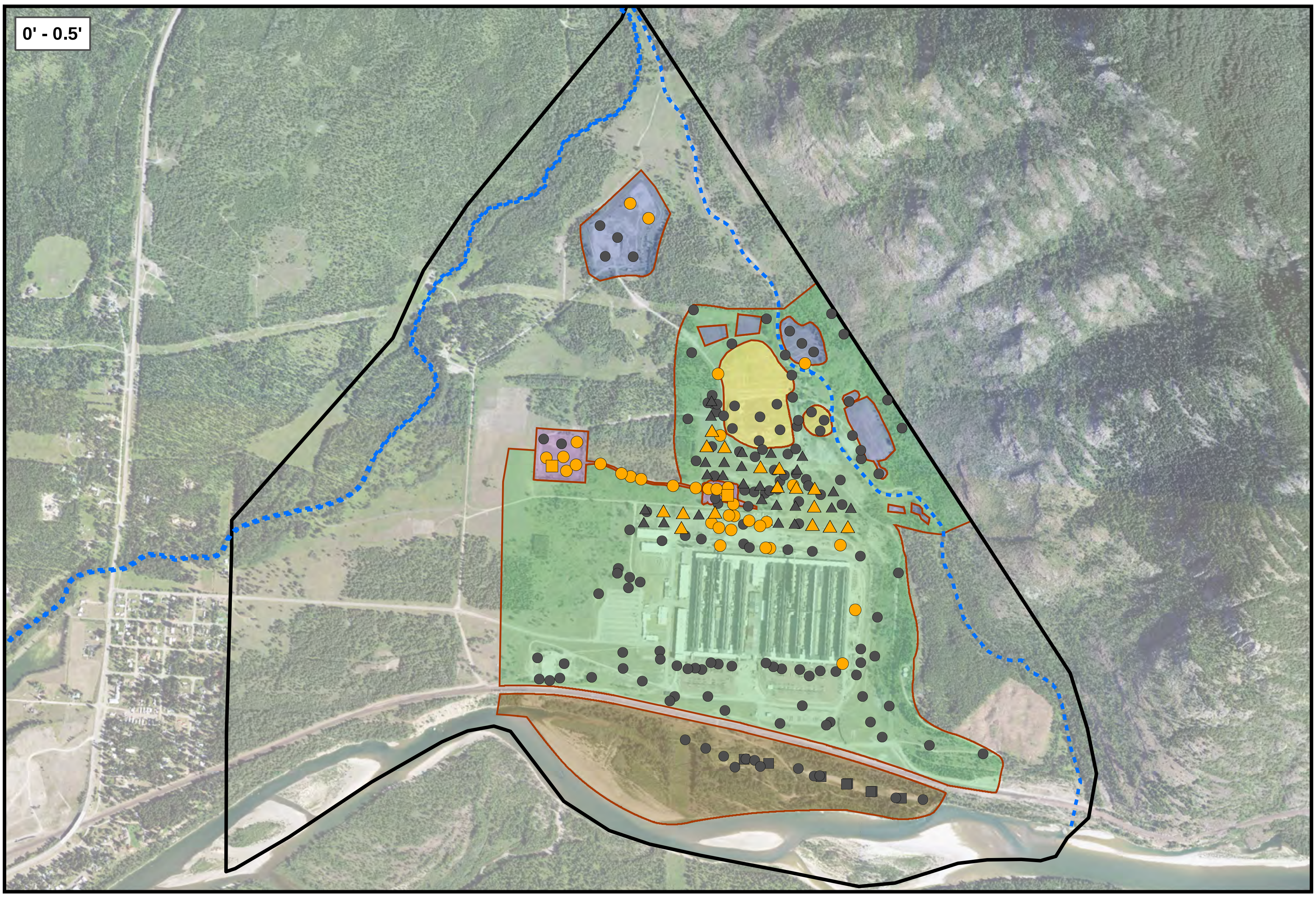
Compiled by: C.S.	Date: 03/16/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	E3
Project Mgr: L.J.	Project: 2476.0001Y008	
File: E3. Fluoride_GW.mxd		

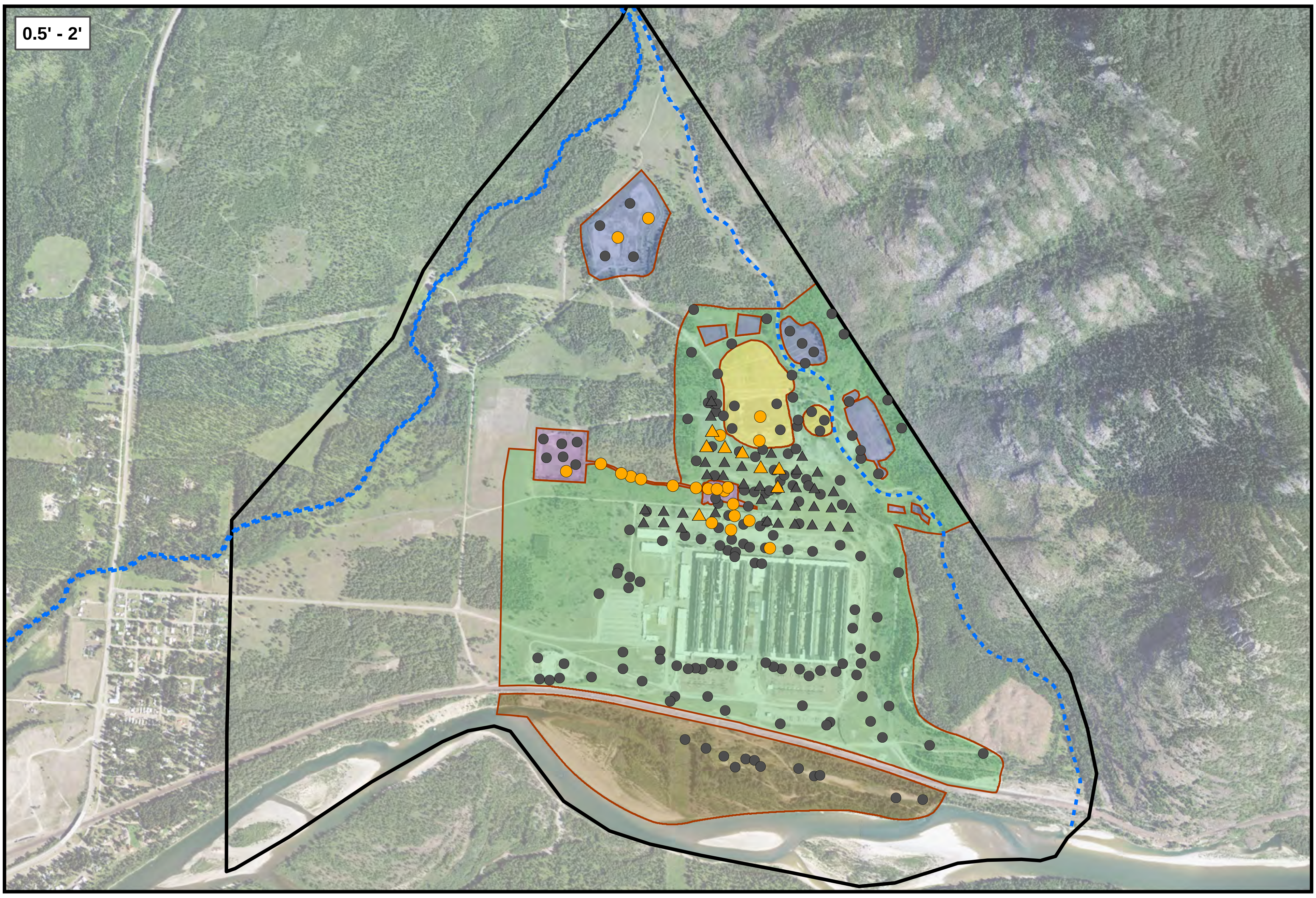
APPENDIX F

Ecological PRG Comparison – Soil Thematic Maps

1. Exceedances of Ecological PRGs in Soil Samples
2. Concentrations of Barium in Soil Samples – Ecological PRG Comparison
3. Concentrations of Copper in Soil Samples – Ecological PRG Comparison
4. Concentrations of Nickel in Soil Samples – Ecological PRG Comparison
5. Concentrations of Selenium in Soil Samples – Ecological PRG Comparison
6. Concentrations of Thallium in Soil Samples – Ecological PRG Comparison
7. Concentrations of Vanadium in Soil Samples – Ecological PRG Comparison
8. Concentrations of Zinc in Soil Samples – Ecological PRG Comparison
9. Concentrations of LMW PAHs in Soil Samples – Ecological PRG Comparison
10. Concentrations of HMW PAHs in Soil Samples – Ecological PRG Comparison

V:\GIS\PROJECTS\2476Y\0001Y\256\F1. EXCEEDANCE_ECO_SO.MXD





CONCENTRATION LEGEND - EA 1, 2, 3, 4, 12, & ISM GRID AREA

SO	ISM	SD	
●	▲	■	LOCATION WITH NO EXCEEDANCES
●	▲	■	LOCATION WITH ONE OR MORE PROTECTIVE SOIL ECO PRG EXCEEDANCE

N

0 1,500'

Title:

EXCEEDANCES OF ECOLOGICAL PRGS IN SOIL SAMPLES

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	F1
Project Mgr: L.J.	Project: 2476.0001Y008	
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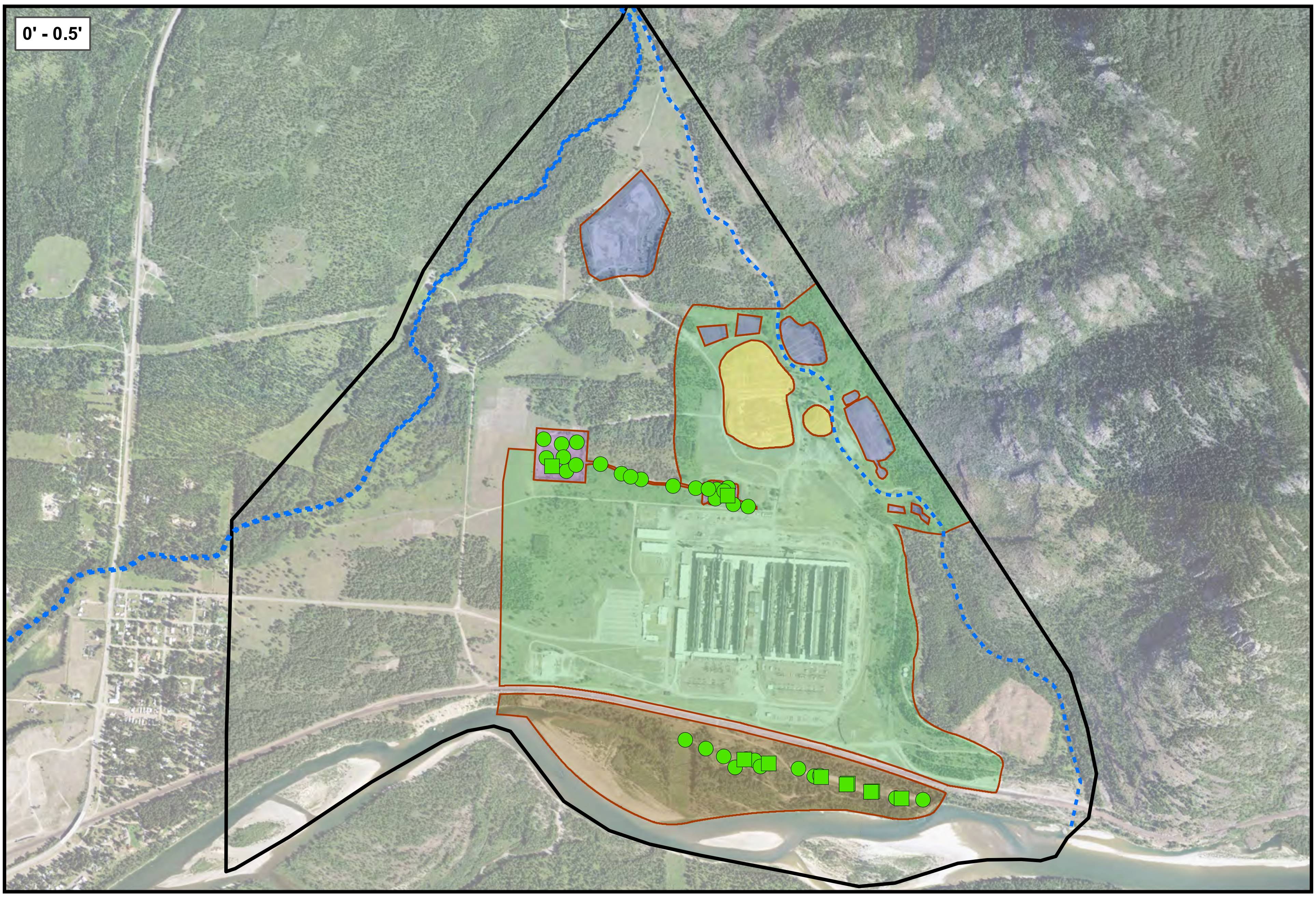

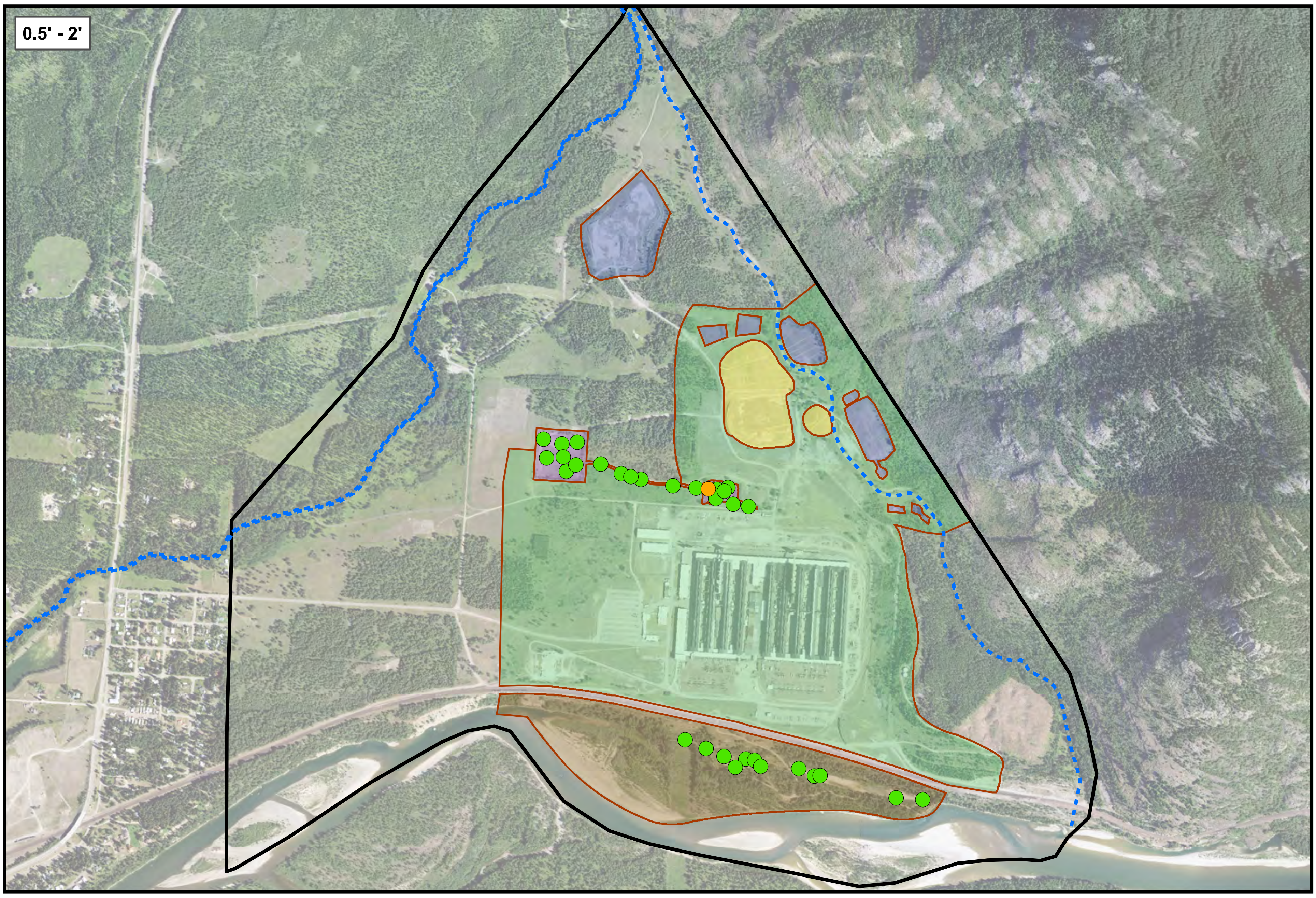

CONCENTRATION LEGEND - EA 2 & 12

SO	ISM	SD	
●	▲	■	ANALYTE NOT DETECTED
●	▲	■	ND - 1,000 (LESS THAN PROTECTIVE SOIL ECO PRG)
●	▲	■	>1,000 (GREATER THAN PROTECTIVE SOIL ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

N

0 1,500'

Title:

CONCENTRATIONS OF BARIUM IN SOIL SAMPLES – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	
Project Mgr: L.J.	Project: 2476.0001Y008	F2
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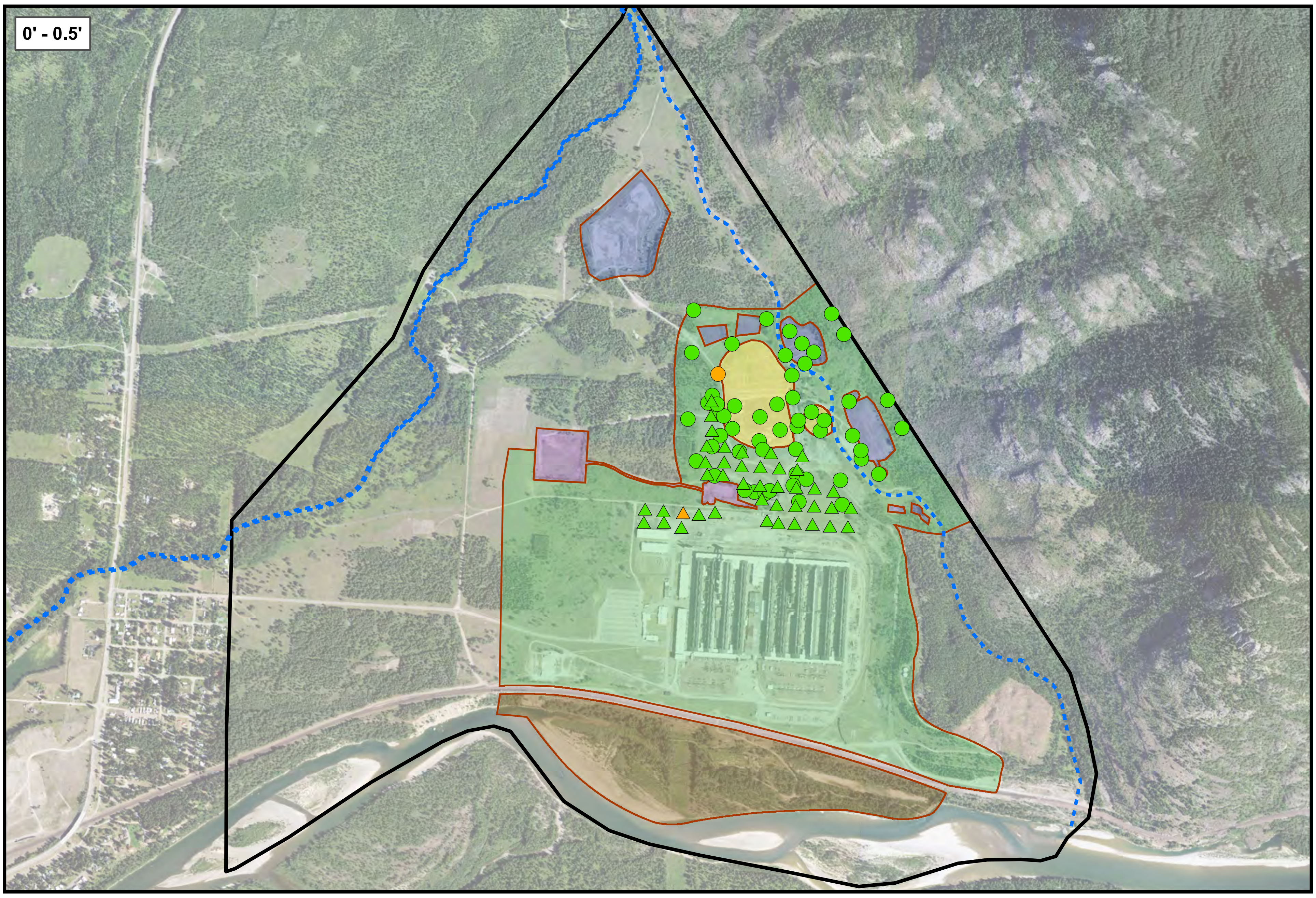

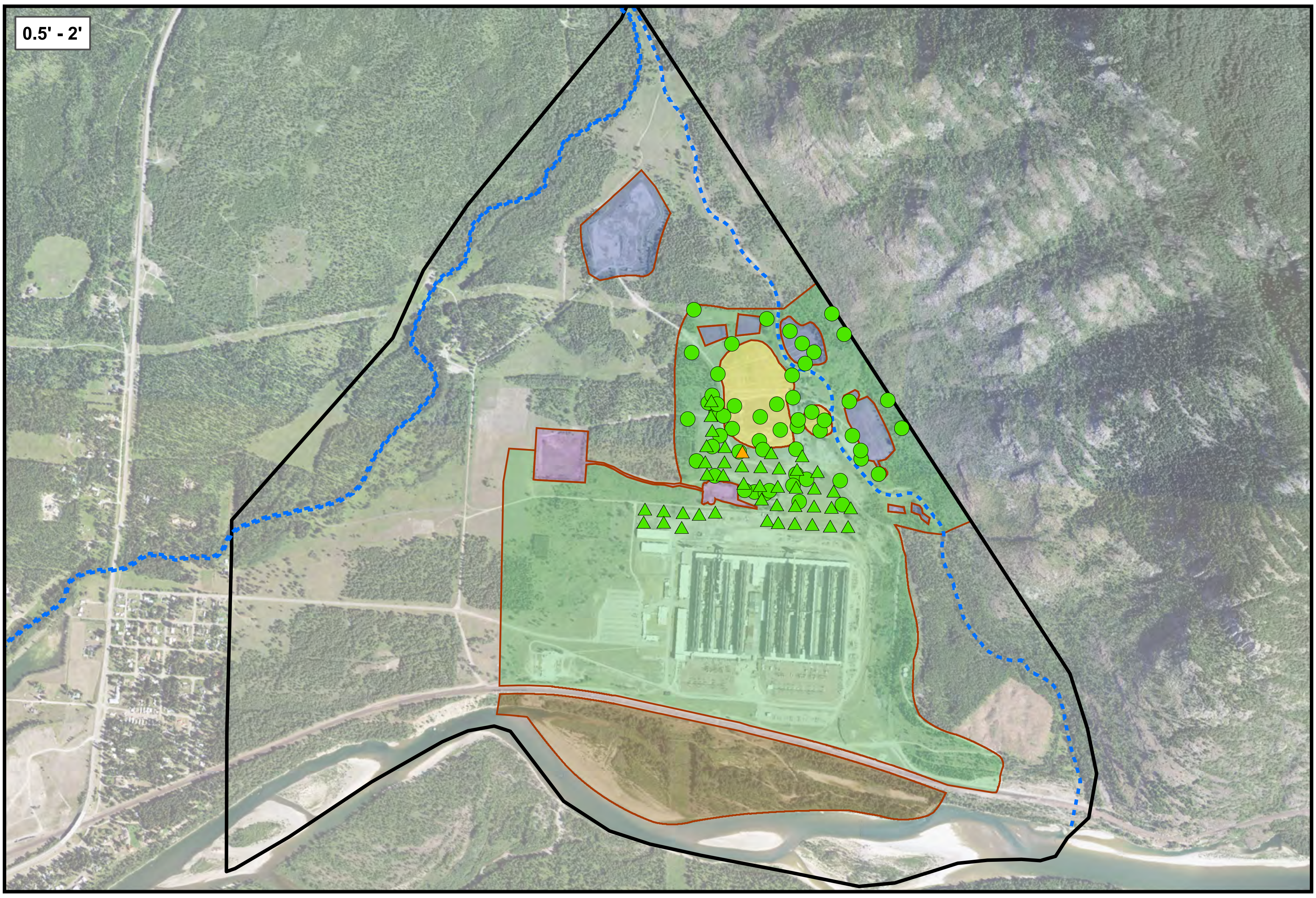

CONCENTRATION LEGEND - EA 3 & ISM GRID AREA

SO	ISM	SD	
●	▲	■	ANALYTE NOT DETECTED
●	▲	■	ND - 490 (LESS THAN PROTECTIVE SOIL ECO PRG)
●	▲	■	>490 (GREATER THAN PROTECTIVE SOIL ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

N

0 1,500'

Title:

CONCENTRATIONS OF COPPER IN SOIL SAMPLES – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/10/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	F3
Project Mgr: L.J.	Project: 2476.0001Y008	
File: F3. Soil_Eco_Copper.mxd		

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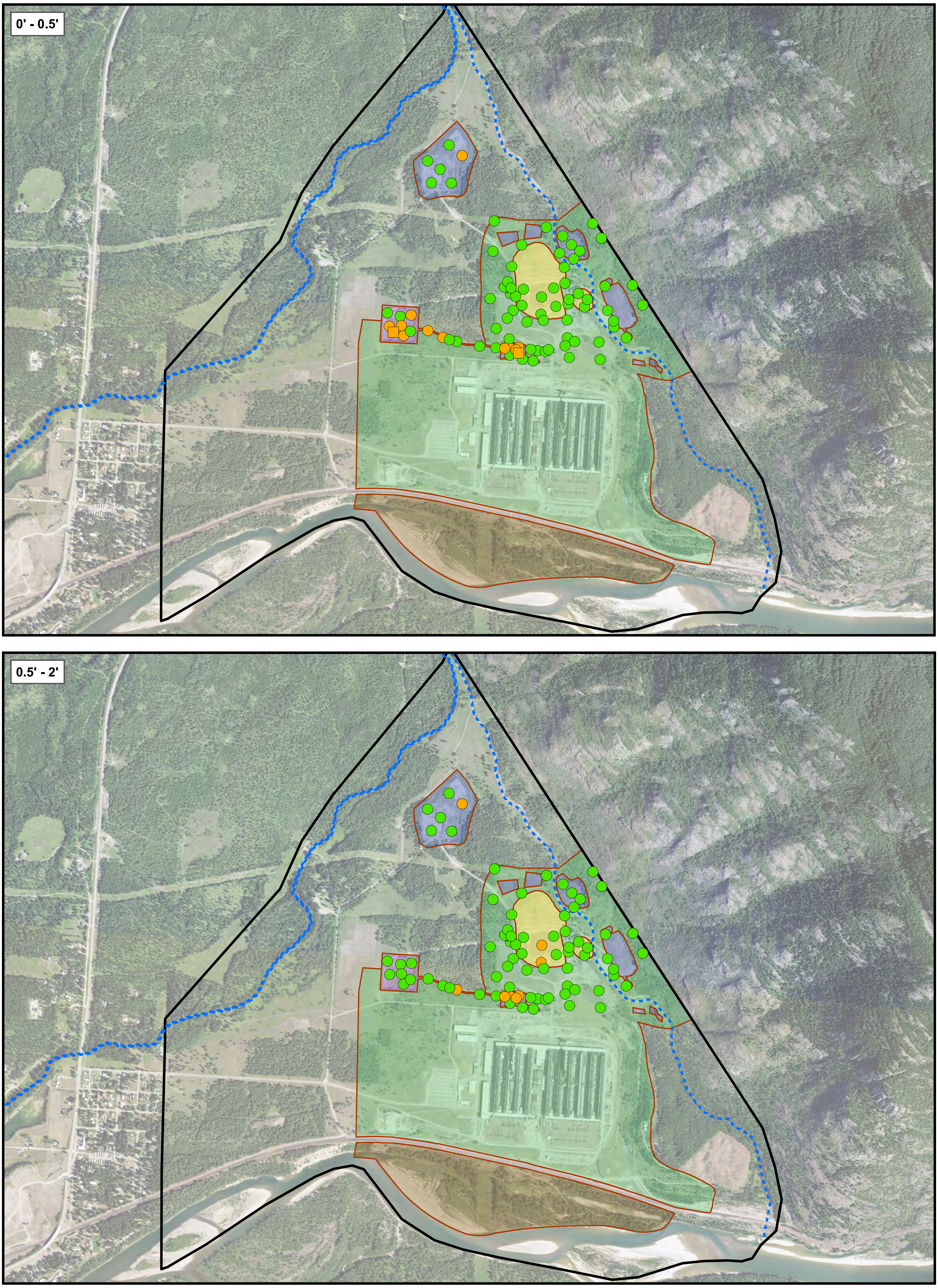

CONCENTRATION LEGEND - EA 2, 3, & 4

SO	ISM	SD	
● (blue)	▲ (blue)	■ (blue)	ANALYTE NOT DETECTED
● (green)	▲ (green)	■ (green)	ND - 140 (LESS THAN PROTECTIVE SOIL ECO PRG)
● (orange)	▲ (orange)	■ (orange)	>140 (GREATER THAN PROTECTIVE SOIL ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

N

0 1,500'

Title:

CONCENTRATIONS OF NICKEL IN SOIL SAMPLES – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/10/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	F4
Project Mgr: L.J.	Project: 2476.0001Y008	
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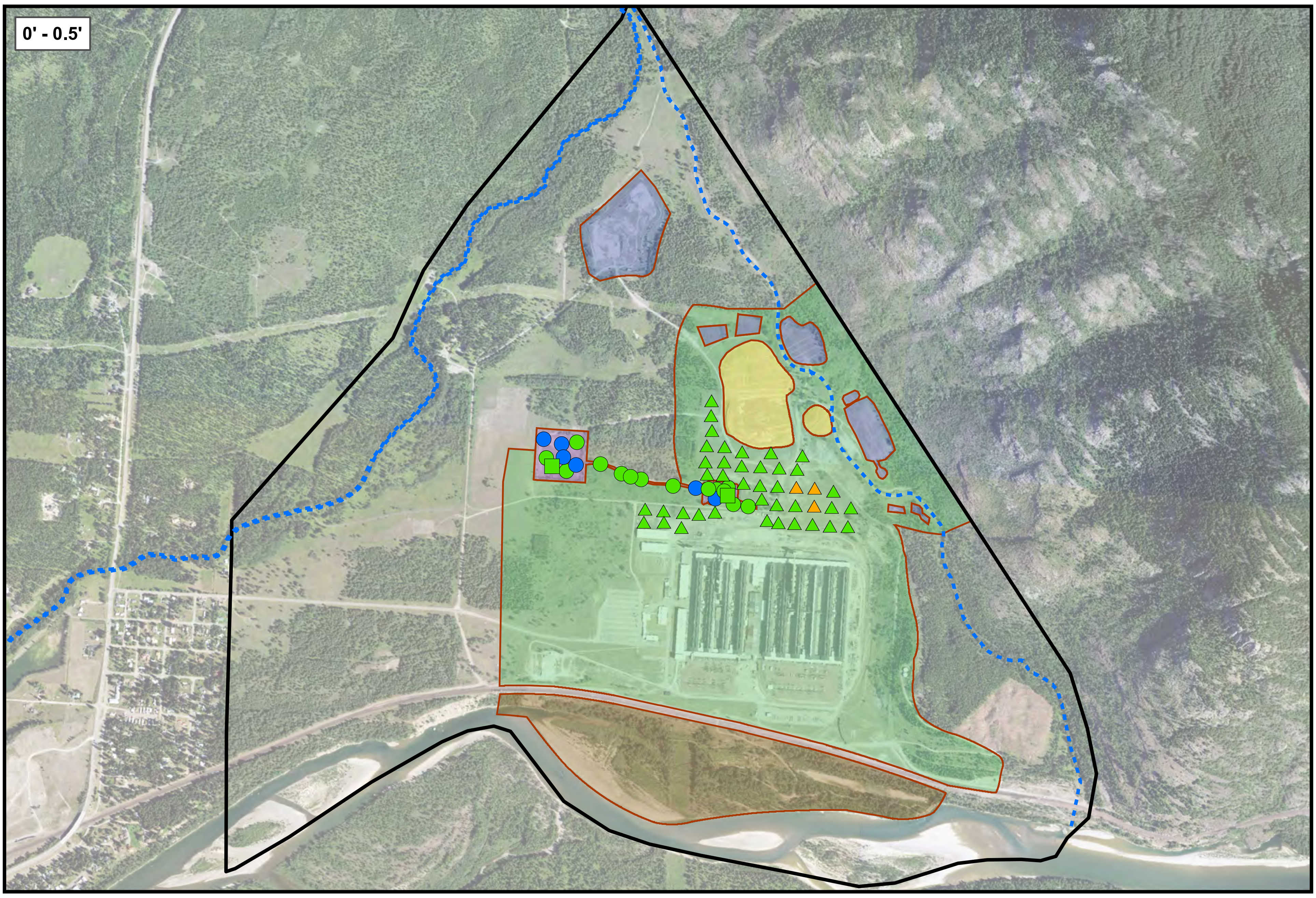

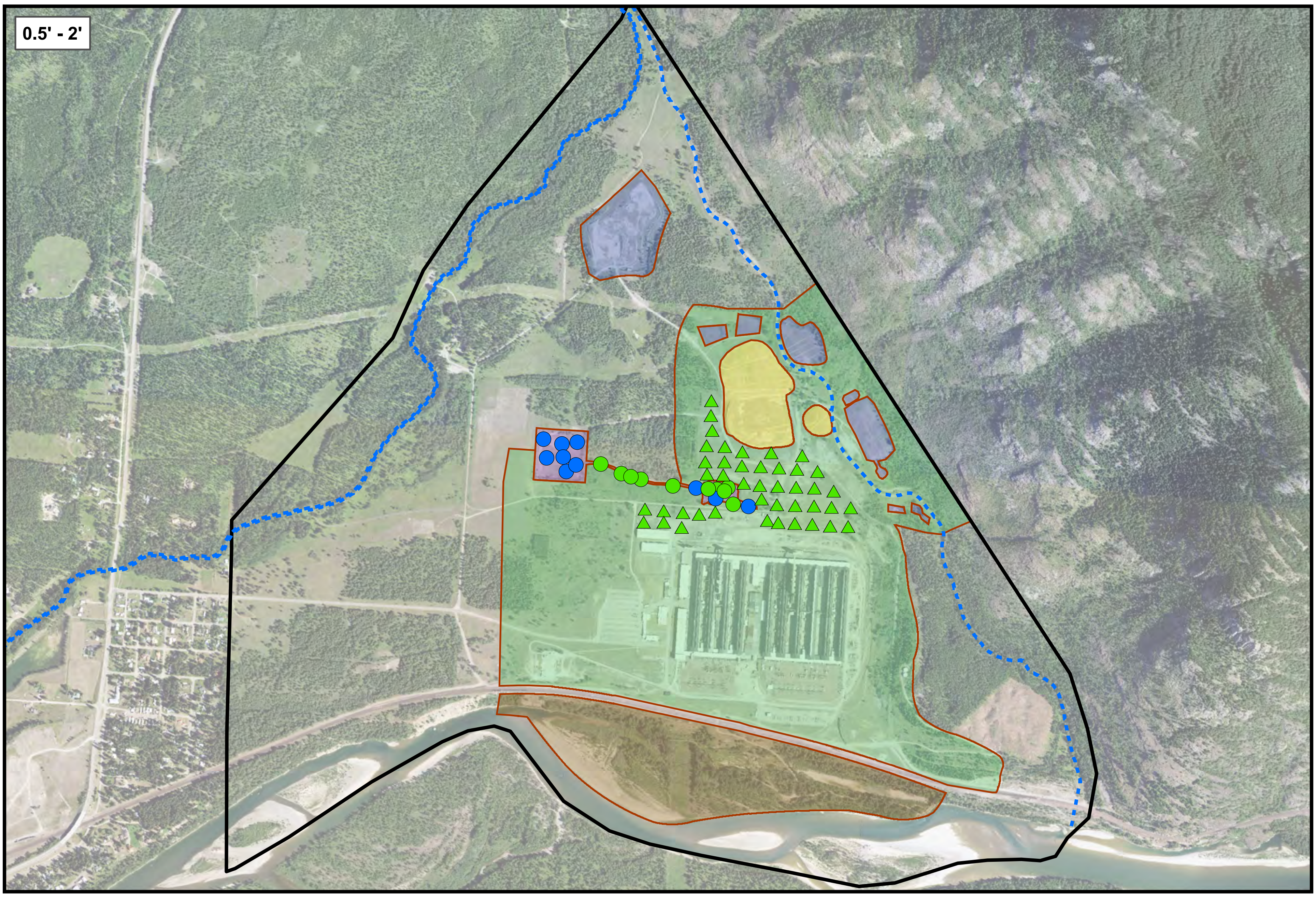

CONCENTRATION LEGEND - EA 2 & ISM GRID AREA

SO	ISM	SD	
● (blue)	▲ (blue)	■ (blue)	ANALYTE NOT DETECTED
● (green)	▲ (green)	■ (green)	ND - 3.4 (LESS THAN PROTECTIVE SOIL ECO PRG)
● (orange)	▲ (orange)	■ (orange)	>3.4 (GREATER THAN PROTECTIVE SOIL ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

N

0 1,500'

Title:

CONCENTRATIONS OF SELENIUM IN SOIL SAMPLES – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	F5
Project Mgr: L.J.	Project: 2476.0001Y008	
File: F5. Soil_Eco_Selenium.mxd		

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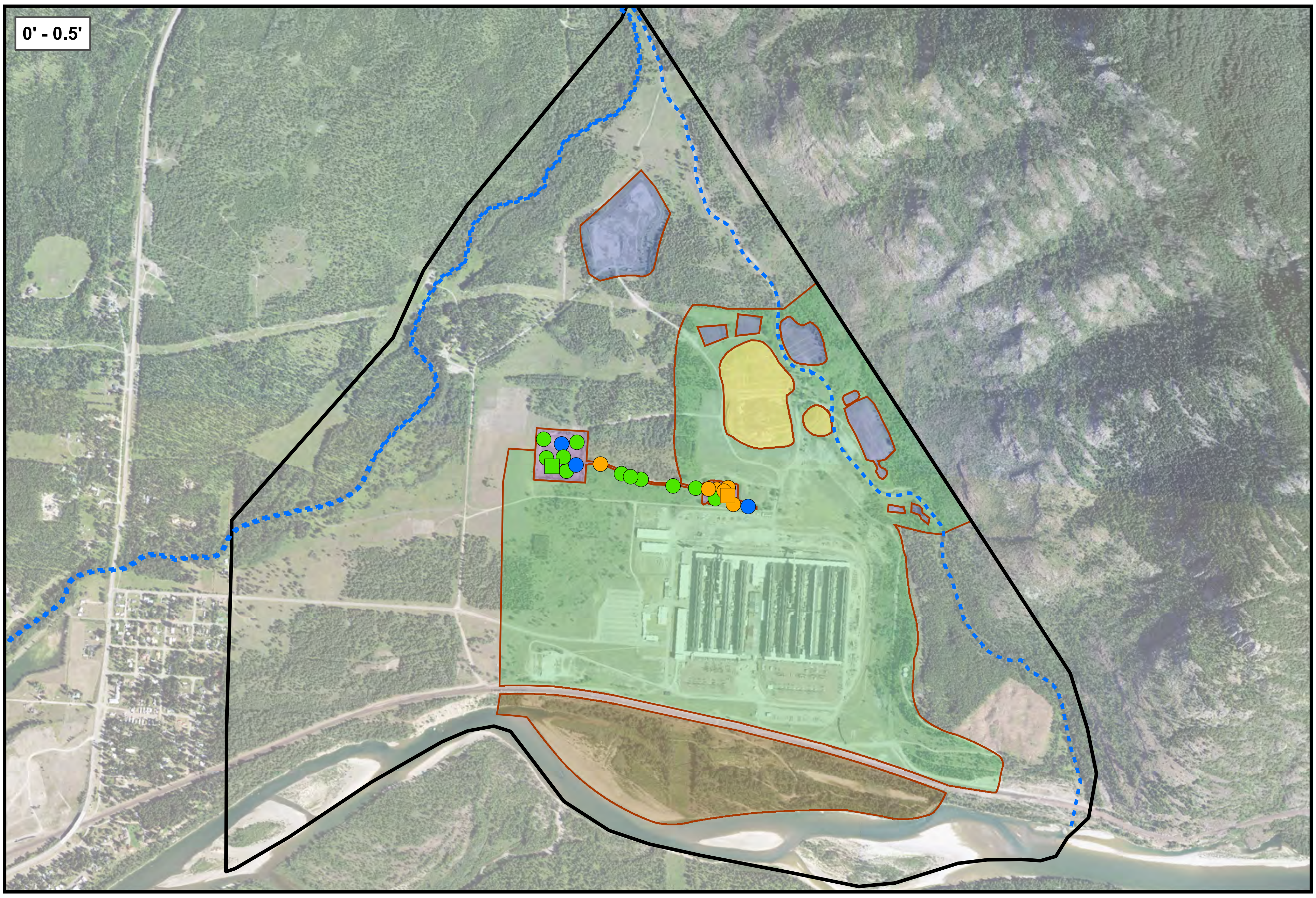
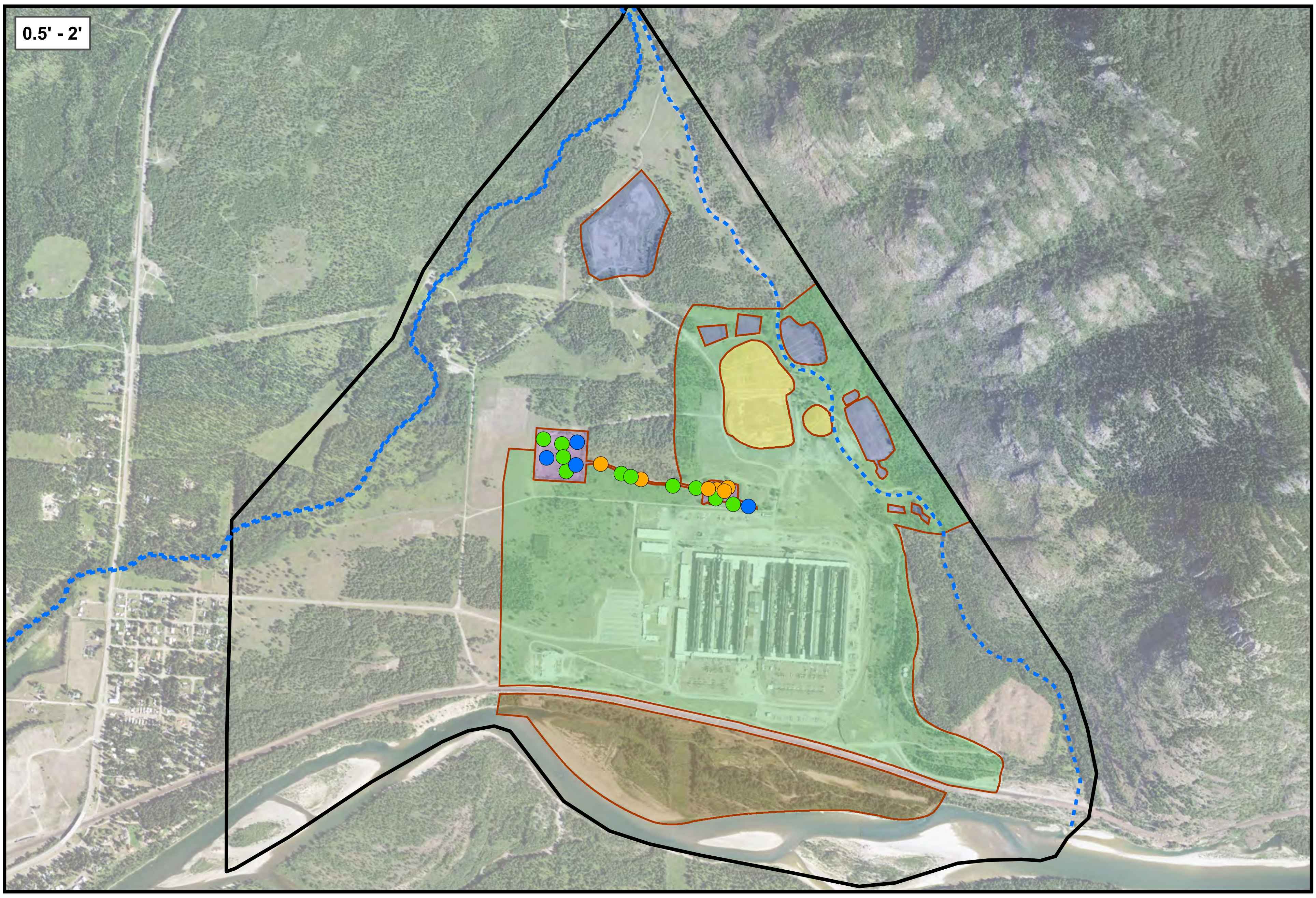




CONCENTRATION LEGEND - EA 2

SO	ISM	SD	
● (blue)	▲ (blue)	■ (blue)	ANALYTE NOT DETECTED
● (green)	▲ (green)	■ (green)	ND - 0.5 (LESS THAN PROTECTIVE SOIL ECO PRG)
● (orange)	▲ (orange)	■ (orange)	>0.5 (GREATER THAN PROTECTIVE SOIL ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

N

0 1,500'

Title:

CONCENTRATIONS OF THALLIUM IN SOIL SAMPLES – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

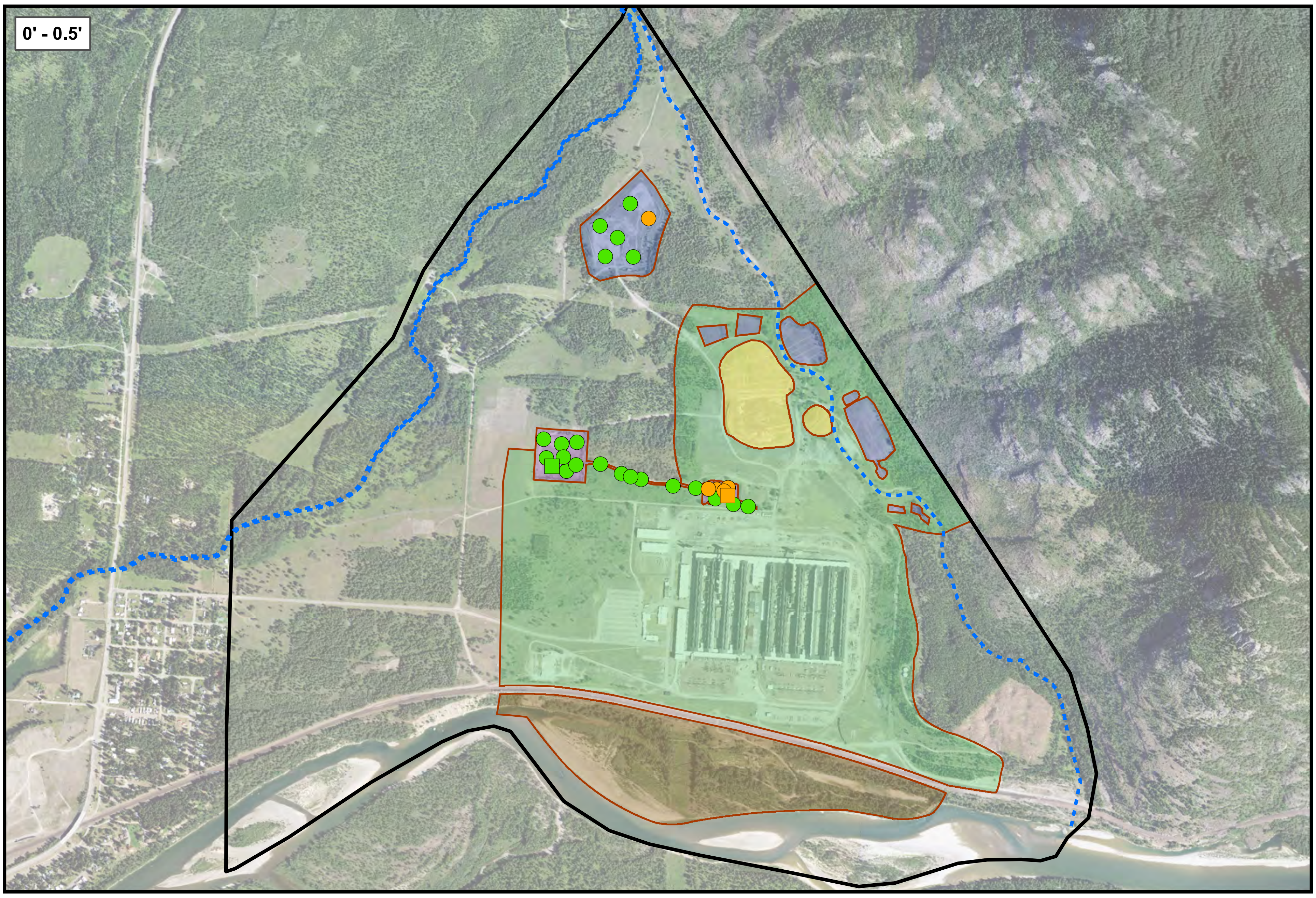
Prepared for:

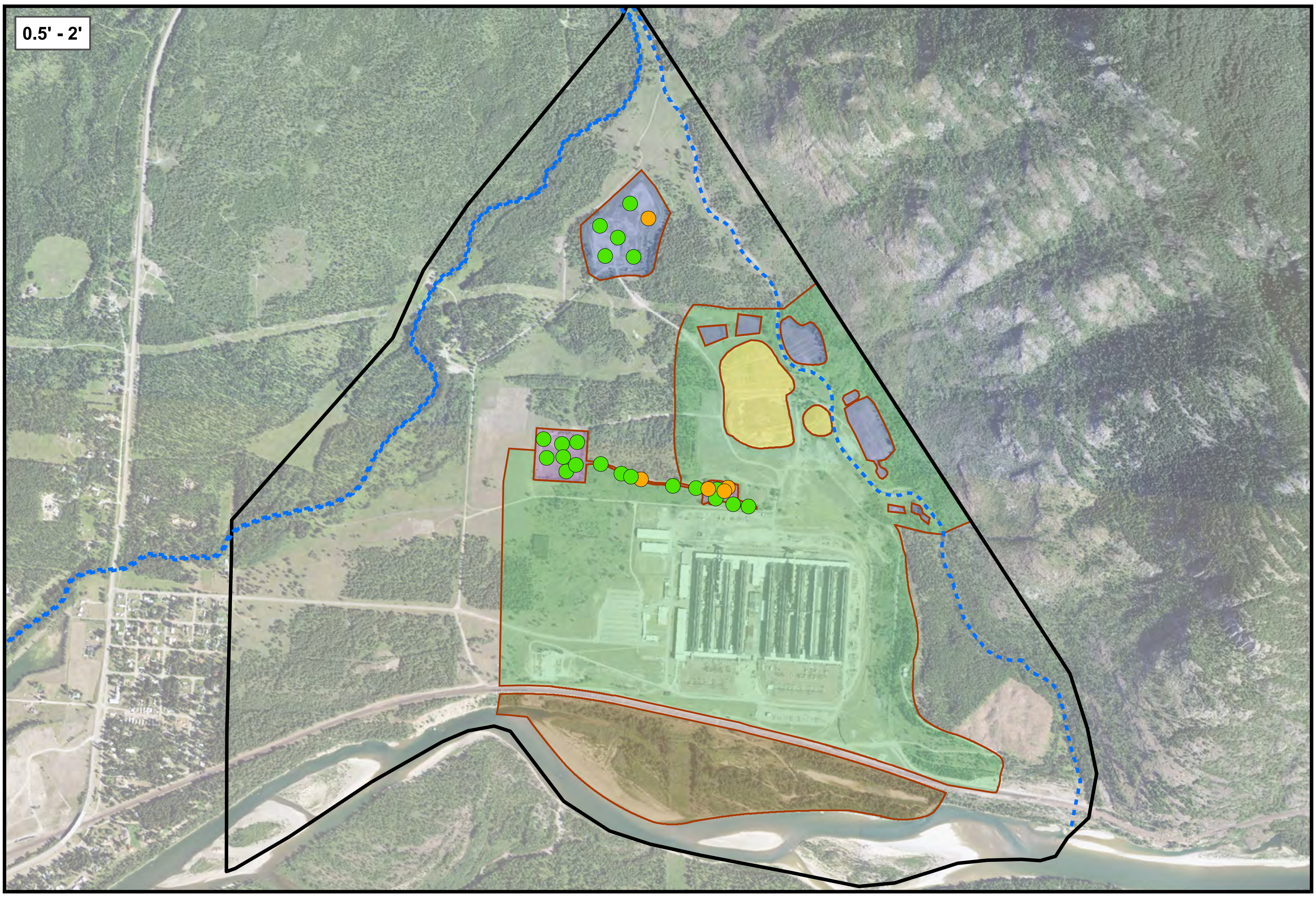
COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	
Project Mgr: L.J.	Project: 2476.0001Y008	F6
File: F6. Soil_Eco_Thallium.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\F7. SOIL_ECO_VANADIUM.MXD





CONCENTRATION LEGEND - EA 2 & 4

SO	ISM	SD	
●	▲	■	ANALYTE NOT DETECTED
●	▲	■	ND - 80 (LESS THAN PROTECTIVE SOIL ECO PRG)
●	▲	■	>80 (GREATER THAN PROTECTIVE SOIL ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

0 1,500'

N

Title:

CONCENTRATIONS OF VANADIUM IN SOIL SAMPLES – ECOLOGICAL PRG COMPARISON

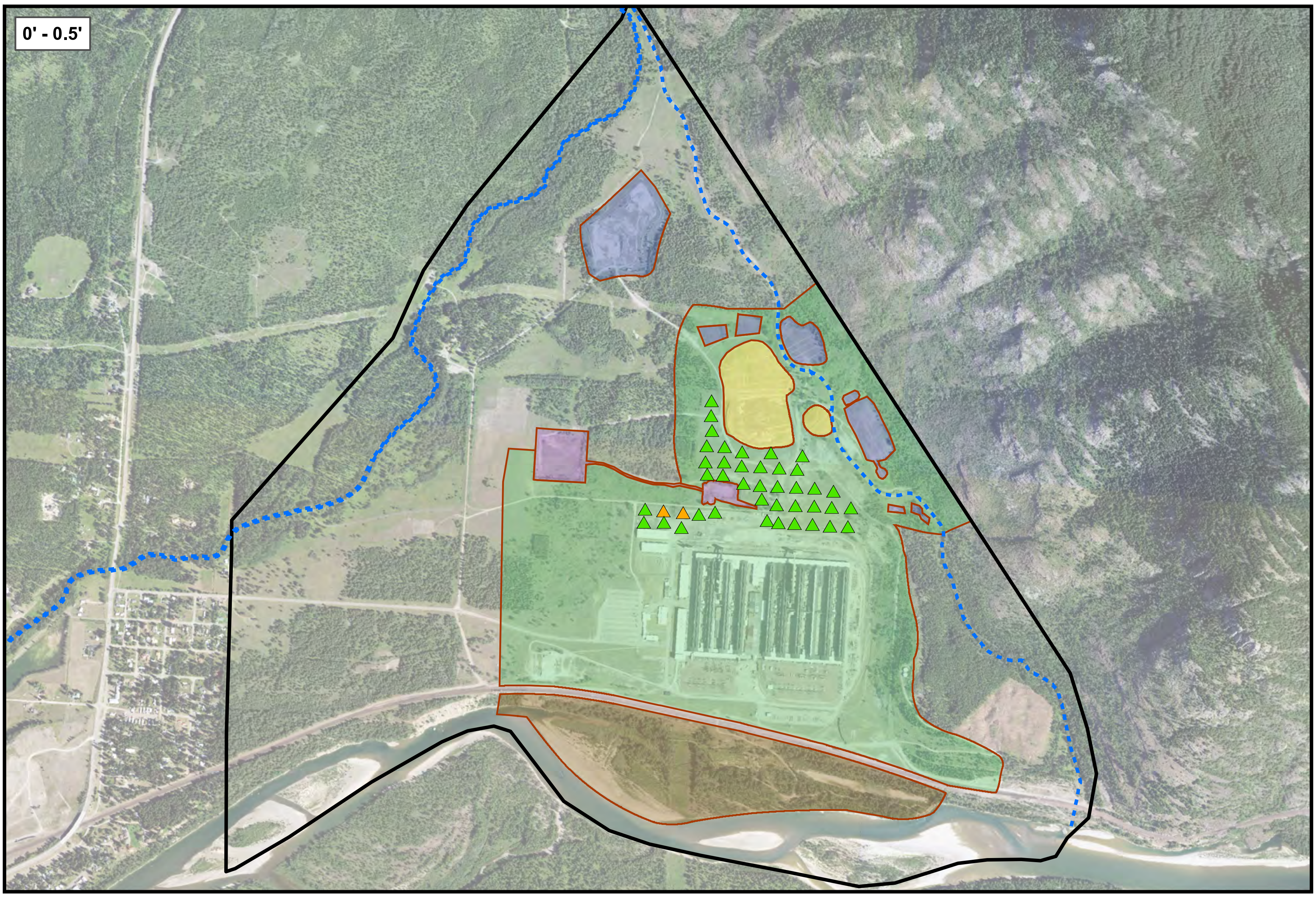
2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

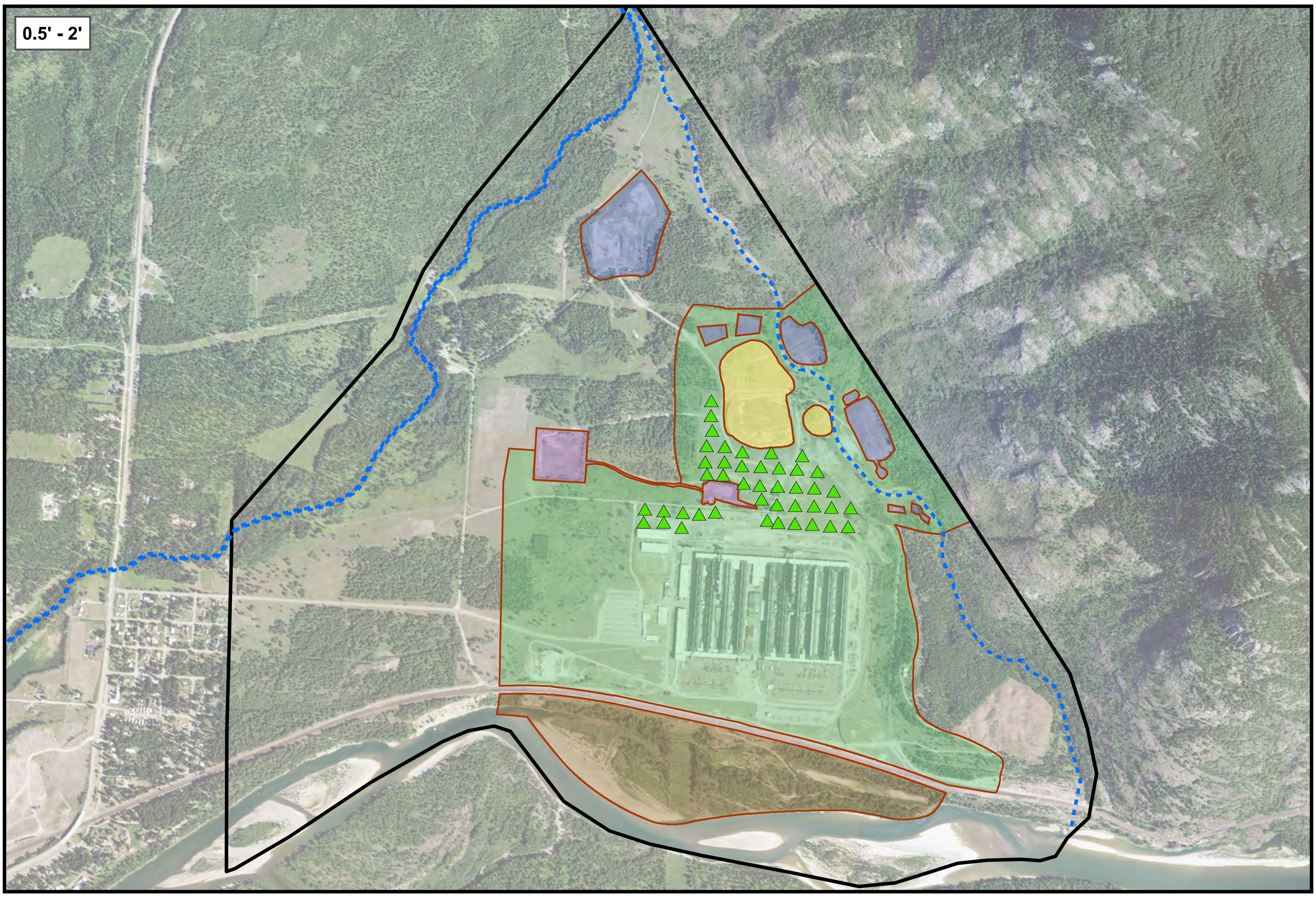
Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/10/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	
Project Mgr: L.J.	Project: 2476.0001Y008	F7
File: F7. Soil_Eco_Vanadium.mxd		





CONCENTRATION LEGEND - ISM GRID AREA

SO	ISM	SD	
●	▲	■	ANALYTE NOT DETECTED
●	▲	■	ND - 810 (LESS THAN PROTECTIVE SOIL ECO PRG)
●	▲	■	>810 (GREATER THAN PROTECTIVE SOIL ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

N

0 1,500'

Title:

CONCENTRATIONS OF ZINC IN SOIL SAMPLES – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

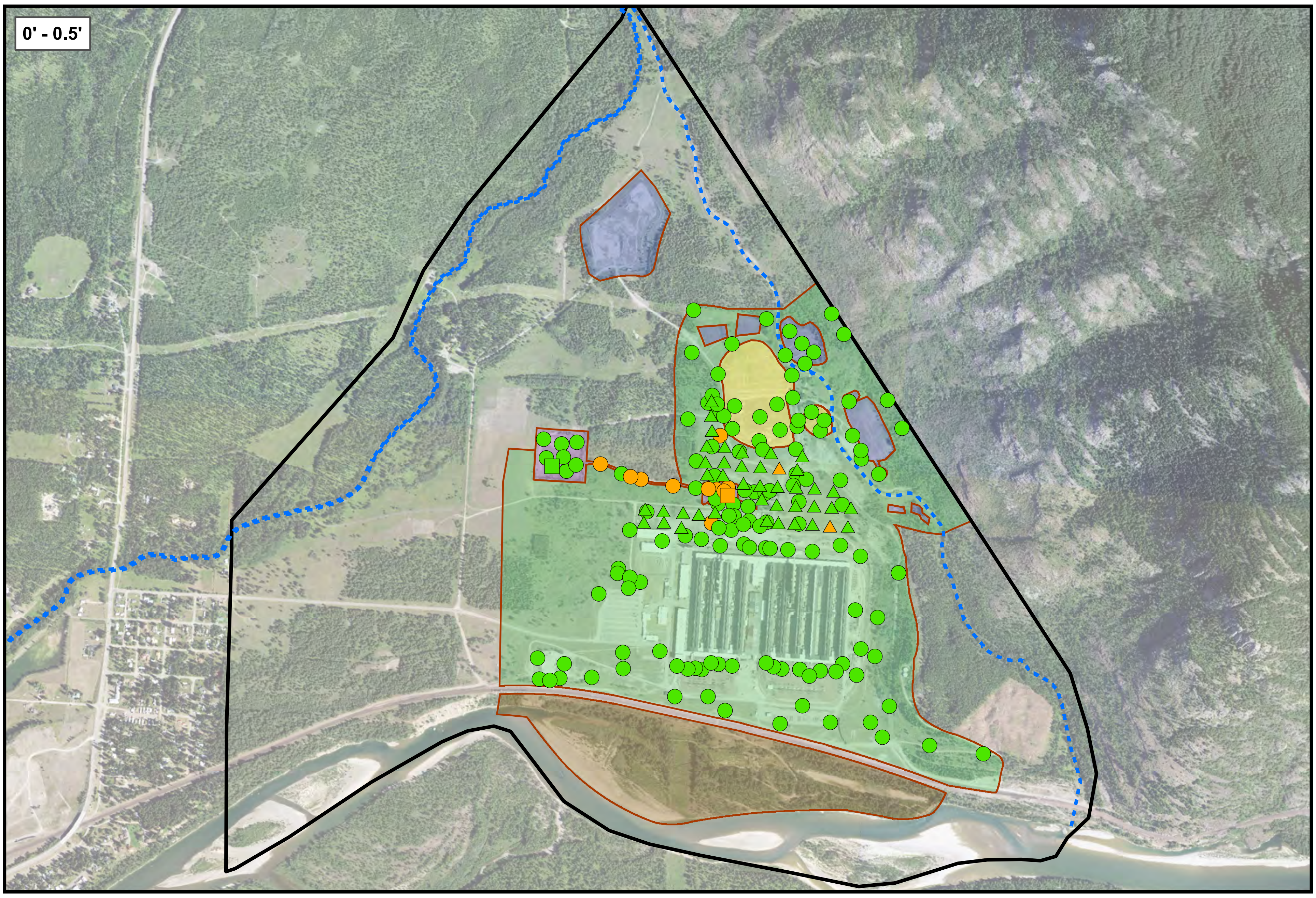
Prepared for:

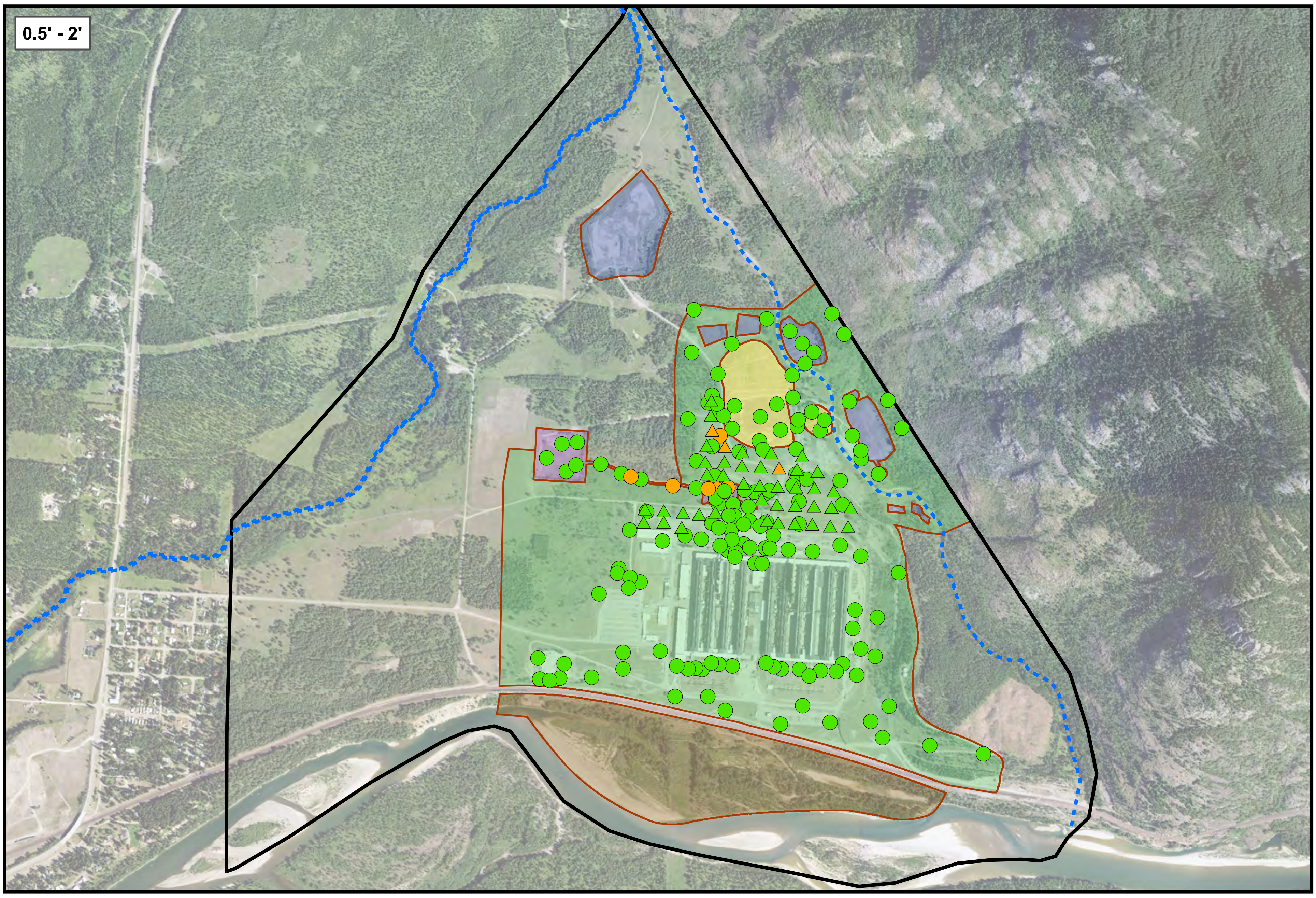
COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/10/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	
Project Mgr: L.J.	Project: 2476.0001Y008	F8
File: F8. Soil_Eco_Zinc.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\F9. SOIL_ECO_LMW_PAHS.MXD





CONCENTRATION LEGEND - EA 1, 2, 3, & ISM GRID AREA

SO	ISM	SD	
● (blue)	▲ (blue)	■ (blue)	ANALYTE NOT DETECTED
● (green)	▲ (green)	■ (green)	ND - 175 (LESS THAN PROTECTIVE SOIL ECO PRG)
● (orange)	▲ (orange)	■ (orange)	>175 (GREATER THAN PROTECTIVE SOIL ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

N

0 1,500'

Title:

CONCENTRATIONS OF LMW PAHS IN SOIL SAMPLES – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

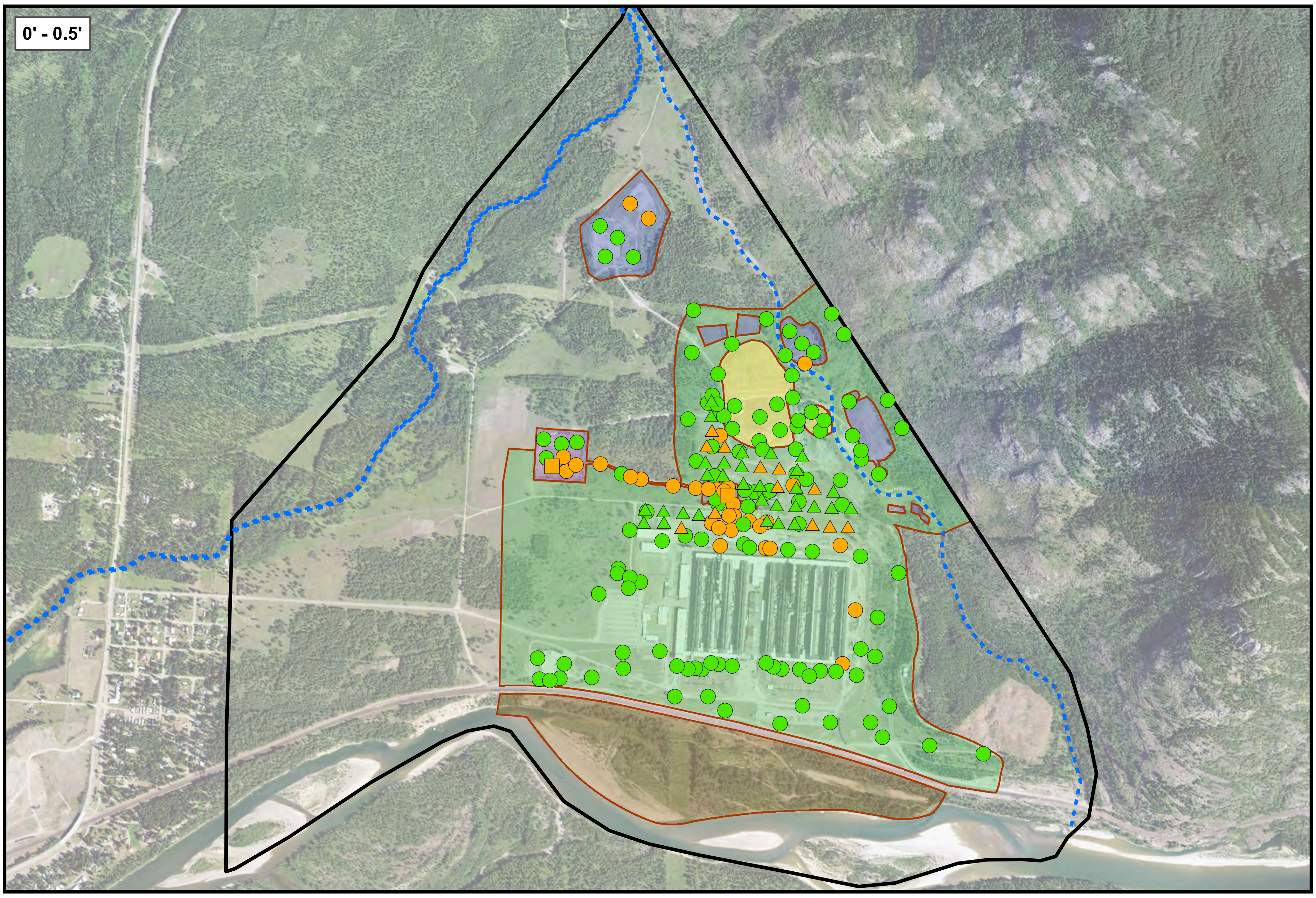
Prepared for:

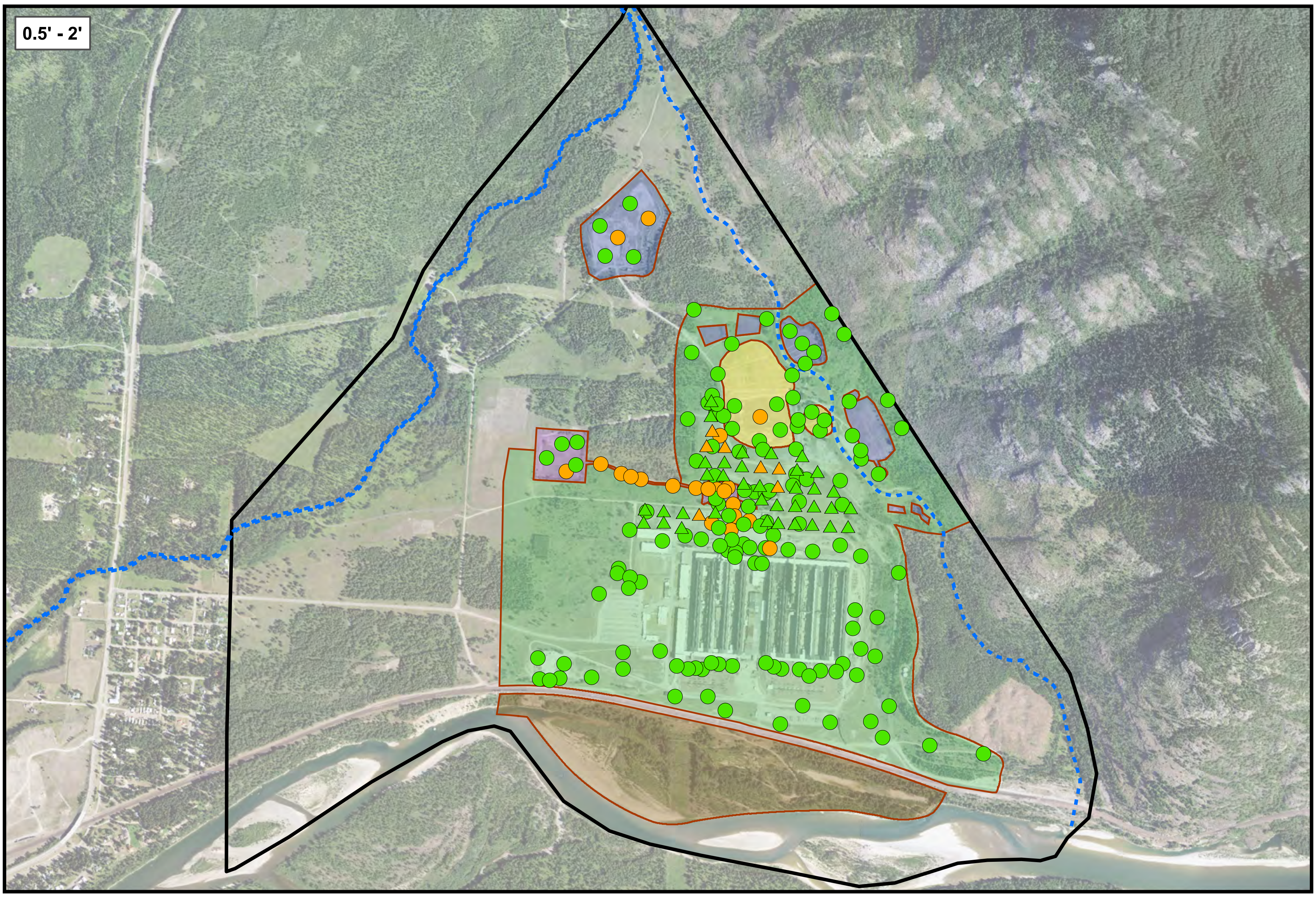
COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/10/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	F9
Project Mgr: L.J.	Project: 2476.0001Y008	
File: F9. Soil_Eco_LMW_PAHs.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\F10. SOIL_ECO_HMW_PAHS.MXD





CONCENTRATION LEGEND - EA 1, 2, 3, 4, & ISM GRID AREA

SO	ISM	SD	
●	▲	■	ANALYTE NOT DETECTED
●	▲	■	ND - 69 (LESS THAN PROTECTIVE SOIL ECO PRG)
●	▲	■	>69 (GREATER THAN PROTECTIVE SOIL ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

N

0 1,500'

Title:

CONCENTRATIONS OF HMW PAHS IN SOIL SAMPLES – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

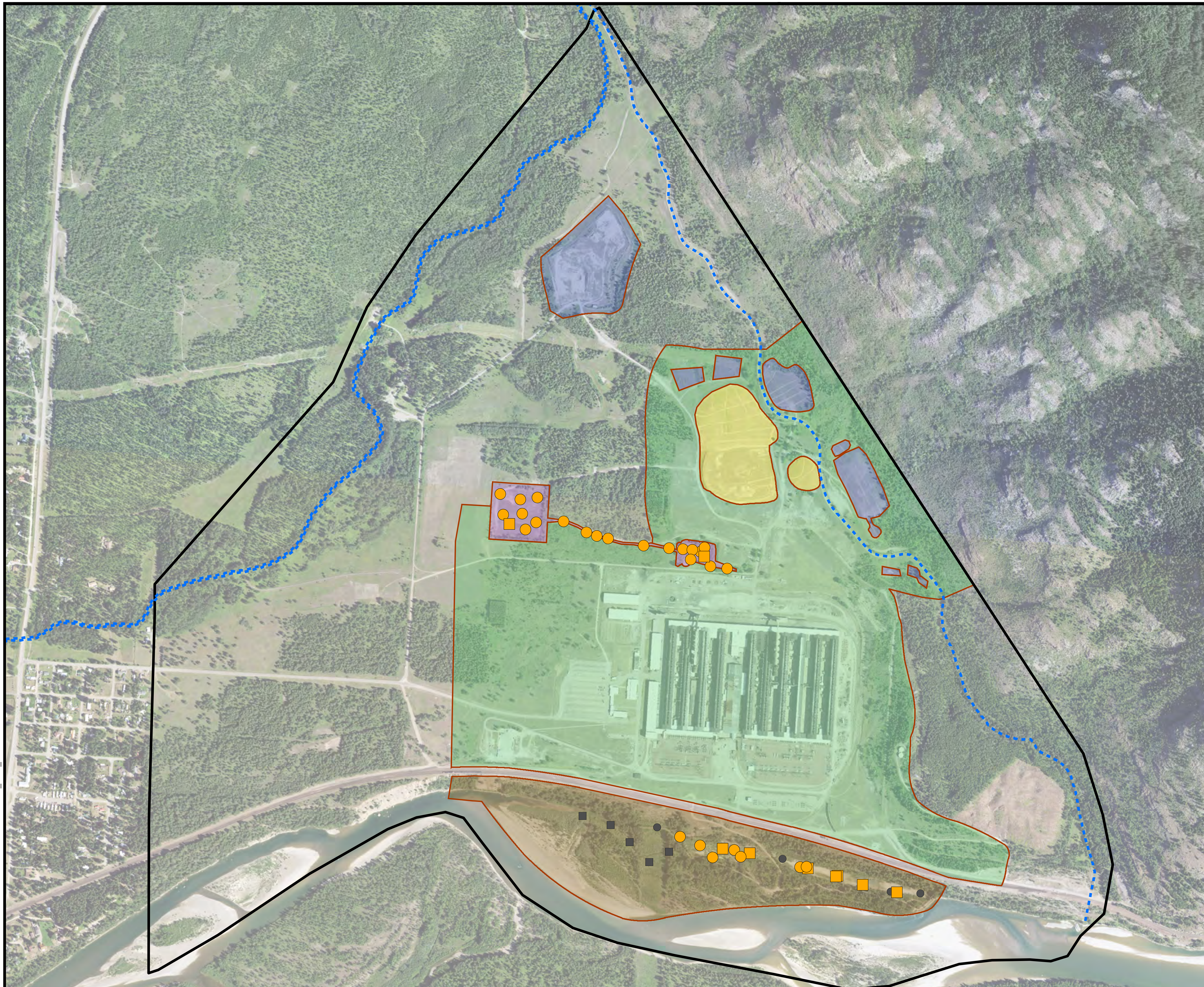
ROUX

Compiled by: C.S.	Date: 03/10/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	F10
Project Mgr: L.J.	Project: 2476.0001Y008	
File: F10. Soil_Eco_HMW_PAHs.mxd		

APPENDIX G

Ecological PRG Comparison – Sediment Thematic Maps

1. Exceedances of Ecological PRGs in Sediment Samples
2. Concentrations of Barium in Sediment – Ecological PRG Comparison
3. Concentrations of Cadmium in Sediment – Ecological PRG Comparison
4. Concentrations of Lead in Sediment – Ecological PRG Comparison
5. Concentrations of Nickel in Sediment – Ecological PRG Comparison
6. Concentrations of Selenium in Sediment – Ecological PRG Comparison
7. Concentrations of Vanadium in Sediment – Ecological PRG Comparison
8. Concentrations of Zinc in Sediment – Ecological PRG Comparison
9. Concentrations of LMW PAHs in Sediment – Ecological PRG Comparison
10. Concentrations of HMW PAHs in Sediment – Ecological PRG Comparison



LEGEND - EA 2, 8, & 12

SO	SD	
●	■	LOCATION WITH NO EXCEEDANCES
●	■	LOCATION WITH ONE OR MORE EXCEEDANCES OF A PROTECTIVE SOIL ECO PRG

N

1,000 0 1,000'

Title:

EXCEEDANCES OF ECOLOGICAL PRGS IN SEDIMENT SAMPLES

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

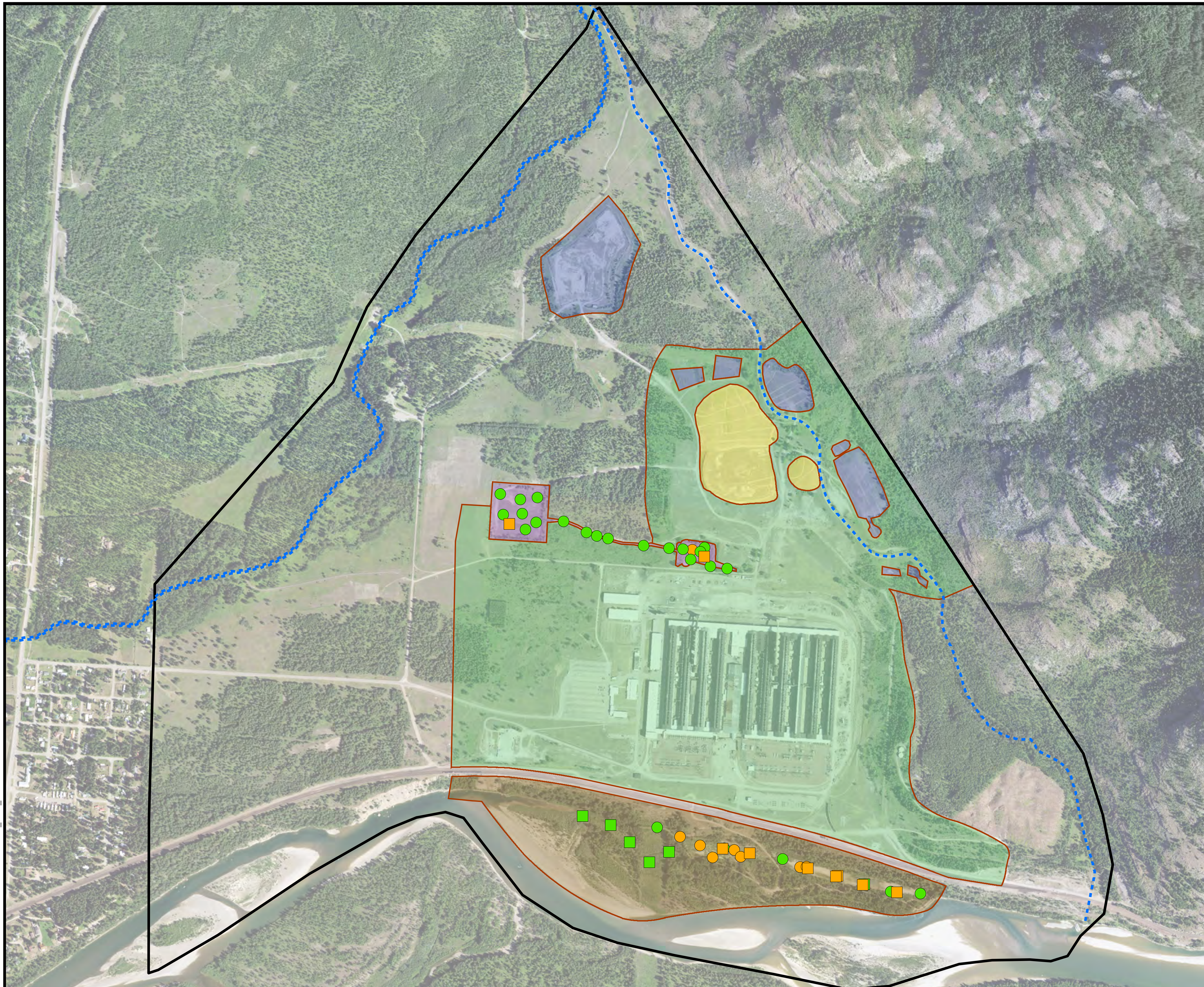
Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	
Project Mgr: L.J.	Project: 2476.0001Y008	G1
File: G1. Exceedance_Eco_Sed.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\G1. EXCEEDANCE_ECO_SED.MXD



N

CONCENTRATION LEGEND - EA 2, 8, & 12

SO	SD	
●	■	ANALYTE NOT DETECTED
●	■	ND - 300 (LESS THAN PROTECTIVE SEDIMENT ECO PRG)
●	■	>300 (GREATER THAN PROTECTIVE SEDIMENT ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

1,000 0 1,000'

Title:

CONCENTRATIONS OF BARIUM IN SEDIMENT – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	G2
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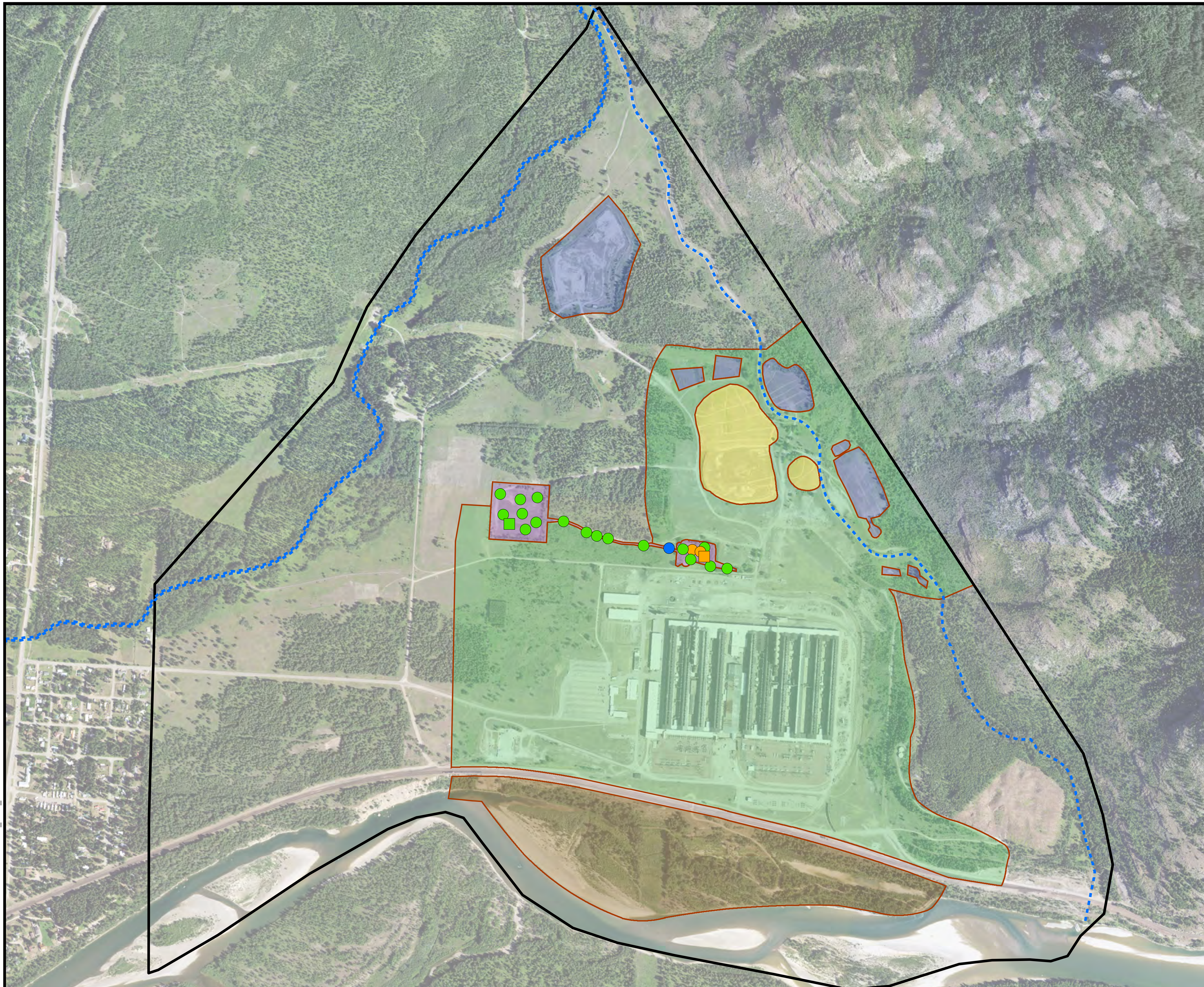


V:\GIS\PROJECTS\2476Y\0001Y\256\G3. SED_ECO_CADMIUM.MXD

Title:

CONCENTRATIONS OF CADMIUM IN SEDIMENT – ECOLOGICAL PRG COMPARISON

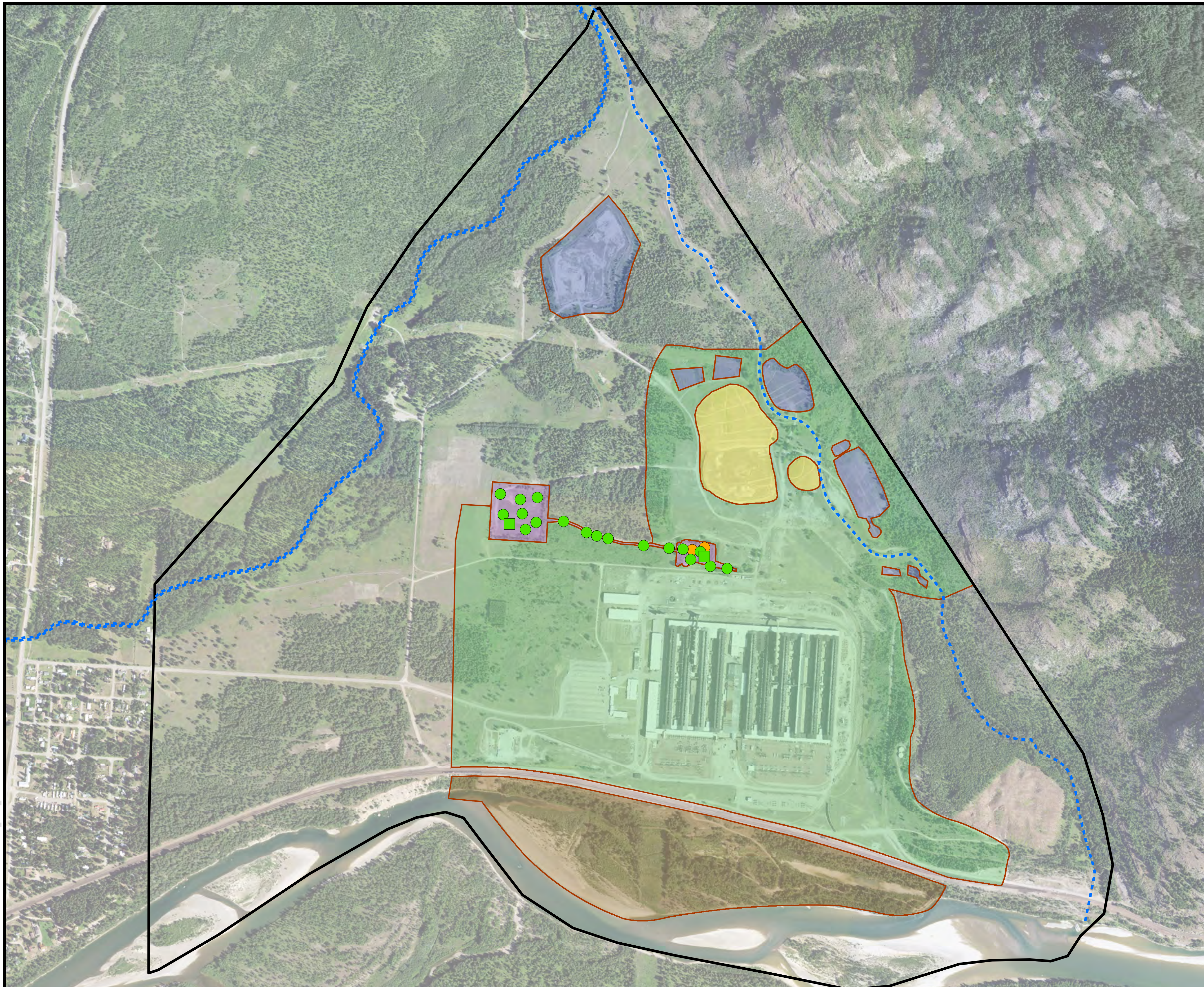
2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	G3
Project Mgr: L.J.	Project: 2476.0001Y008	
File: G3. Sed_Eco_Cadmium.mxd		



V:\GIS\PROJECTS\2476Y\0001Y\256\G4. SED_ECO_LEAD.MXD

CONCENTRATION LEGEND - EA 2

SO	SD	
●	■	ANALYTE NOT DETECTED
●	■	ND - 120 (LESS THAN PROTECTIVE SEDIMENT ECO PRG)
●	■	>120 (GREATER THAN PROTECTIVE SEDIMENT ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

N

1,000 0 1,000'

Title:

CONCENTRATIONS OF LEAD IN SEDIMENT – ECOLOGICAL PRG COMPARISON

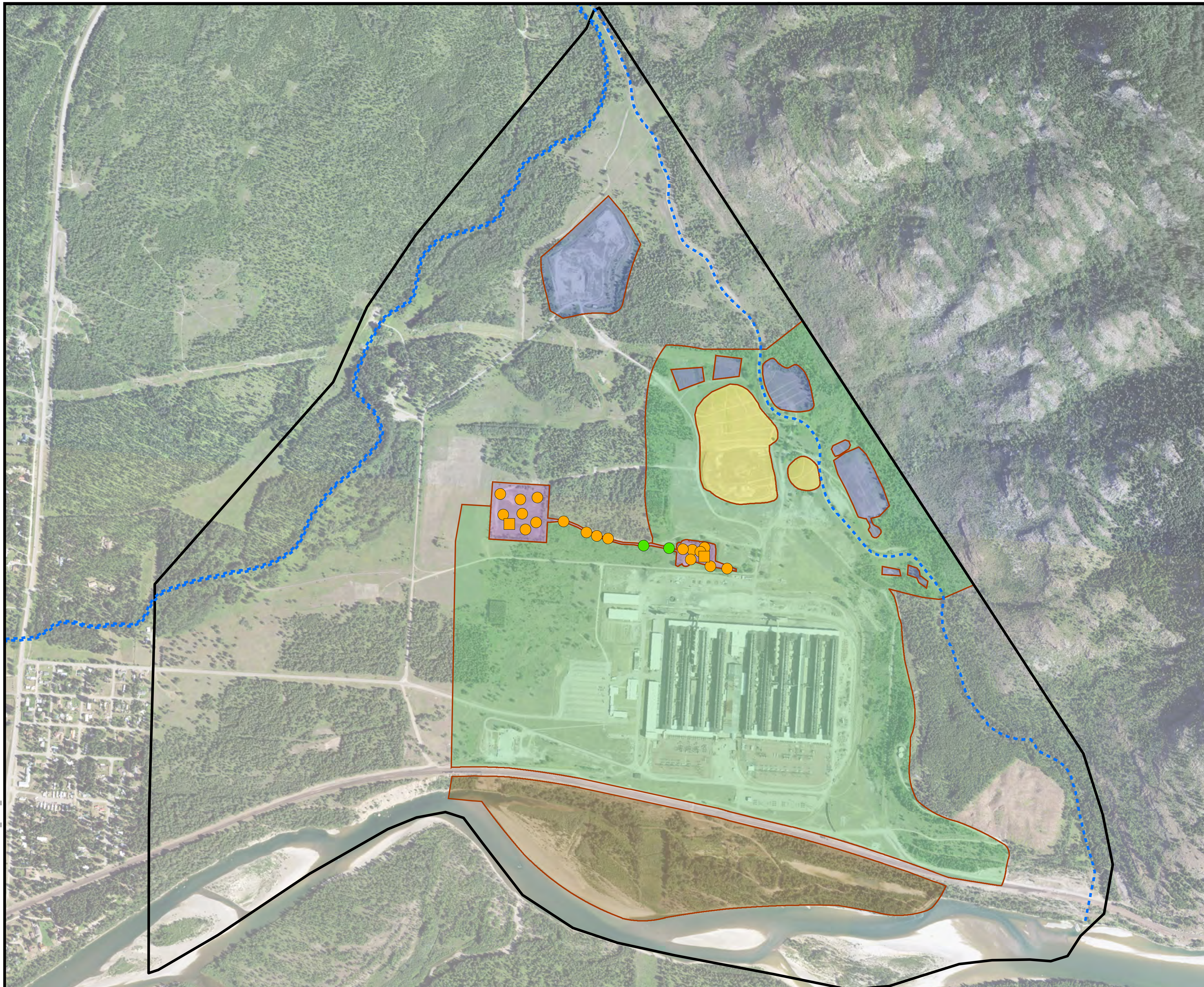
2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	
Project Mgr: L.J.	Project: 2476.0001Y008	G4
File: G4. Sed_Eco_Lead.mxd		



N

CONCENTRATION LEGEND - EA 2

SO SD

ANALYTE NOT DETECTED

ND - 48 (LESS THAN PROTECTIVE SEDIMENT ECO PRG)

>48 (GREATER THAN PROTECTIVE SEDIMENT ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

1,000 0 1,000'

Title:

CONCENTRATIONS OF NICKEL IN SEDIMENT – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX	
Prepared by: M.S.R.	Scale: AS SHOWN		G5
Project Mgr: L.J.	Project: 2476.0001Y008		
File: G5. Sed_Eco_Nickel.mxd			

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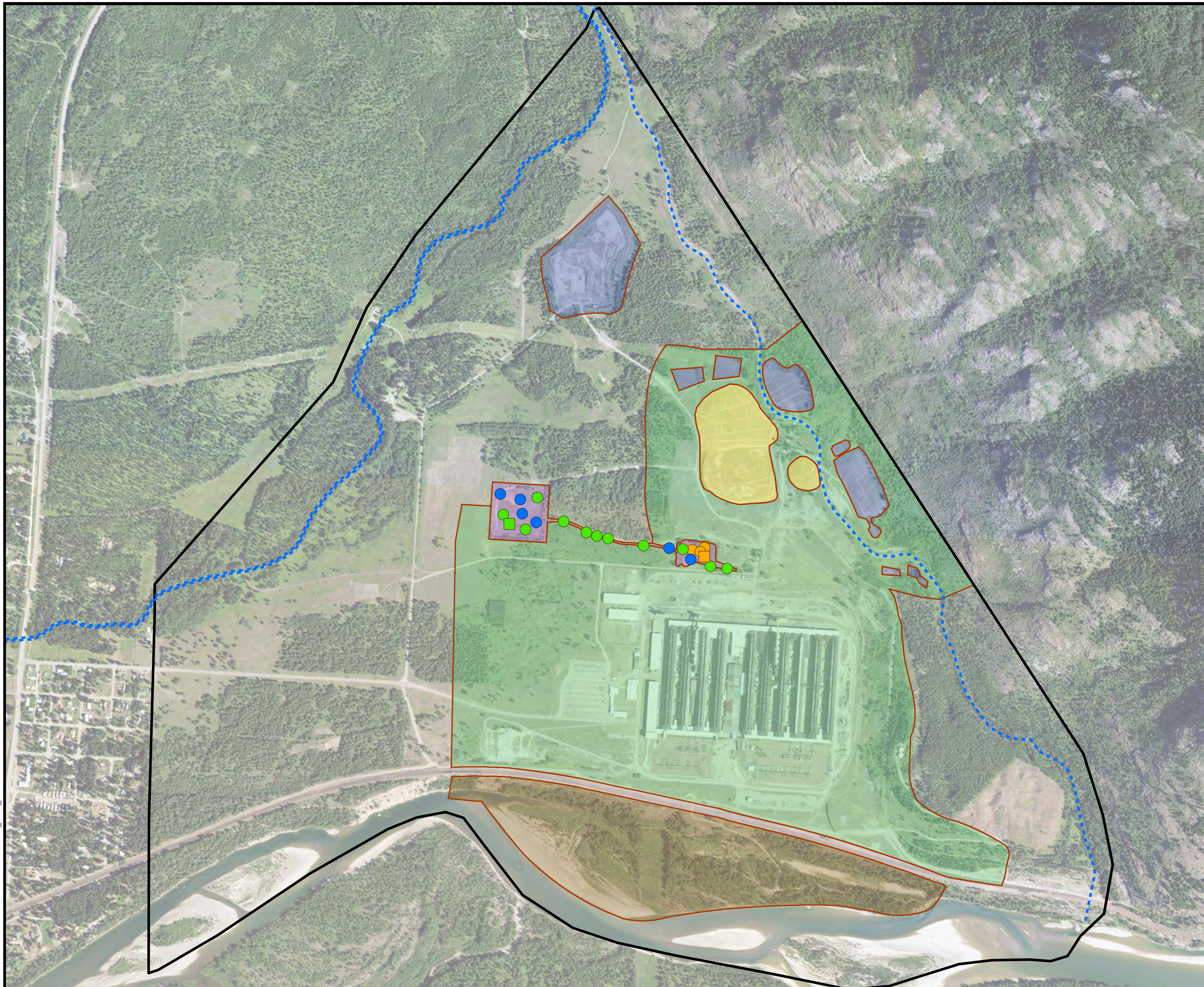

N

CONCENTRATION LEGEND - EA 2

SO	SD	
● (blue)	■ (blue)	ANALYTE NOT DETECTED
● (green)	■ (green)	ND - 1.38 (LESS THAN PROTECTIVE SEDIMENT ECO PRG)
● (orange)	■ (orange)	>1.38 (GREATER THAN PROTECTIVE SEDIMENT ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

1,000 0 1,000'

Title:

CONCENTRATIONS OF SELENIUM IN SEDIMENT – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	G6
Project Mgr: L.J.	Project: 2476.0001Y008	
File: G6. Sed_Eco_Selenium.mxd		

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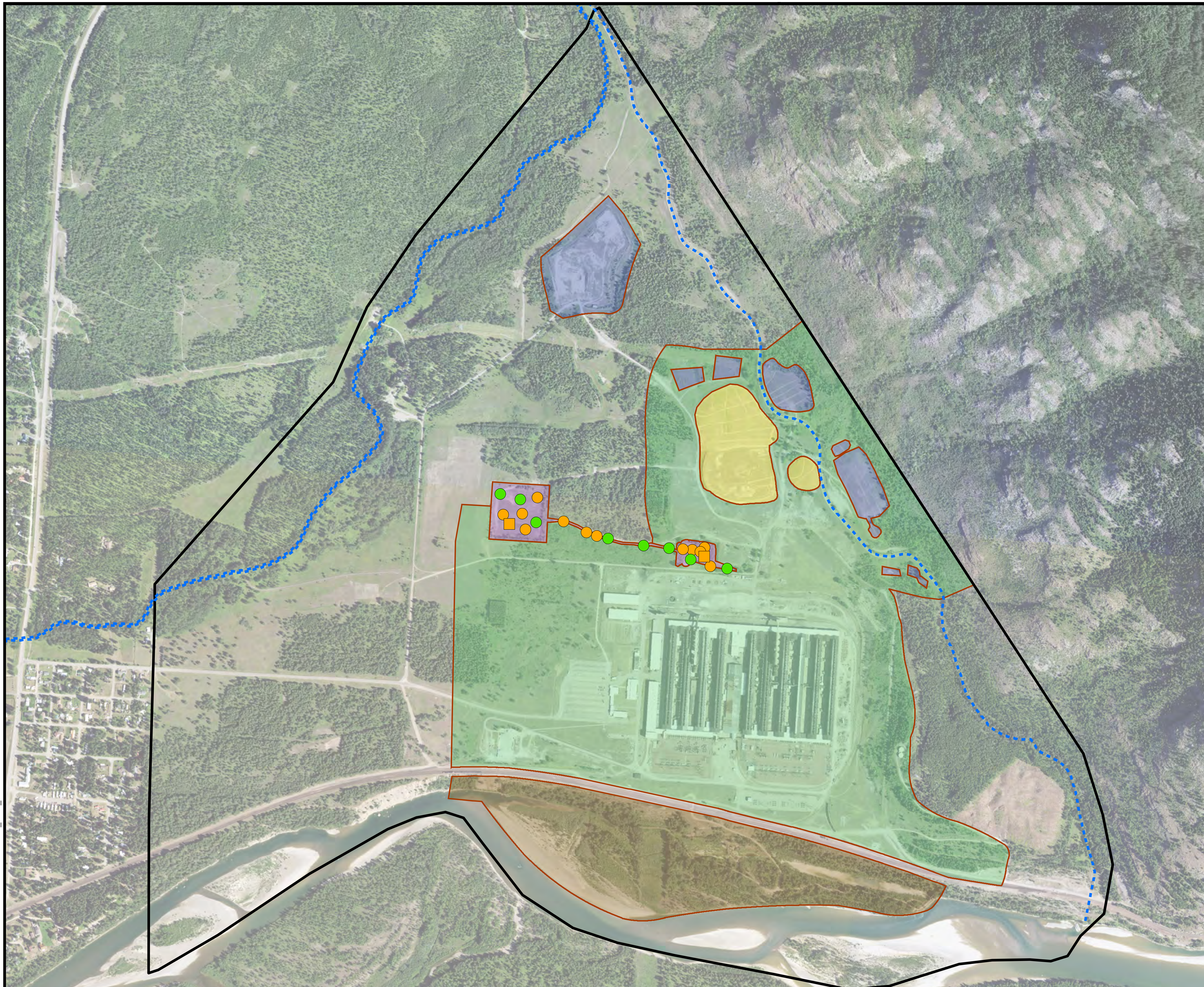

CONCENTRATION LEGEND - EA 2

SO	SD	
●	■	ANALYTE NOT DETECTED
●	■	ND - 38 (LESS THAN PROTECTIVE SEDIMENT ECO PRG)
●	■	>38 (GREATER THAN PROTECTIVE SEDIMENT ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

1,000 0 1,000'

N

Title:

CONCENTRATIONS OF VANADIUM IN SEDIMENT – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	G7
Project Mgr: L.J.	Project: 2476.0001Y008	
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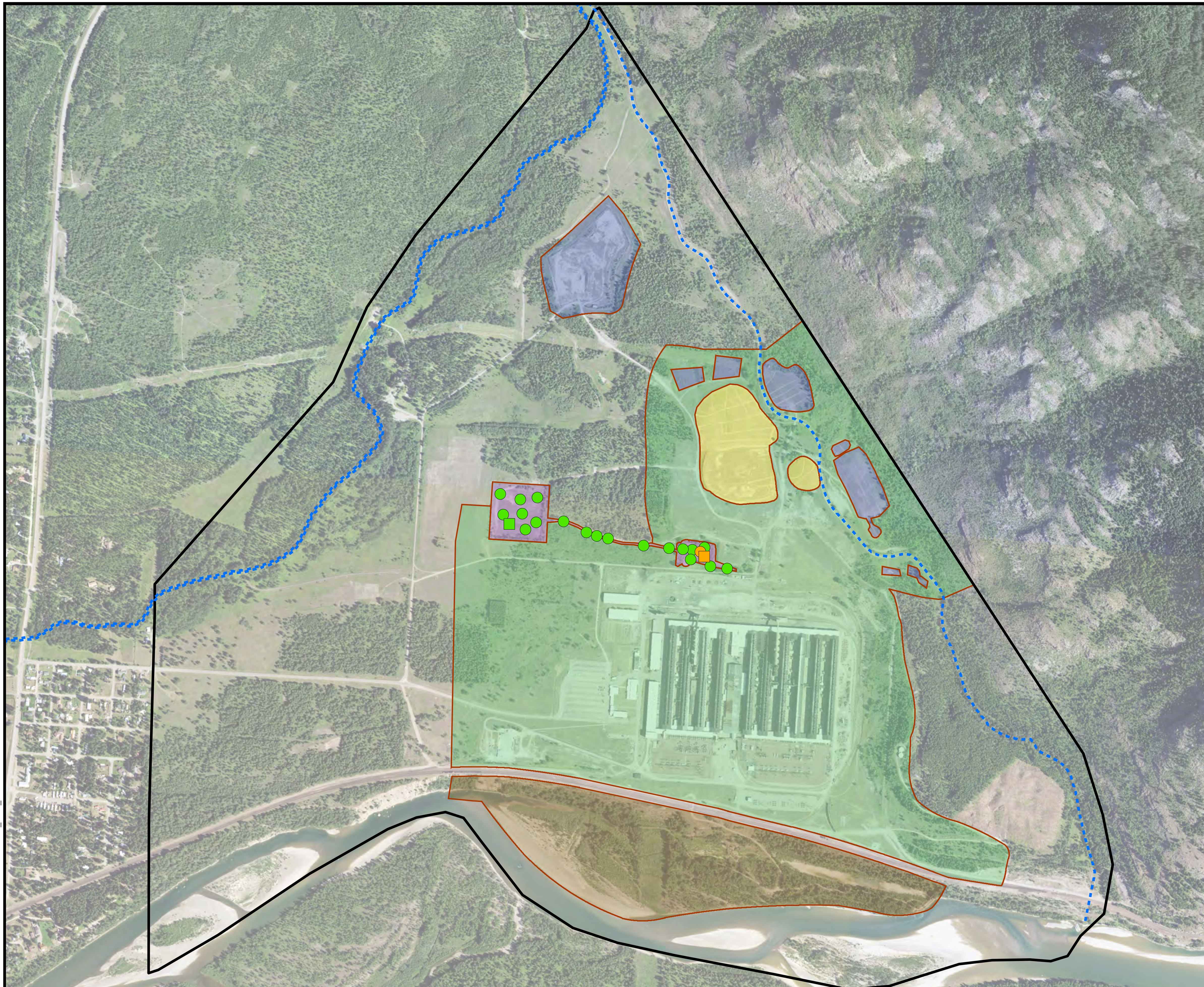
V:\GIS\PROJECTS\2476Y\0001Y\256\G7. SED_ECO_VANADIUM.MXD



Title:

CONCENTRATIONS OF ZINC IN SEDIMENT – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	
Project Mgr: L.J.	Project: 2476.0001Y008	G8
File: G8. Sed_Eco_Zinc.mxd		

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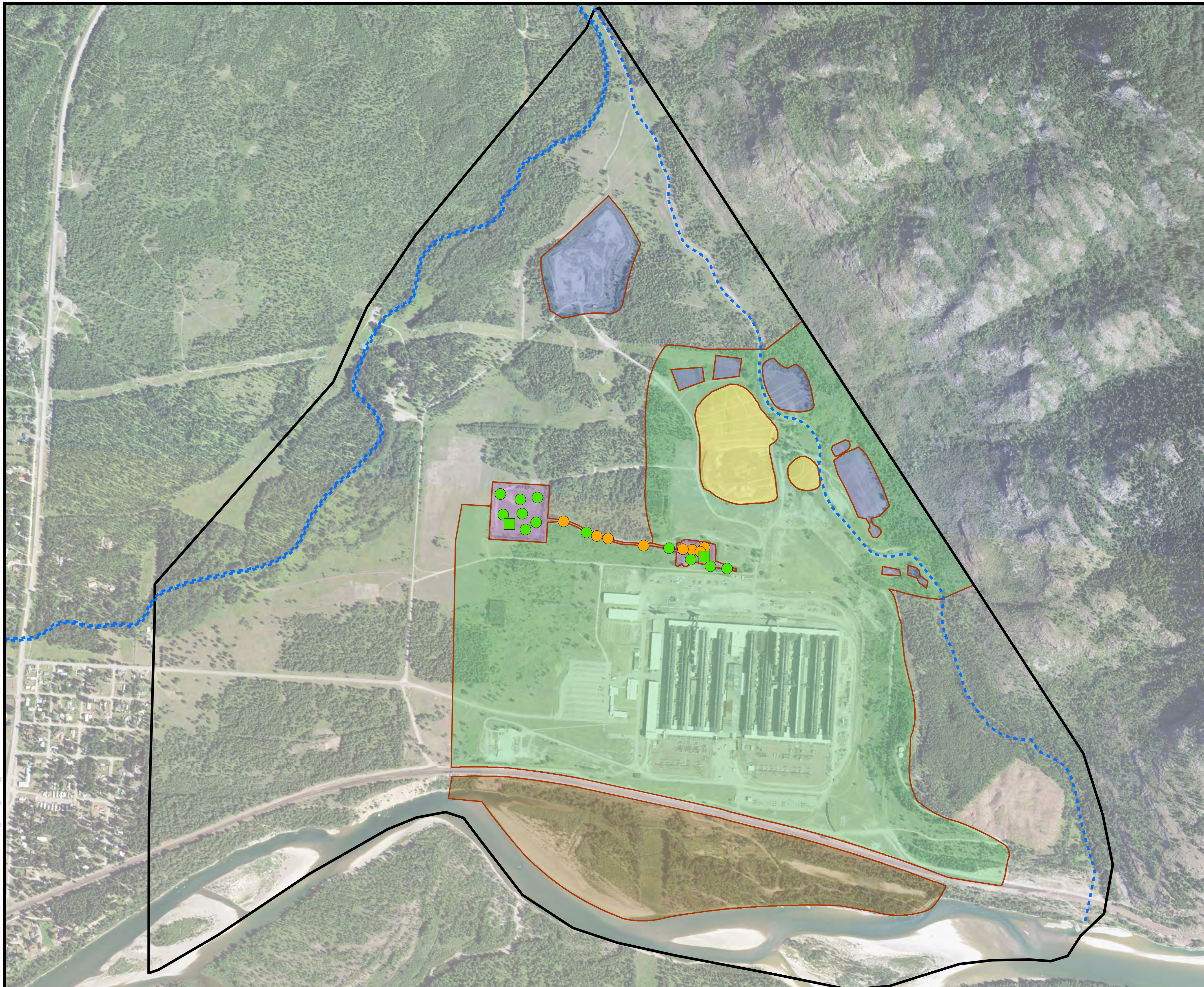

CONCENTRATION LEGEND - EA 2

SO	SD	
● (blue)	■ (blue)	ANALYTE NOT DETECTED
● (green)	■ (green)	ND - 196 (LESS THAN PROTECTIVE SEDIMENT ECO PRG)
● (orange)	■ (orange)	>196 (GREATER THAN PROTECTIVE SEDIMENT ECO PRG)

ALL CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM (MG/KG)

1,000 0 1,000'

Title:

CONCENTRATIONS OF LMW PAHS IN SEDIMENT – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	G9
Project Mgr: L.J.	Project: 2476.0001Y008	
File: G9. Sed_Eco_LMW_PAHs.mxd		

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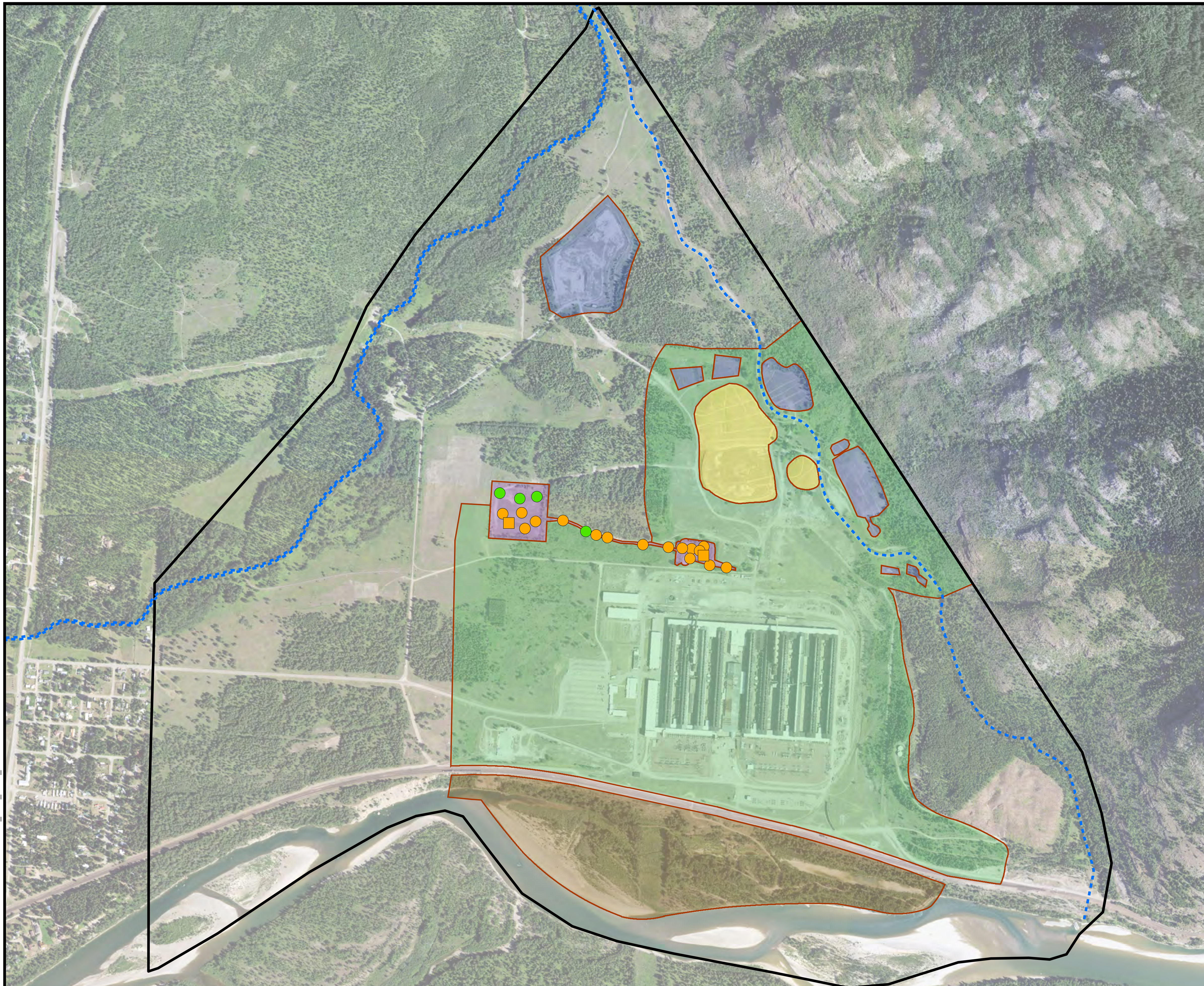


Title:

CONCENTRATIONS OF HMW PAHS IN SEDIMENT – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

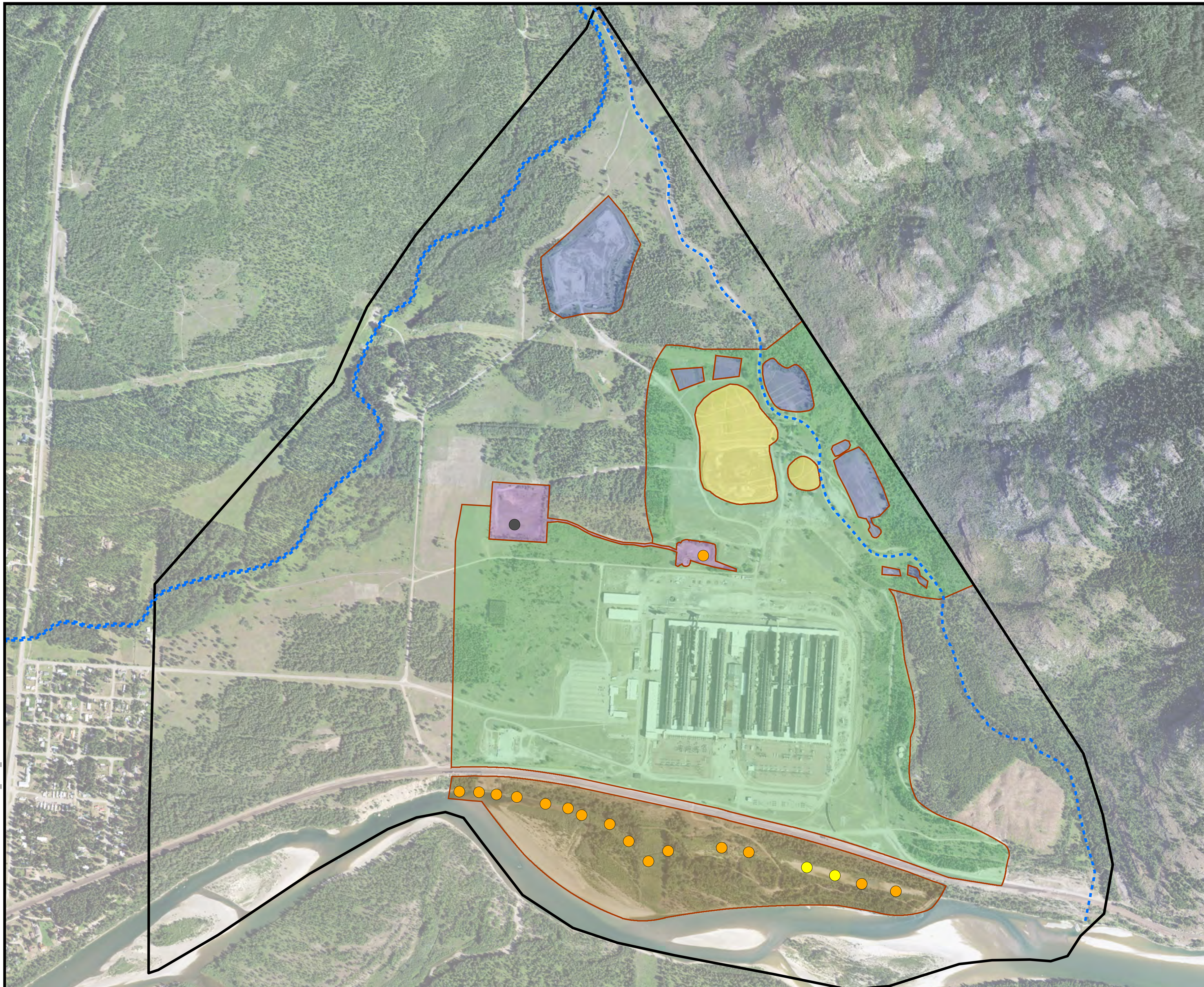
Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	G10
Project Mgr: L.J.	Project: 2476.0001Y008	
File: G10. Sed_Eco_HMW_PAHs.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\G10. SED_ECO_HMW_PAHS.MXD

APPENDIX H

Ecological PRG Comparison – Surface Water Thematic Maps

1. Exceedances of Ecological PRGs in Surface Water Samples
2. Concentrations of Dissolved Aluminum in Surface Water – Ecological PRG Comparison
3. Concentrations of Barium in Surface Water – Ecological PRG Comparison
4. Concentrations of Cadmium in Surface Water – Ecological PRG Comparison
5. Concentrations of Copper in Surface Water – Ecological PRG Comparison
6. Concentrations of Iron in Surface Water – Ecological PRG Comparison
7. Concentrations of Zinc in Surface Water – Ecological PRG Comparison
8. Concentrations of Total Cyanide in Surface Water – Ecological PRG Comparison
9. Concentrations of Dissolved Cyanide in Surface Water – Ecological PRG Comparison
10. Concentrations of Free Cyanide in Surface Water – Ecological PRG Comparison
11. Concentrations of Dissolved Free Cyanide in Surface Water – Ecological PRG Comparison
12. Concentrations of Benzo(a)anthracene in Surface Water – Ecological PRG Comparison
13. Concentrations of Benzo(a)pyrene in Surface Water – Ecological PRG Comparison
14. Concentrations of Benzo(b)fluoranthene in Surface Water – Ecological PRG Comparison
15. Concentrations of Benzo(g,h,i)perylene in Surface Water – Ecological PRG Comparison
16. Concentrations of Chrysene in Surface Water – Ecological PRG Comparison
17. Concentrations of Fluoranthene in Surface Water – Ecological PRG Comparison
18. Concentrations of Indeno(1,2,3-c,d)pyrene in Surface Water – Ecological PRG Comparison



LEGEND - EA 2, 8, 9, & 12

- LOCATION WITH NO EXCEEDANCES
- LOCATION WITH ONE OR MORE EXCEEDANCES OF A CHRONIC CRITERION PRG
- LOCATION WITH ONE OR MORE EXCEEDANCES OF AN ACUTE CRITERION PRG

N

1,000 0 1,000'

Title:

EXCEEDANCES OF ECOLOGICAL PRGS IN SURFACE WATER SAMPLES

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H1
Project Mgr: L.J.	Project: 2476.0001Y008	
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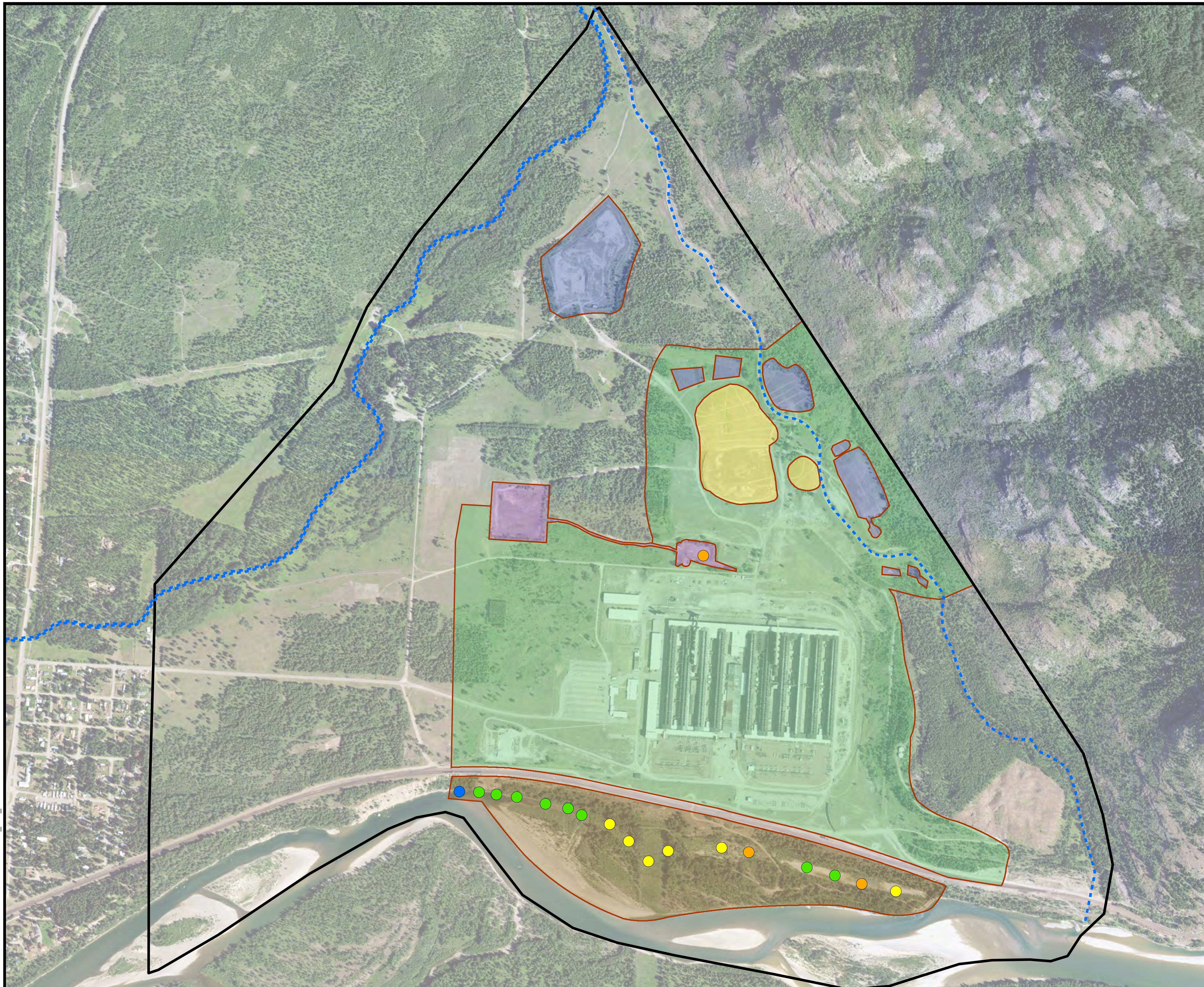
V:\GIS\PROJECTS\2476Y\0001Y\256\H1. EXCEEDANCE_ECO_SW.MXD



N

CONCENTRATION LEGEND - EA 2, 8, 9, & 12

- ANALYTE NOT DETECTED
- ND - 87 (LESS THAN CHRONIC CRITERION PRG)
- 87 - 750 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >750 (GREATER THAN ACUTE CRITERION PRG)

ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

1,000 0 1,000'

Title:

CONCENTRATIONS OF DISSOLVED ALUMINUM IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H2
Project Mgr: L.J.	Project: 2476.0001Y008	
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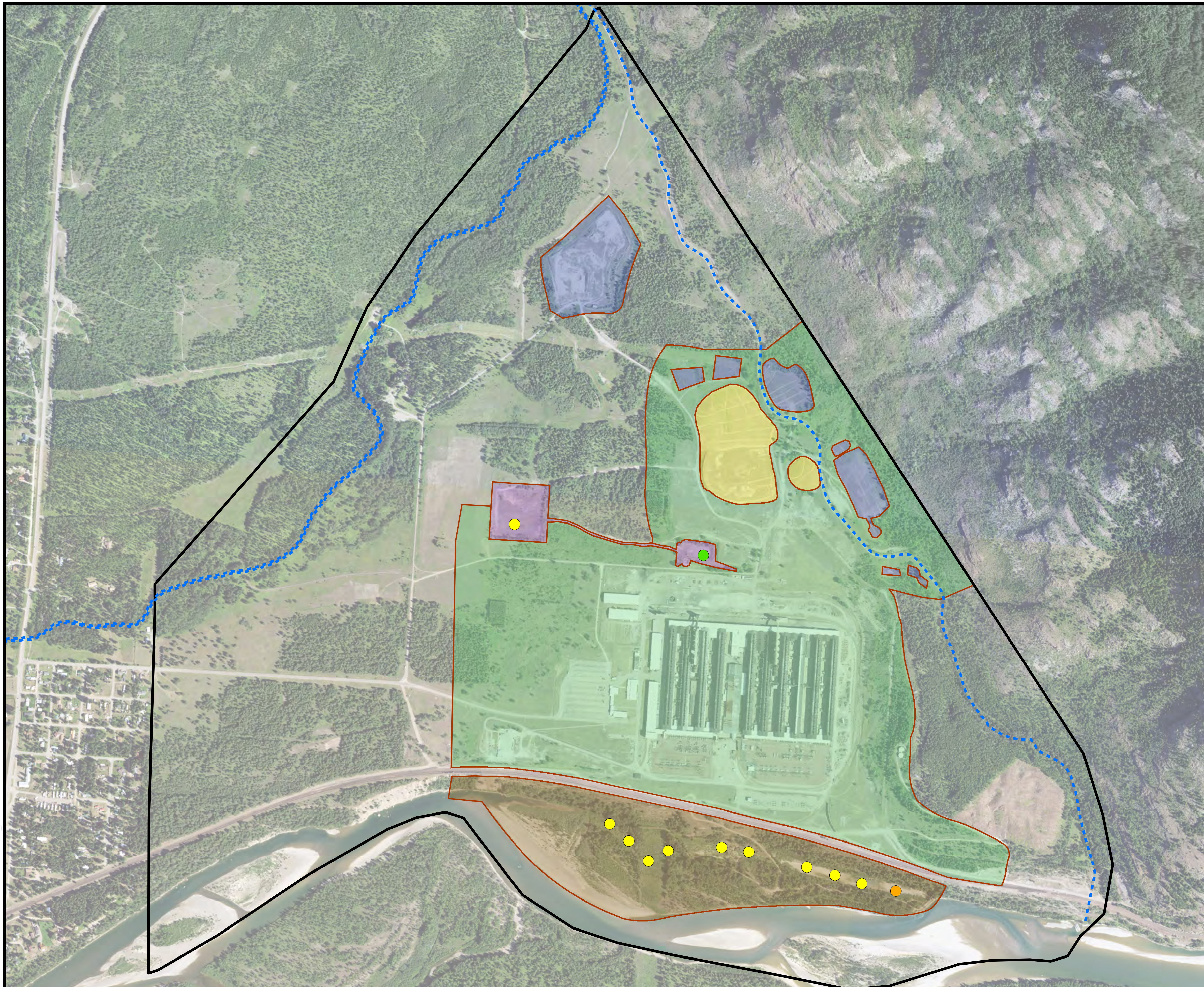

N

CONCENTRATION LEGEND - EA 2, 8, &12

- ANALYTE NOT DETECTED
- ND - 220 (LESS THAN CHRONIC CRITERION PRG)
- 220 - 2,000 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >2,000 (GREATER THAN ACUTE CRITERION PRG)

NOTES

1. DEQ-7 ACUTE AQUATIC LIFE STANDARDS ARE NOT AVAILABLE FOR BARIUM; CHRONIC AND ACUTE CRITERION DERIVED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY (SEE APPENDIX B).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

1,000 0 1,000'

Title:

CONCENTRATIONS OF BARIUM IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/16/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H3
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H3. SW_Barium.mxd		

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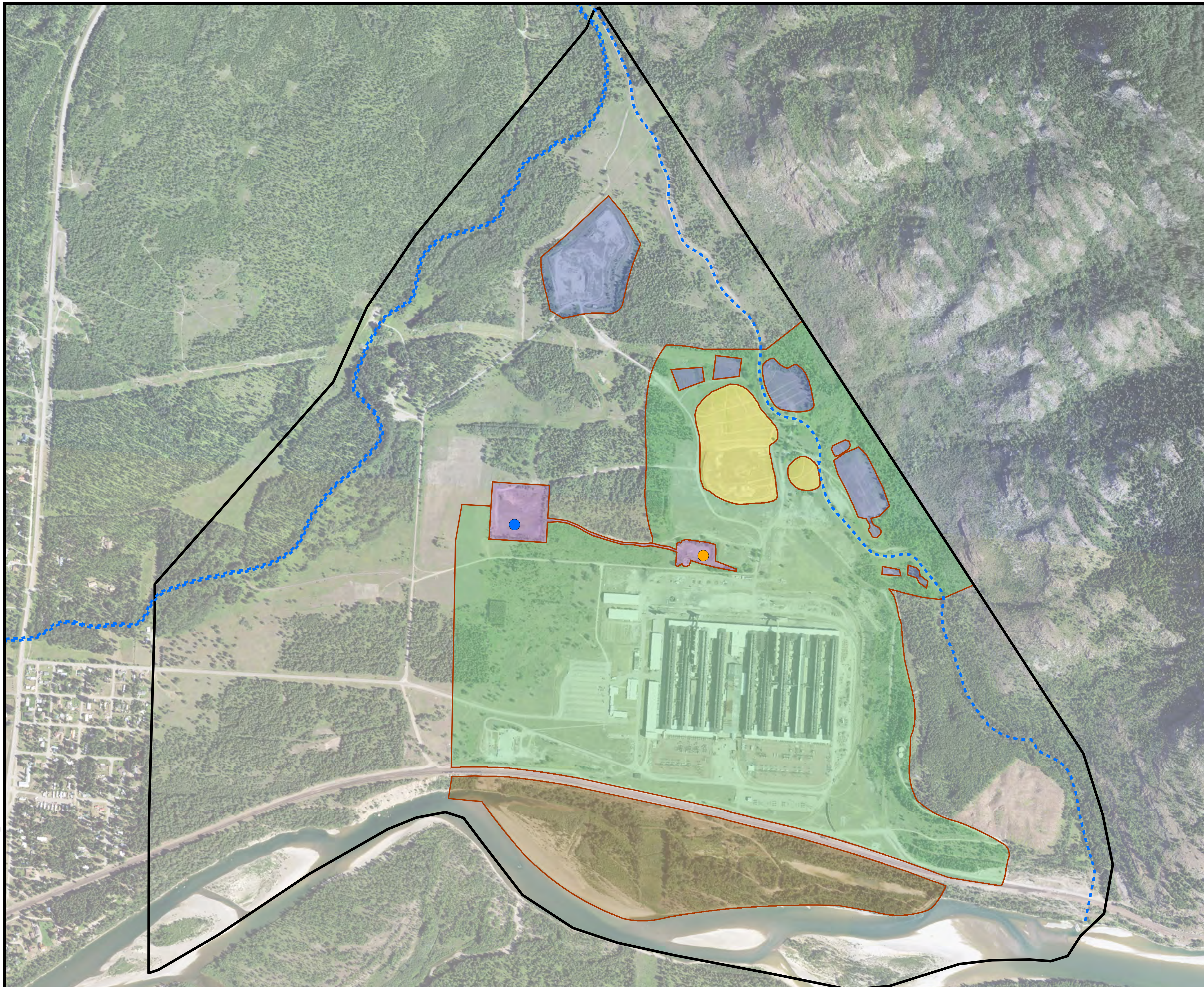

CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- ND - 0.45 (LESS THAN CHRONIC CRITERION PRG)
- 0.45 - 0.96 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >0.96 (GREATER THAN ACUTE CRITERION PRG)

NOTES

1. DEQ-7 AQUATIC LIFE STANDARDS FOR THIS METAL ARE HARDNESS SPECIFIC; VALUES REPRESENTATIVE OF SITE-SPECIFIC DATA USED AS PRGS (SEE SECTION 4.3.2).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

Title:

CONCENTRATIONS OF CADMIUM IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/12/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H4
Project Mgr: L.J.	Project: 2476.0001Y008	
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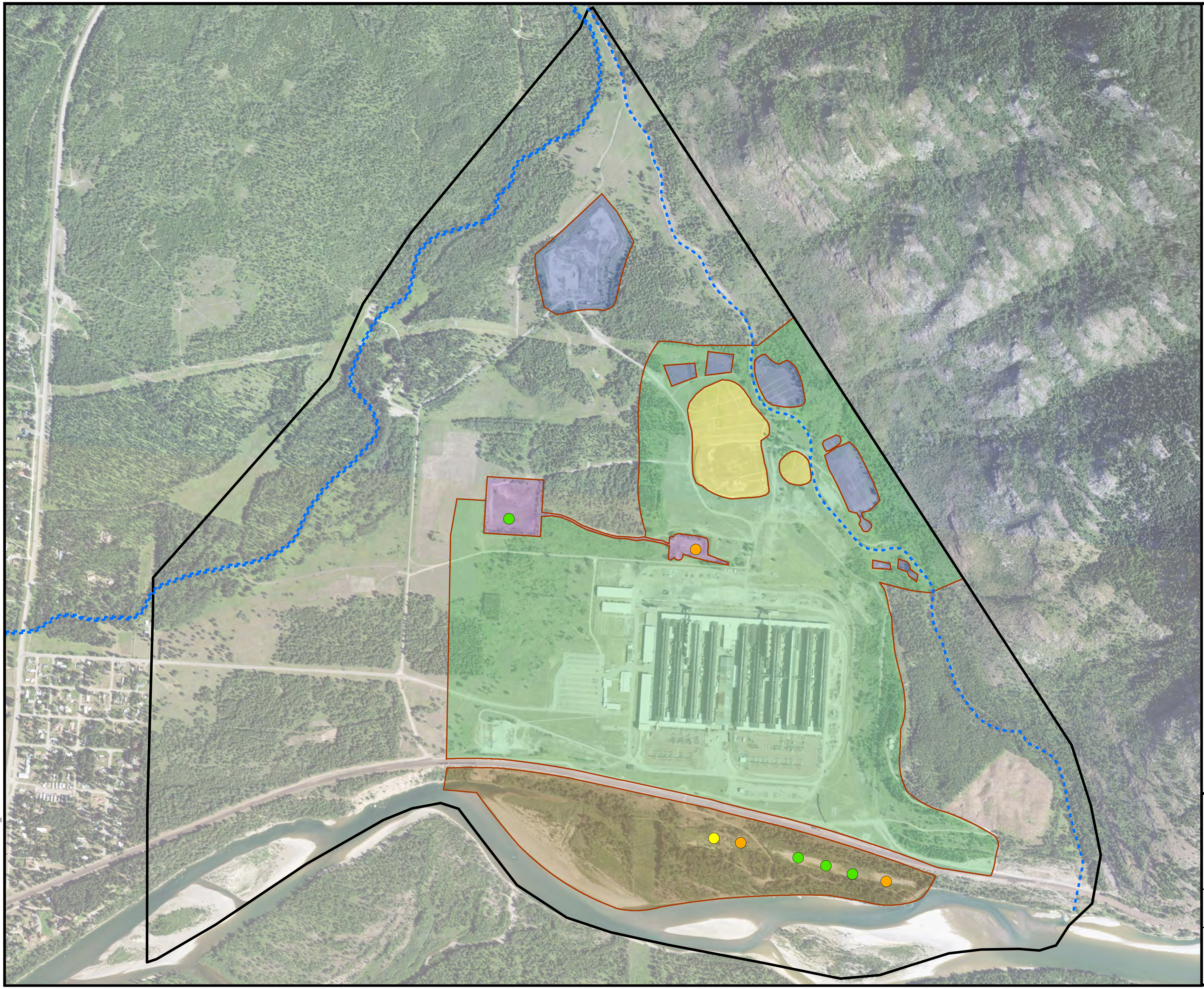

N

CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- ND - 5.16 (LESS THAN CHRONIC CRITERION PRG)
- 5.16 - 7.29 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >7.29 (GREATER THAN ACUTE CRITERION PRG)

CONCENTRATION LEGEND - EA 12

- ANALYTE NOT DETECTED
- ND - 15.27 (LESS THAN CHRONIC CRITERION PRG)
- 15.27 - 24.10 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >24.10 (GREATER THAN ACUTE CRITERION PRG)

NOTES

1. DEQ-7 AQUATIC LIFE STANDARDS FOR THIS METAL ARE HARDNESS SPECIFIC; VALUES REPRESENTATIVE OF SITE-SPECIFIC DATA USED AS PRGS (SEE SECTION 4.3.2).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

1,000 0 1,000'

Title:

CONCENTRATIONS OF COPPER IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX	Compiled by: C.S.	Date: 03/12/20	APPENDIX
	Prepared by: M.S.R.	Scale: AS SHOWN	
	Project Mgr: L.J.	Project: 2476.0001Y008	H5
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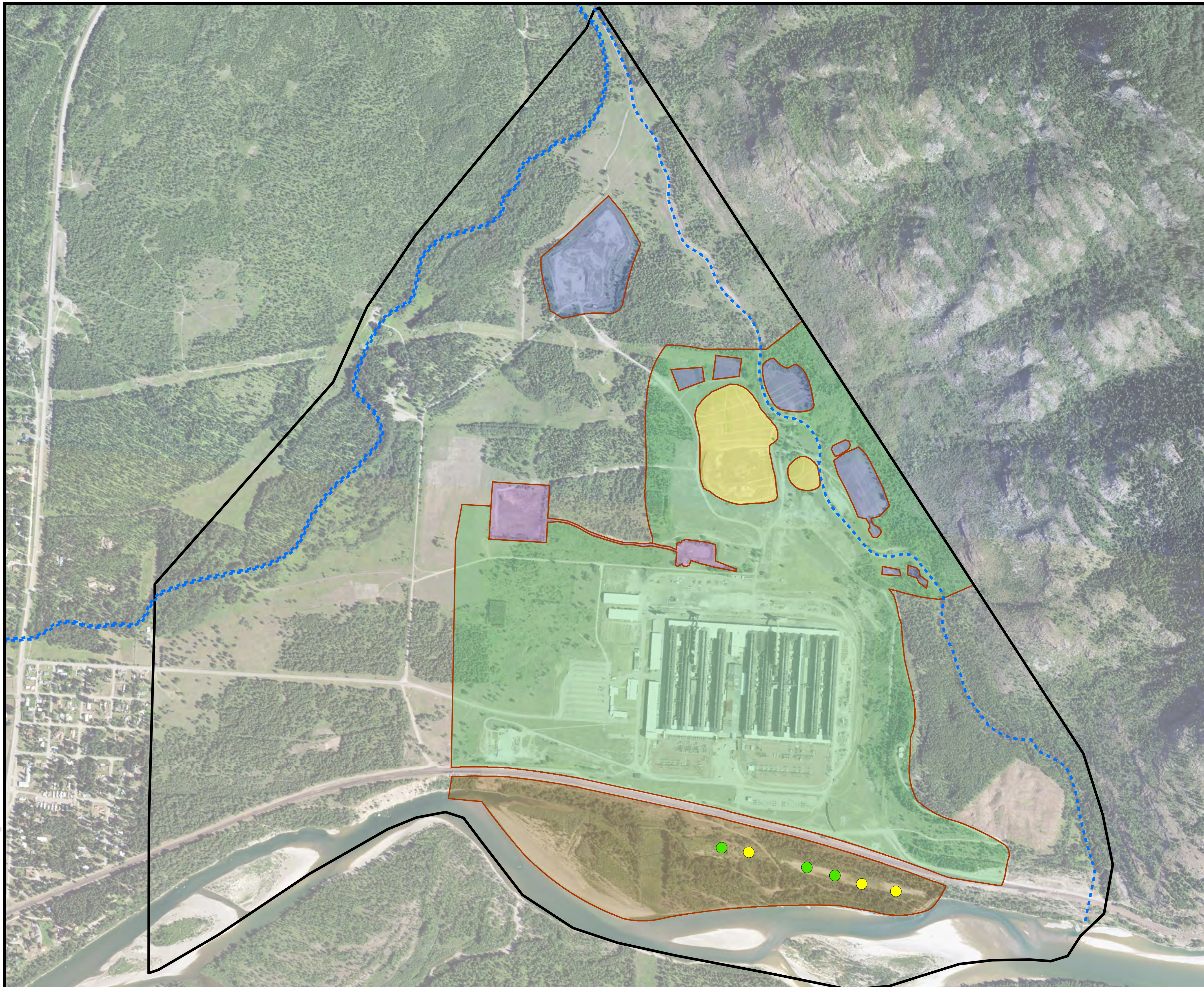


V:\GIS\PROJECTS\2476Y\0001Y\256\H6. SW_IRON.MXD

CONCENTRATION LEGEND - EA 12

- ANALYTE NOT DETECTED
- ND - 1,000 (LESS THAN CHRONIC CRITERION PRG)
- >1,000 (GREATER THAN CHRONIC CRITERION PRG)

NOTES

1. DEQ-7 ACUTE AQUATIC LIFE STANDARDS ARE NOT AVAILABLE FOR IRON
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

1,000 0 1,000'

Title:

CONCENTRATIONS OF IRON IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

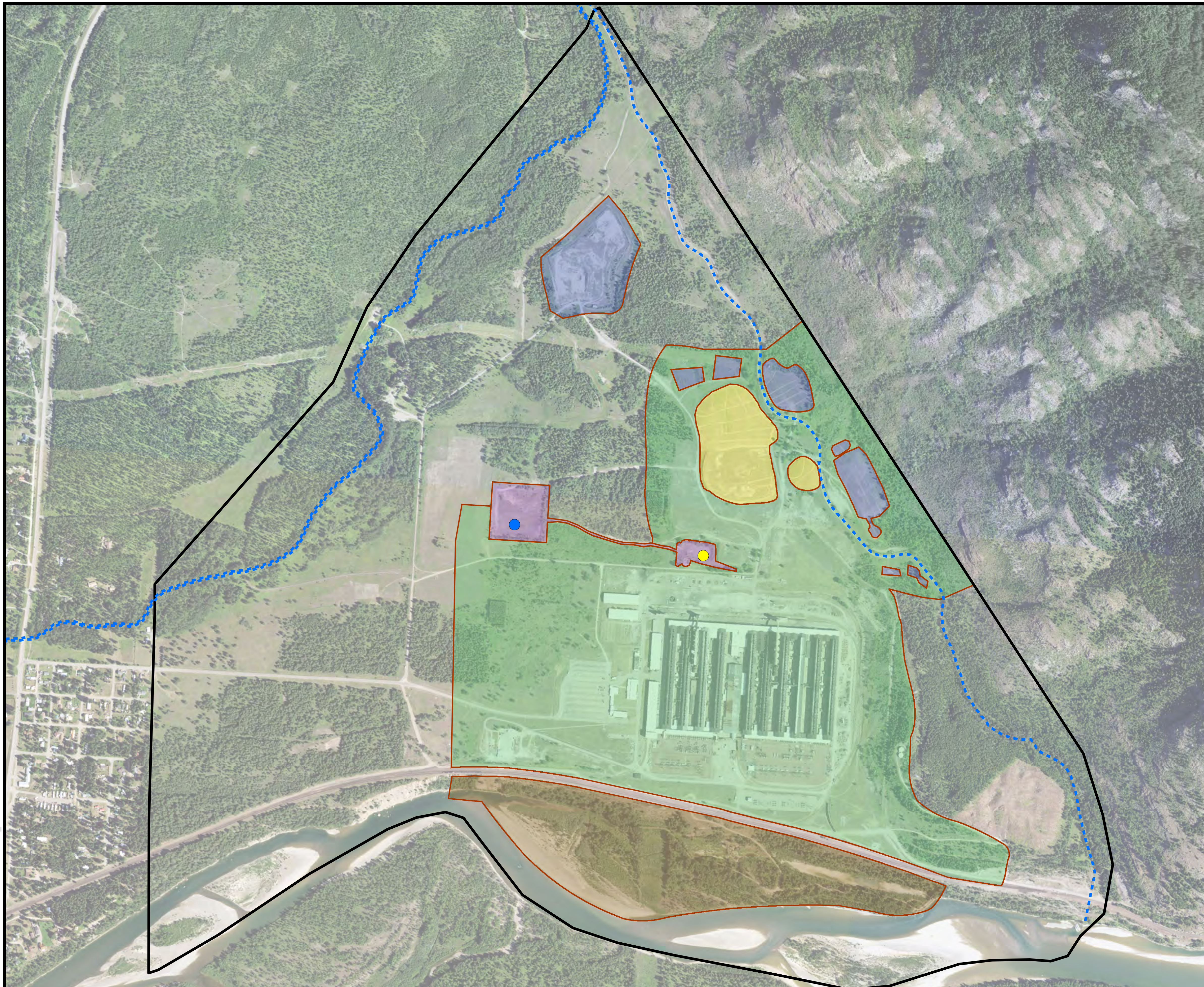
2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/12/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H6
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H6. SW_Iron.mxd		



CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED (blue)
- ND - 66.6 (LESS THAN CHRONIC/ACUTE CRITERION PRG) (green)
- >66.6 (GREATER THAN CHRONIC/ACUTE CRITERION PRG) (yellow)

NOTES

1. DEQ-7 AQUATIC LIFE STANDARDS FOR THIS METAL ARE HARDNESS SPECIFIC; VALUES REPRESENTATIVE OF SITE-SPECIFIC DATA USED AS PRGS (SEE SECTION 4.3.2).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

Title:

CONCENTRATIONS OF ZINC IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/12/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H7
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H7. SW_Zinc.mxd		

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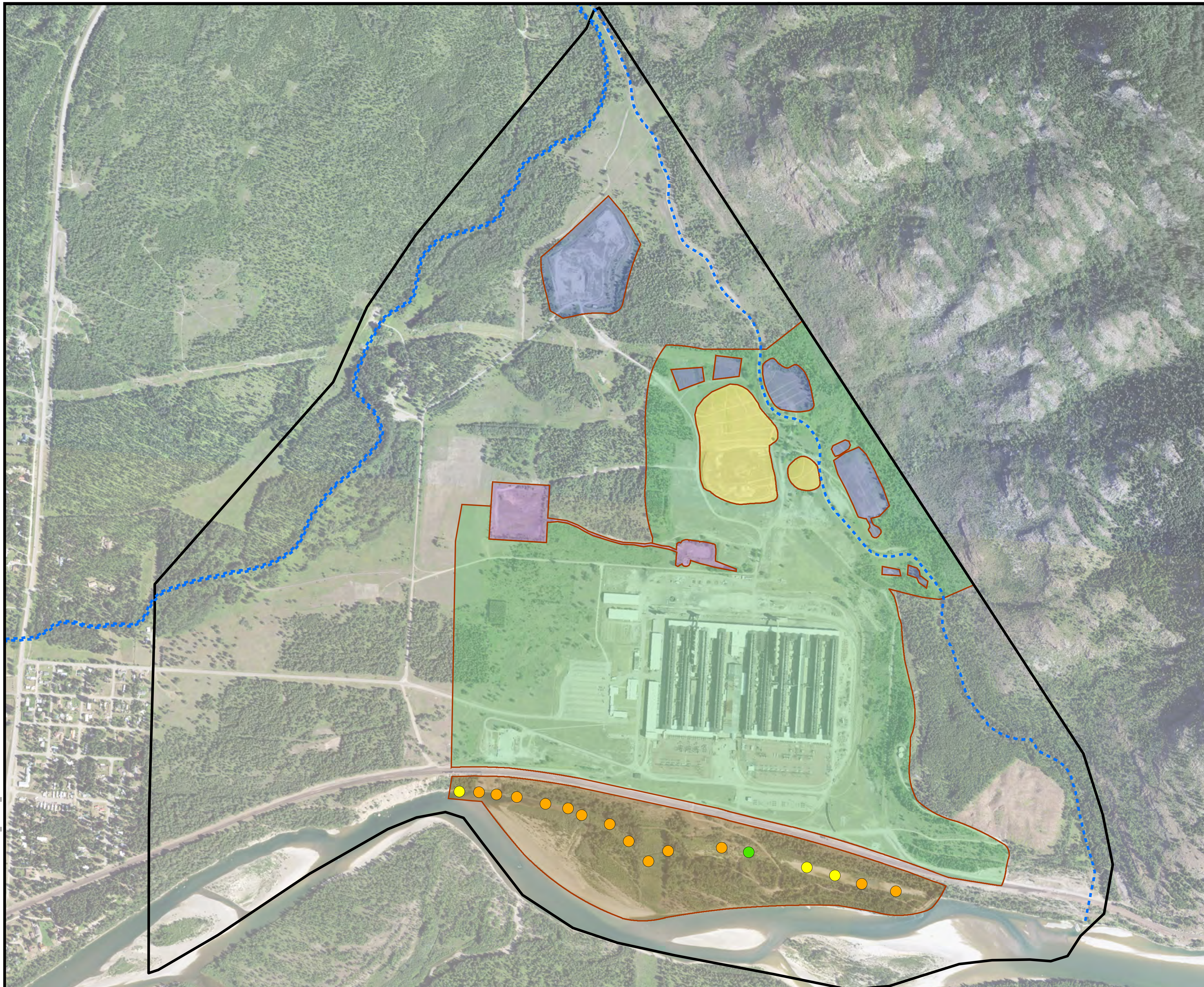


N

CONCENTRATION LEGEND - EA 8, 9, & 12

- ANALYTE NOT DETECTED
- ND - 5.2 (LESS THAN CHRONIC CRITERION PRG)
- 5.2 - 22 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >22 (GREATER THAN ACUTE CRITERION PRG)

ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

1,000 0 1,000'

Title:

CONCENTRATIONS OF TOTAL CYANIDE IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

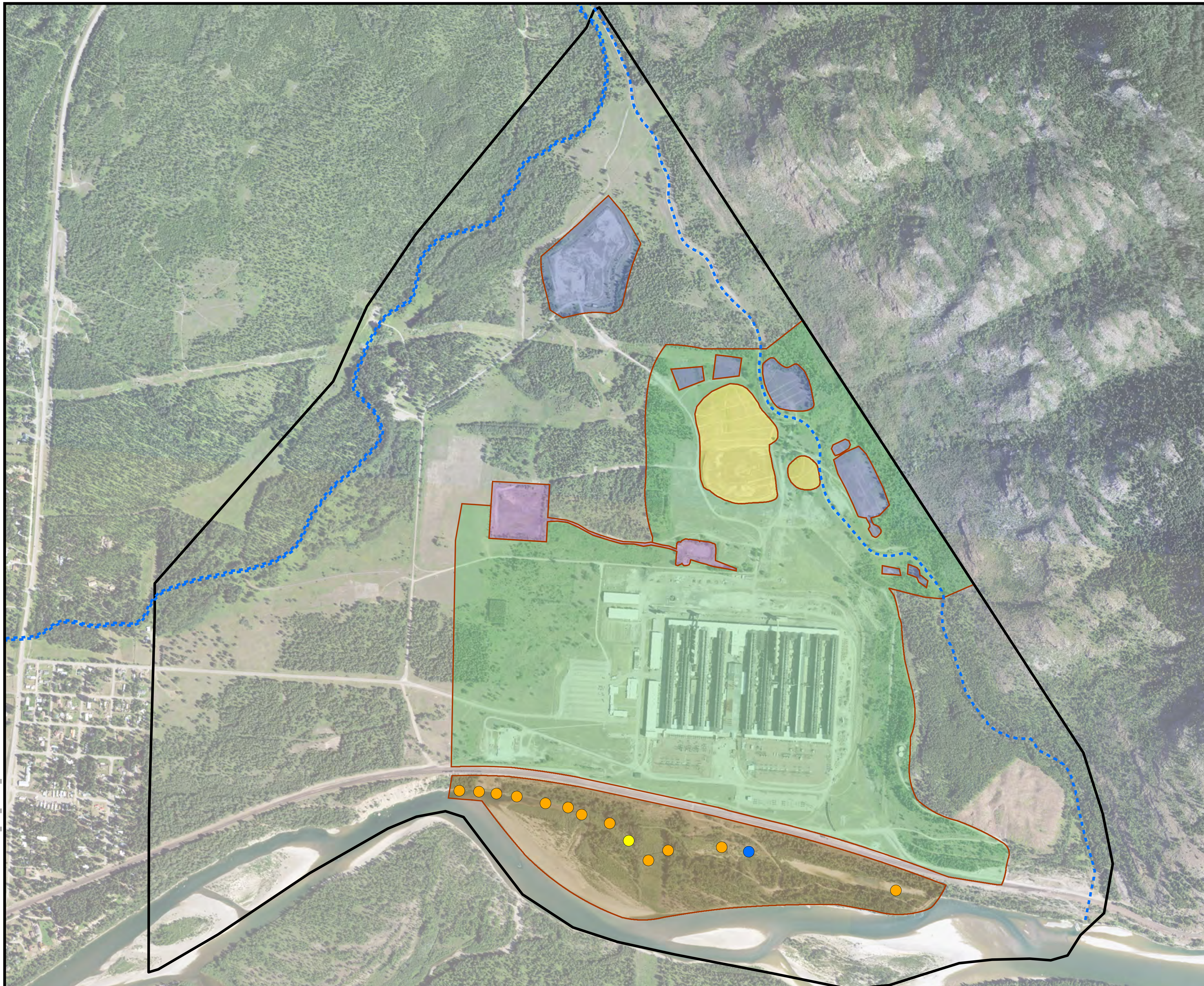
Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H8
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H8. SW_Total_Cyanide.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\H8. SW_TOTAL_CYANIDE.MXD



Title:

CONCENTRATIONS OF DISSOLVED CYANIDE IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H9
Project Mgr: L.J.	Project: 2476.0001Y008	
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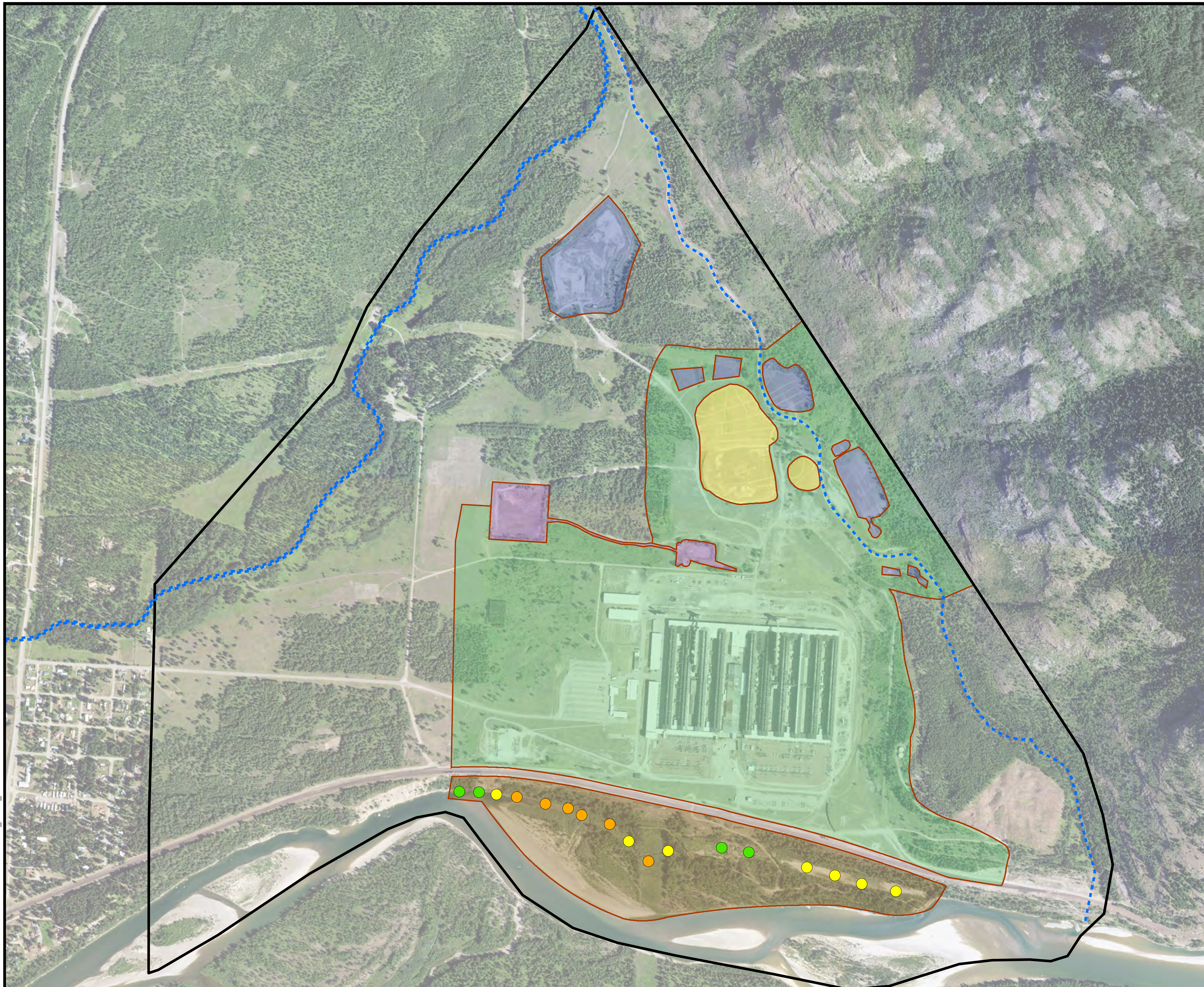
V:\GIS\PROJECTS\2476Y\0001Y\256\H9. SW_DIS_TOTAL_CYANIDE.MXD



CONCENTRATION LEGEND - EA 8, 9, & 12

- ANALYTE NOT DETECTED
- ND - 5.2 (LESS THAN CHRONIC CRITERION PRG)
- 5.2 - 22 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >22 (GREATER THAN ACUTE CRITERION PRG)

ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

1,000 0 1,000'

N

Title:

CONCENTRATIONS OF FREE CYANIDE IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H10
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H10. SW_Free_Cyanide.mxd		

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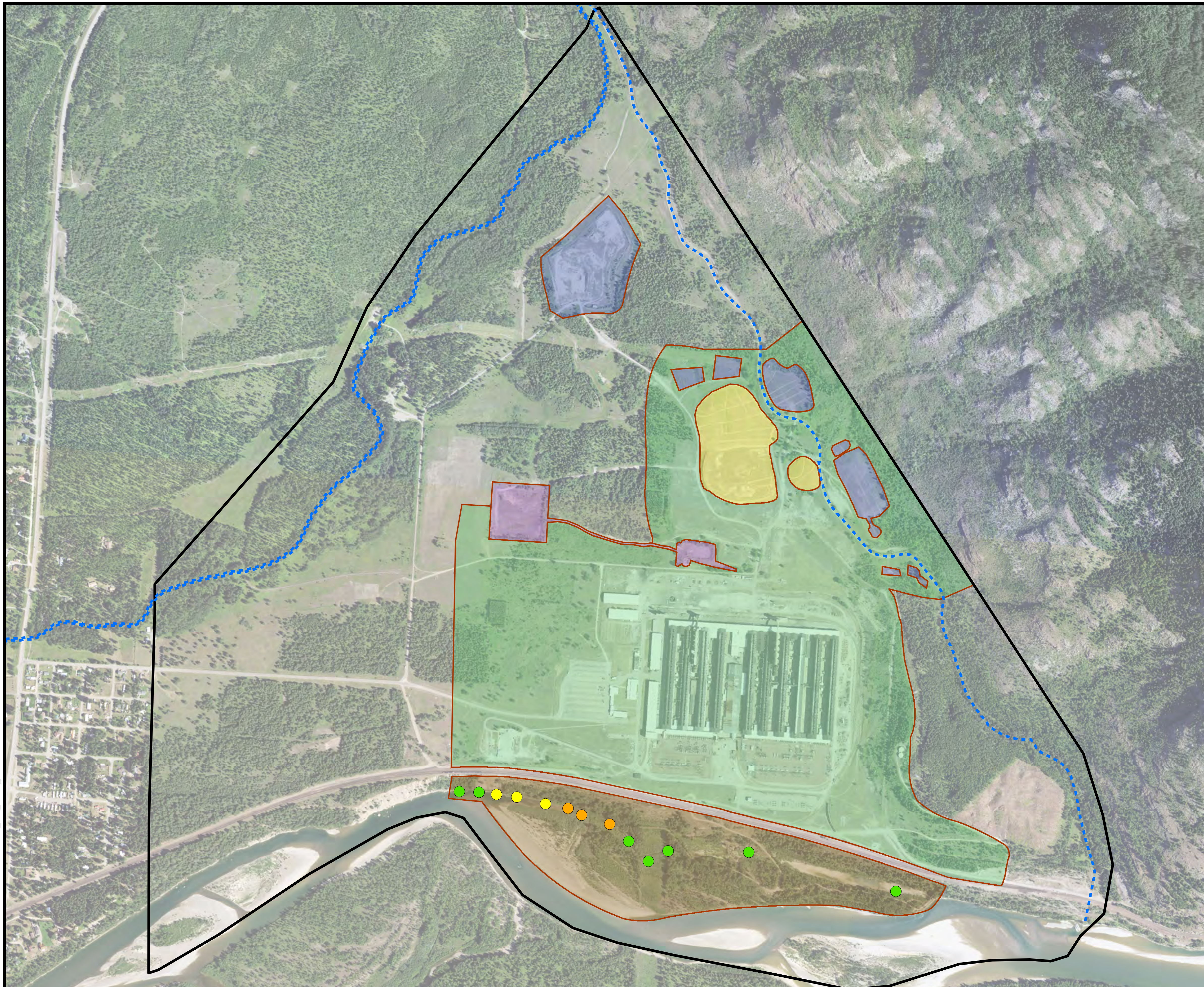


CONCENTRATION LEGEND - EA 8, 9, & 12

- ANALYTE NOT DETECTED
- ND - 5.2 (LESS THAN CHRONIC CRITERION PRG)
- 5.2 - 22 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >22 (GREATER THAN ACUTE CRITERION PRG)

NOTES

1. DEQ-7 AQUATIC LIFE STANDARDS ARE NOT AVAILABLE FOR THIS PAH; FINAL CHRONIC VALUE AND FINAL ACUTE VALUE PROVIDED BY USEPA (SEE APPENDIX B).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

N

1,000 0 1,000'

Title:

CONCENTRATIONS OF DISSOLVED FREE CYANIDE IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

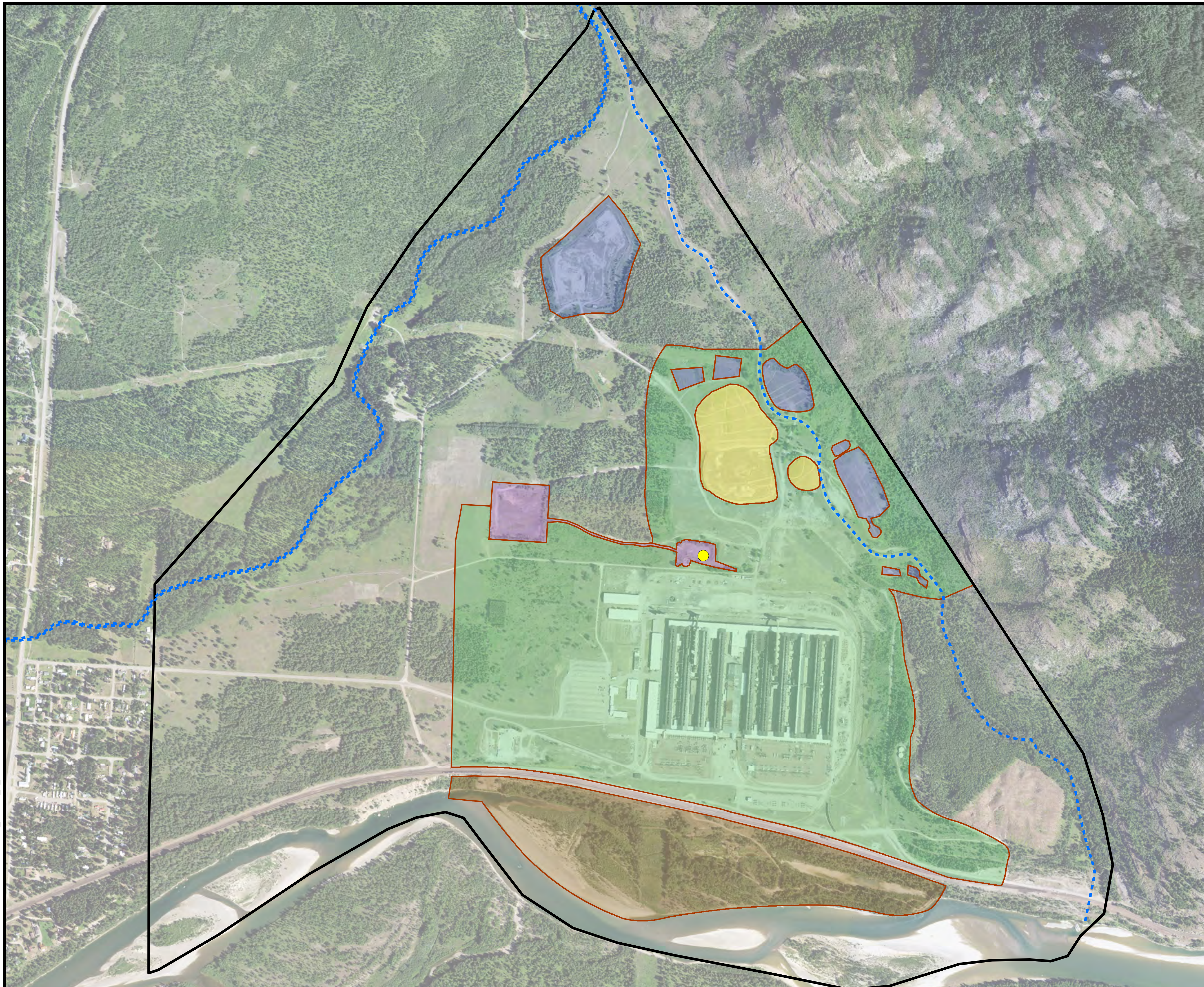
Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/12/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H11
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H11. SW_Dis_Free_Cyanide.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\H11. SW_DIS_FREE_CYANIDE.MXD



CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- ND - 2.23 (LESS THAN CHRONIC CRITERION PRG)
- 2.23 - 9.25 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >9.25 (GREATER THAN ACUTE CRITERION PRG)

NOTES

1. DEQ-7 AQUATIC LIFE STANDARDS ARE NOT AVAILABLE FOR THIS PAH; FINAL CHRONIC VALUE AND FINAL ACUTE VALUE PROVIDED BY USEPA (SEE APPENDIX B).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

Title:

CONCENTRATIONS OF BENZO[A]ANTHRACENE IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/12/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H12
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H12. SW_Benzo_a_an.mxd		

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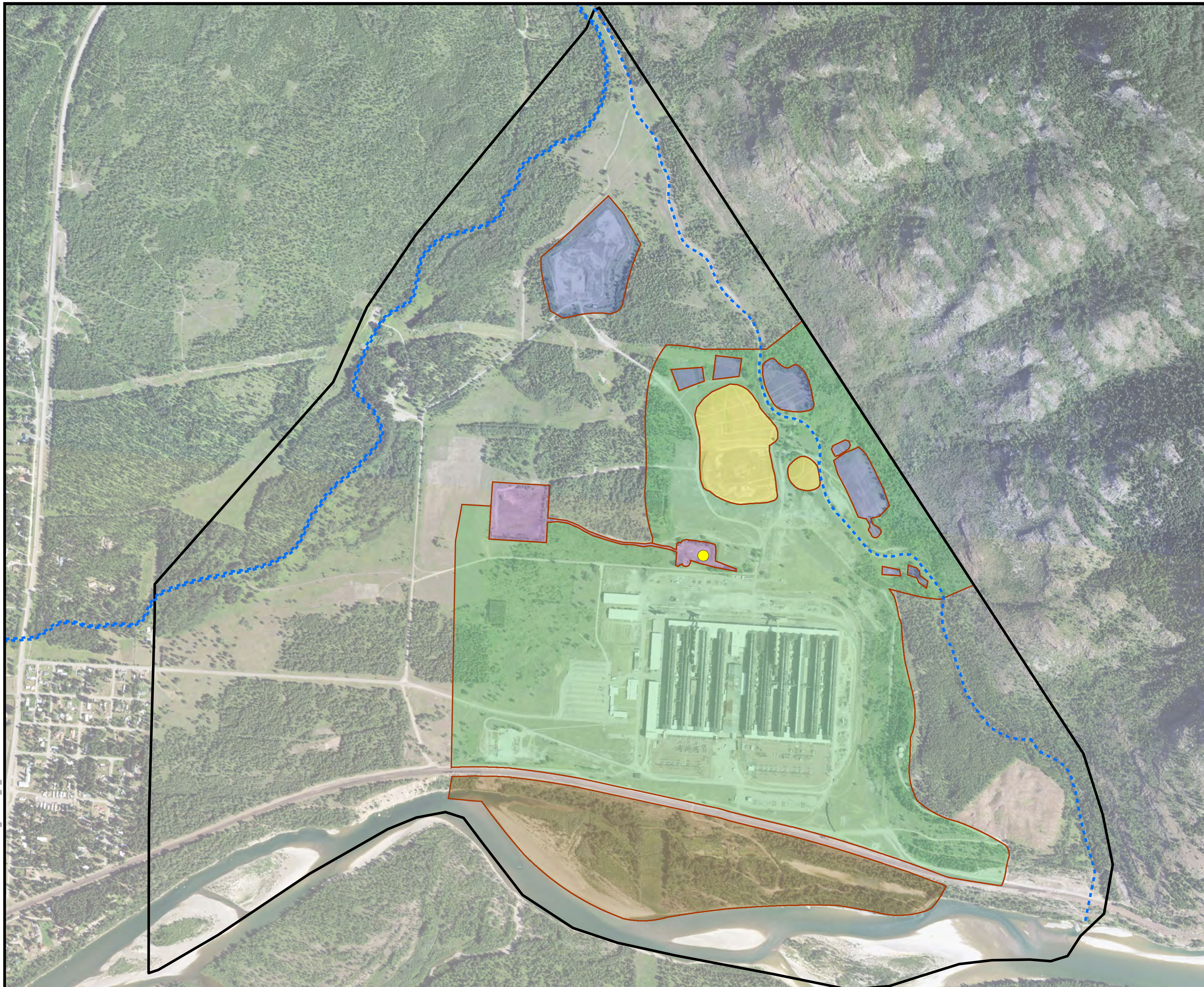

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CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- ND - 0.96 (LESS THAN CHRONIC CRITERION PRG)
- 0.96 - 3.98 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >3.98 (GREATER THAN ACUTE CRITERION PRG)

NOTES

1. DEQ-7 AQUATIC LIFE STANDARDS ARE NOT AVAILABLE FOR THIS PAH; FINAL CHRONIC VALUE AND FINAL ACUTE VALUE PROVIDED BY USEPA (SEE APPENDIX B).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

1,000 0 1,000'

Title:

CONCENTRATIONS OF BENZO[A]PYRENE IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/12/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H13
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H13. SW_Benzo_a_py.mxd		

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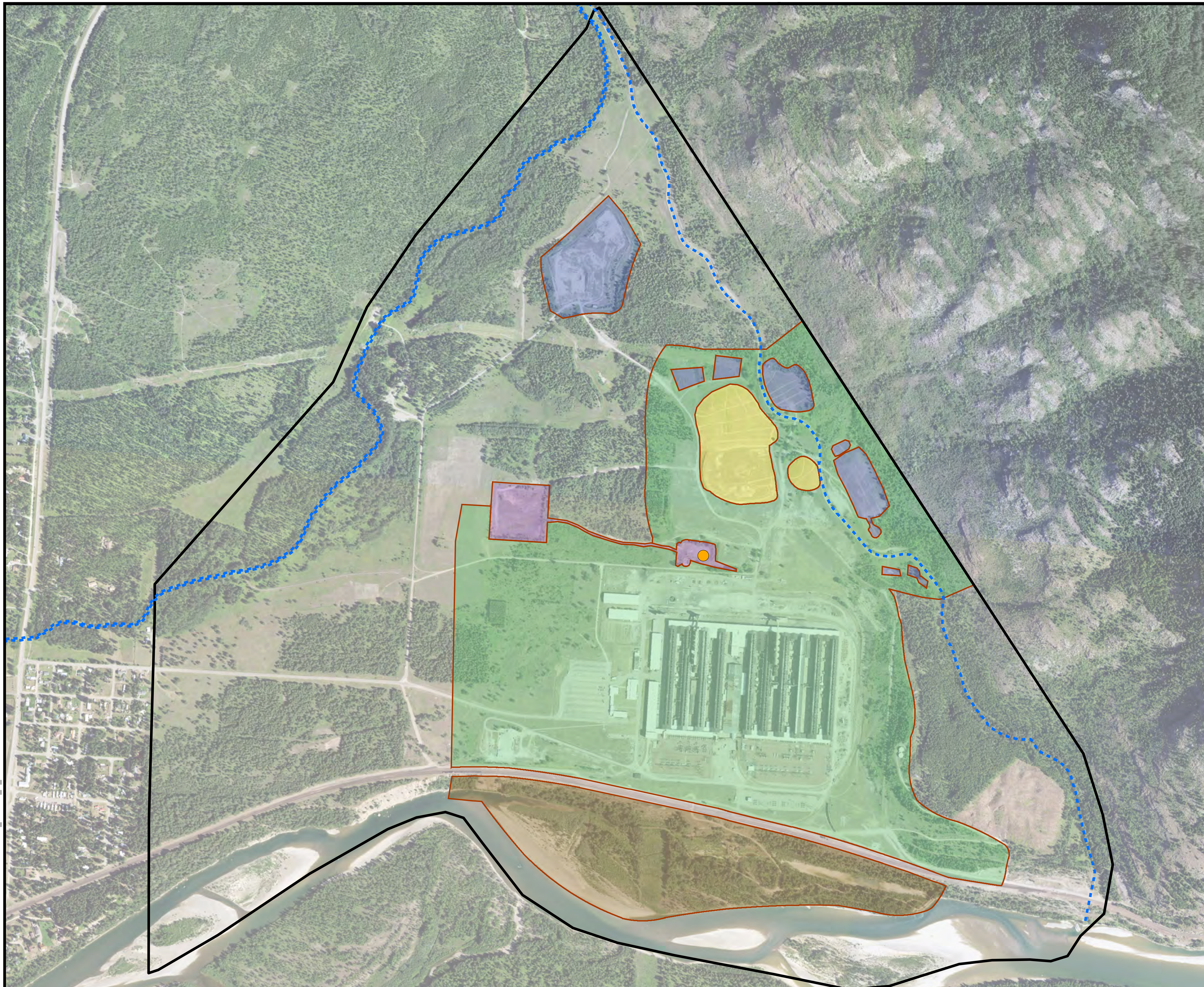

CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- ND - 0.68 (LESS THAN CHRONIC CRITERION PRG)
- 0.68 - 2.81 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >2.81 (GREATER THAN ACUTE CRITERION PRG)

NOTES

1. DEQ-7 AQUATIC LIFE STANDARDS ARE NOT AVAILABLE FOR THIS PAH; FINAL CHRONIC VALUE AND FINAL ACUTE VALUE PROVIDED BY USEPA (SEE APPENDIX B).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

1,000 0 1,000'

Title:

CONCENTRATIONS OF BENZO[B]FLUORANTHENE IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/12/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H14
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H14. SW_Benzo_b_fl.mxd		

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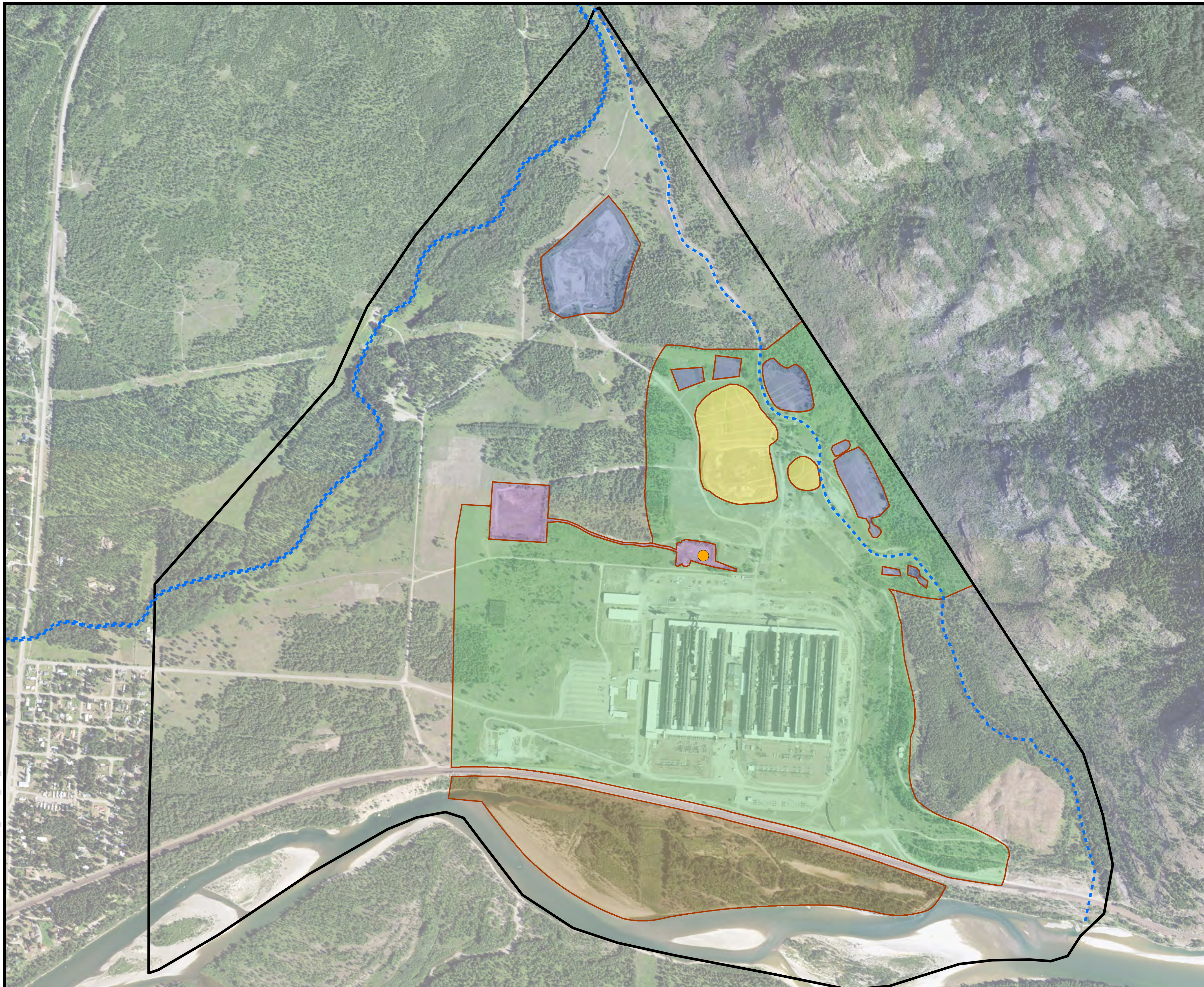


V:\GIS\PROJECTS\2476Y\0001Y\256\H15. SW_BENZO_GHI_P.MXD

CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- ND - 0.44 (LESS THAN CHRONIC CRITERION PRG)
- 0.44 - 1.82 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >1.82 (GREATER THAN ACUTE CRITERION PRG)

NOTES

1. DEQ-7 AQUATIC LIFE STANDARDS ARE NOT AVAILABLE FOR THIS PAH; FINAL CHRONIC VALUE AND FINAL ACUTE VALUE PROVIDED BY USEPA (SEE APPENDIX B).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

Title:

CONCENTRATIONS OF BENZO[G,H,I]PERYLENE IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

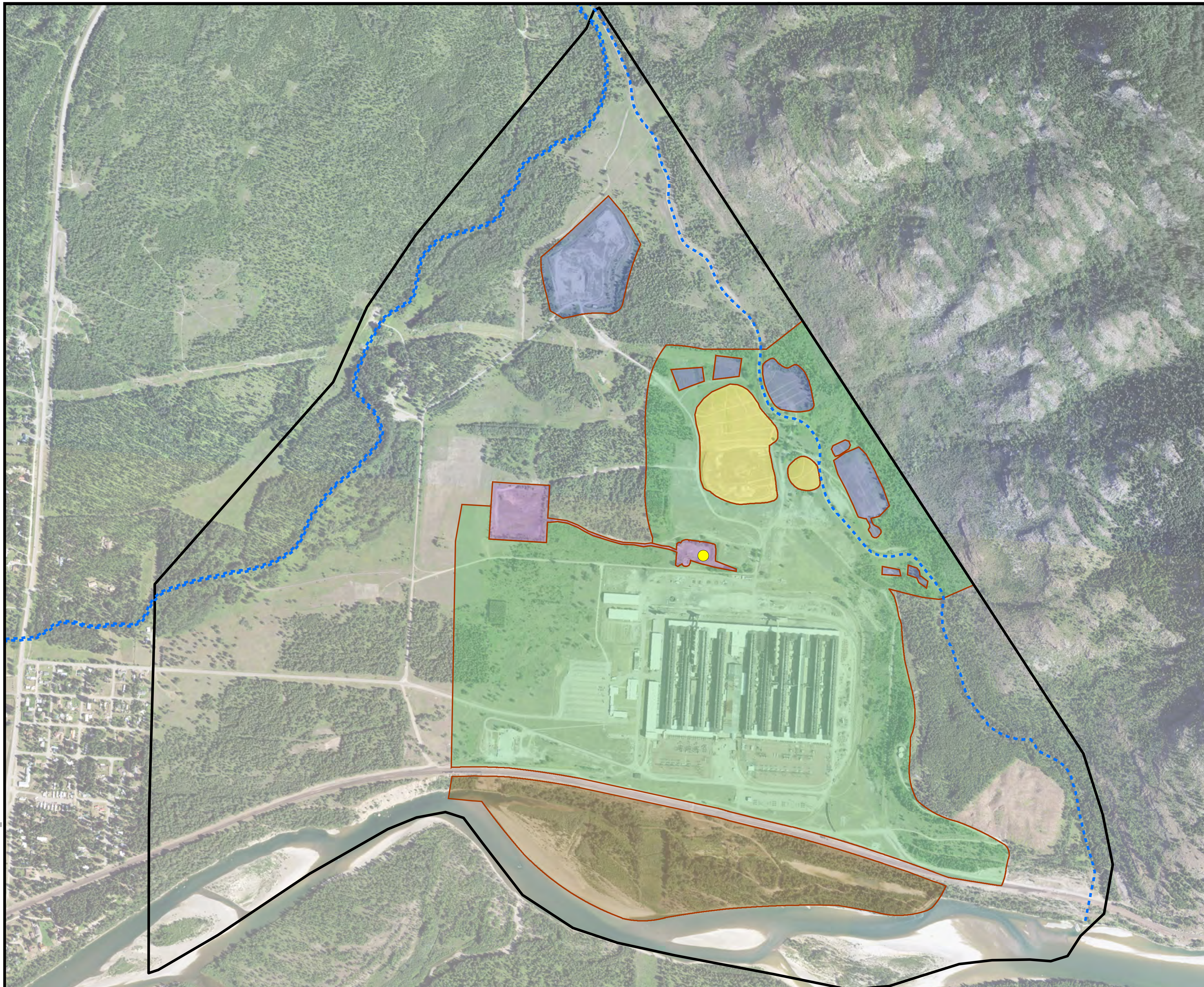
2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/12/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H15
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H15. SW_Benzo_ghi_p.mxd		



CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- ND - 2.04 (LESS THAN CHRONIC CRITERION PRG)
- 2.04 - 8.49 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >8.49 (GREATER THAN ACUTE CRITERION PRG)

NOTES

1. DEQ-7 AQUATIC LIFE STANDARDS ARE NOT AVAILABLE FOR THIS PAH; FINAL CHRONIC VALUE AND FINAL ACUTE VALUE PROVIDED BY USEPA (SEE APPENDIX B).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

N

1,000 0 1,000'

Title:

CONCENTRATIONS OF CHRYSENE IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

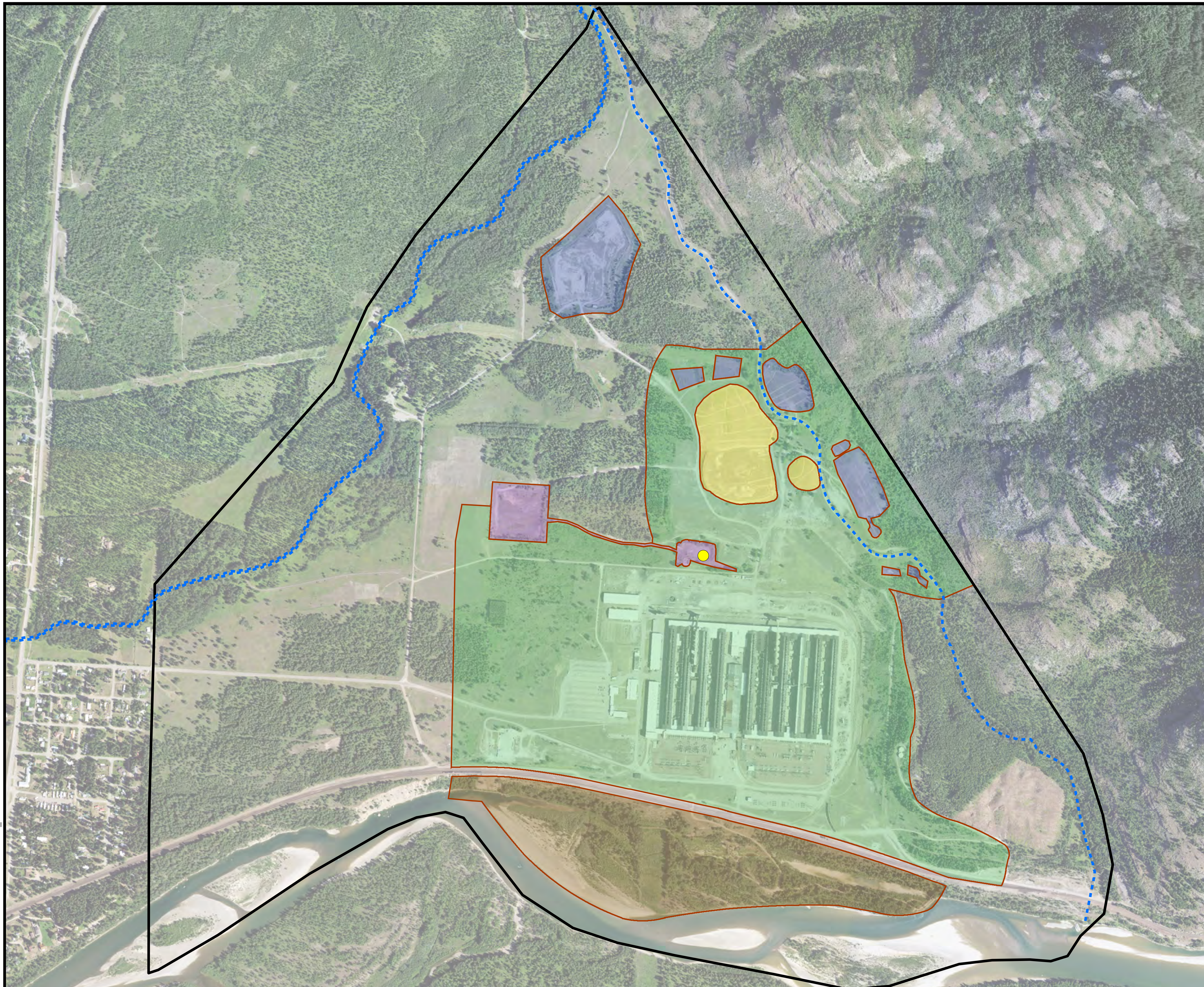
Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/12/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H16
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H16. SW_Chrysene.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\H16. SW_CHRYSENE.MXD



CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- ND - 7.11 (LESS THAN CHRONIC CRITERION PRG)
- 7.11 - 29.5 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >29.5 (GREATER THAN ACUTE CRITERION PRG)

NOTES

1. DEQ-7 AQUATIC LIFE STANDARDS ARE NOT AVAILABLE FOR THIS PAH; FINAL CHRONIC VALUE AND FINAL ACUTE VALUE PROVIDED BY USEPA (SEE APPENDIX B).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

Title:

CONCENTRATIONS OF FLUORANTHENE IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

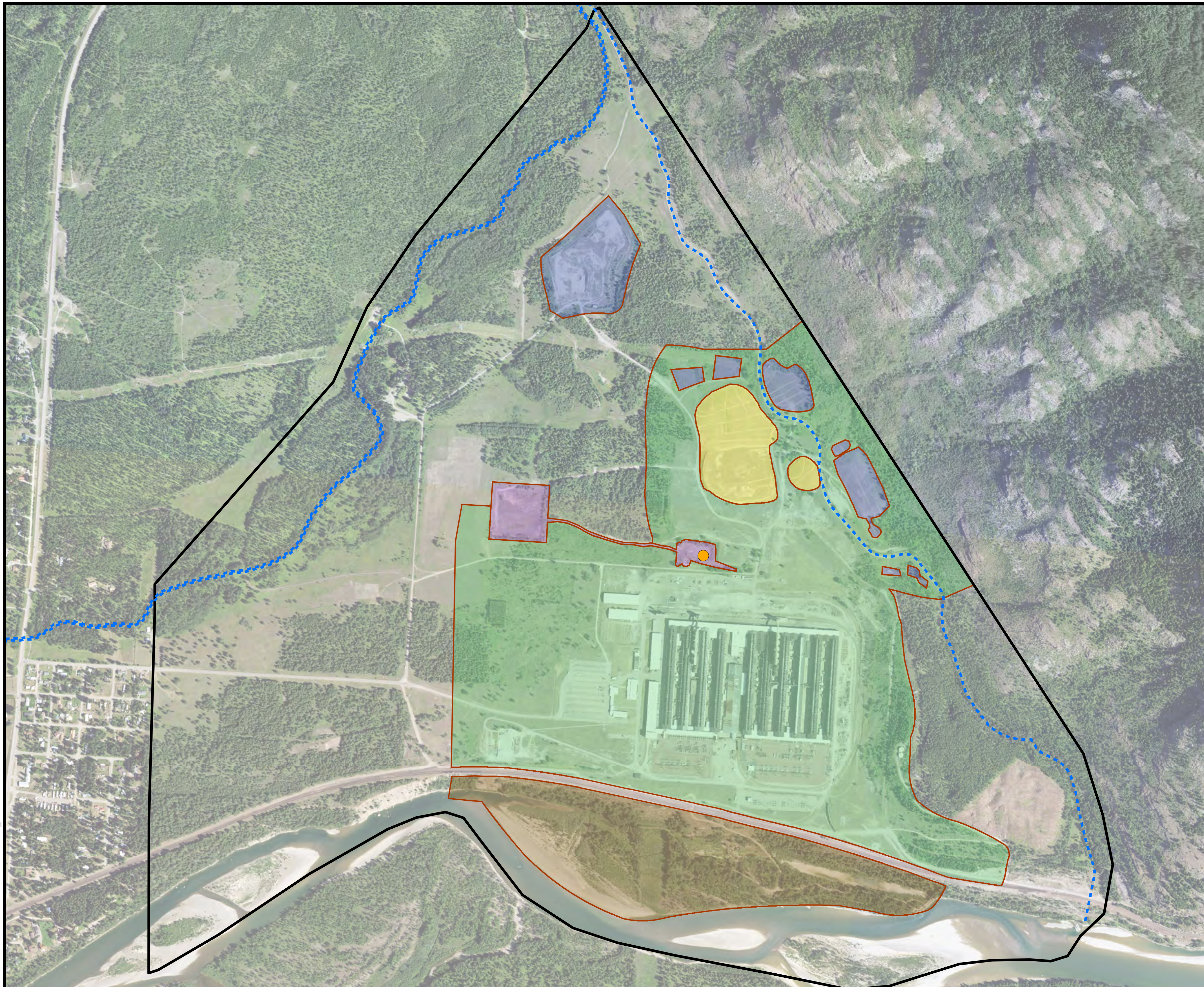
Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/12/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H17
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H17. SW_Fluoranthene.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\H17. SW_FLUORANTHENE.MXD



CONCENTRATION LEGEND - EA 2

- ANALYTE NOT DETECTED
- ND - 0.28 (LESS THAN CHRONIC CRITERION PRG)
- 0.28 - 1.14 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >1.14 (GREATER THAN ACUTE CRITERION PRG)

NOTES

1. DEQ-7 AQUATIC LIFE STANDARDS ARE NOT AVAILABLE FOR THIS PAH; FINAL CHRONIC VALUE AND FINAL ACUTE VALUE PROVIDED BY USEPA (SEE APPENDIX B).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

Title:

CONCENTRATIONS OF INDENO[1,2,3-CD]PYRENE IN SURFACE WATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/12/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	H18
Project Mgr: L.J.	Project: 2476.0001Y008	
File: H18. SW_Indeno.mxd		

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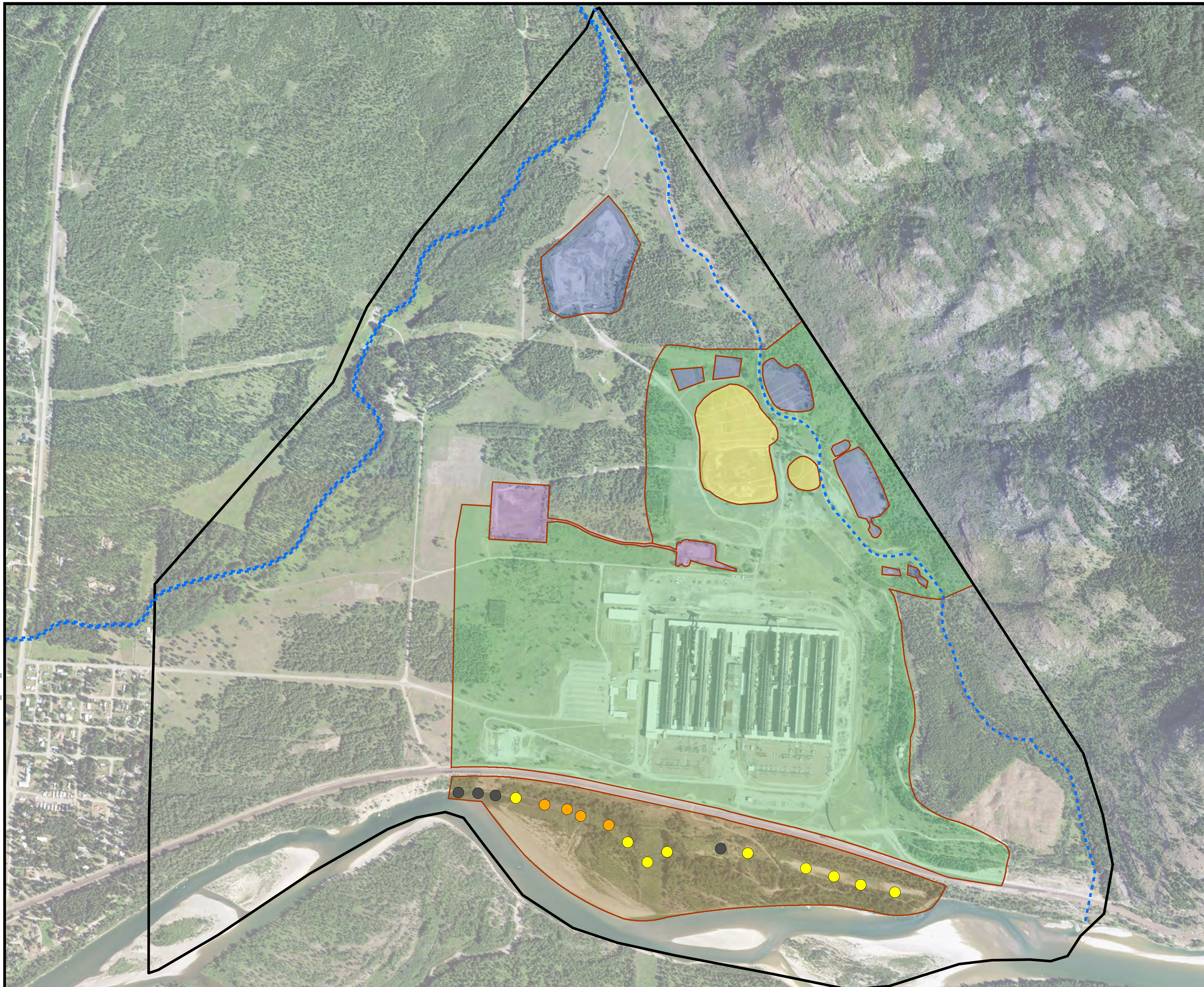
APPENDIX I

Ecological PRG Comparison – Porewater Thematic Maps

1. Exceedances of Ecological PRGs in Porewater Samples
2. Concentrations of Dissolved Barium in Porewater – Ecological PRG Comparison
3. Concentrations of Dissolved Cyanide in Porewater – Ecological PRG Comparison
4. Concentrations of Dissolved Free Cyanide in Porewater – Ecological PRG Comparison



N

CONCENTRATION LEGEND - EA 8, 9, 12 & BSSA

- LOCATION WITH NO EXCEEDANCES
- LOCATION WITH ONE OR MORE EXCEEDANCES OF A CHRONIC CRITERION PRG
- LOCATION WITH ONE OR MORE EXCEEDANCES OF AN ACUTE CRITERION PRG

NOTE

1. DEQ-7 AQUATIC LIFE STANDARDS FOR SURFACE WATER ARE USED AS THE POREWATER ECOLOGICAL PRGS.

1,000 0 1,000'

Title:

EXCEEDANCES OF ECOLOGICAL PRGS IN POREWATER SAMPLES

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

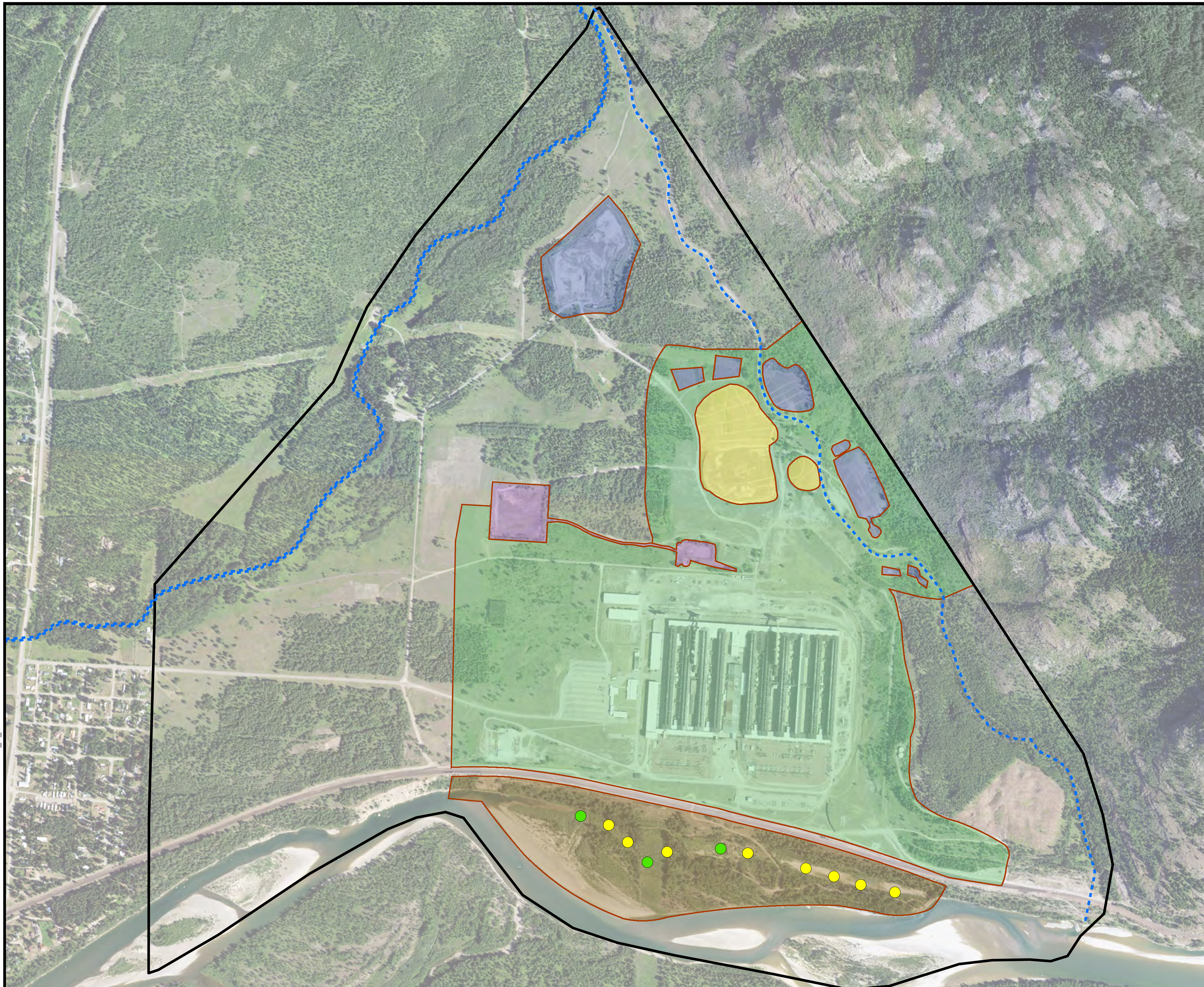
Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	I1
Project Mgr: L.J.	Project: 2476.0001Y008	
File: I1. Exceedances_Eco_PW.mxd		

V:\GIS\PROJECTS\2476Y\0001Y\256\APPENDIX I - ECO PW\I1. EXCEEDANCES_ECO_PW.MXD



N

1,000 0 1,000'

CONCENTRATION LEGEND - EA 8 & 12

- ANALYTE NOT DETECTED
- ND - 220 (LESS THAN CHRONIC CRITERION PRG)
- 220 - 2,000 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >2,000 (GREATER THAN ACUTE CRITERION PRG)

NOTES

1. DEQ-7 ACUTE AQUATIC LIFE STANDARDS ARE NOT AVAILABLE FOR BARIUM; CHRONIC AND ACUTE CRITERION DERIVED BY THE OHIO ENVIRONMENTAL PROTECTION AGENCY (SEE APPENDIX B).
2. ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

Title:

CONCENTRATIONS OF DISSOLVED BARIUM IN POREWATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	I2
Project Mgr: L.J.	Project: 2476.0001Y008	
File: I2. PW_D_Barium.mxd		

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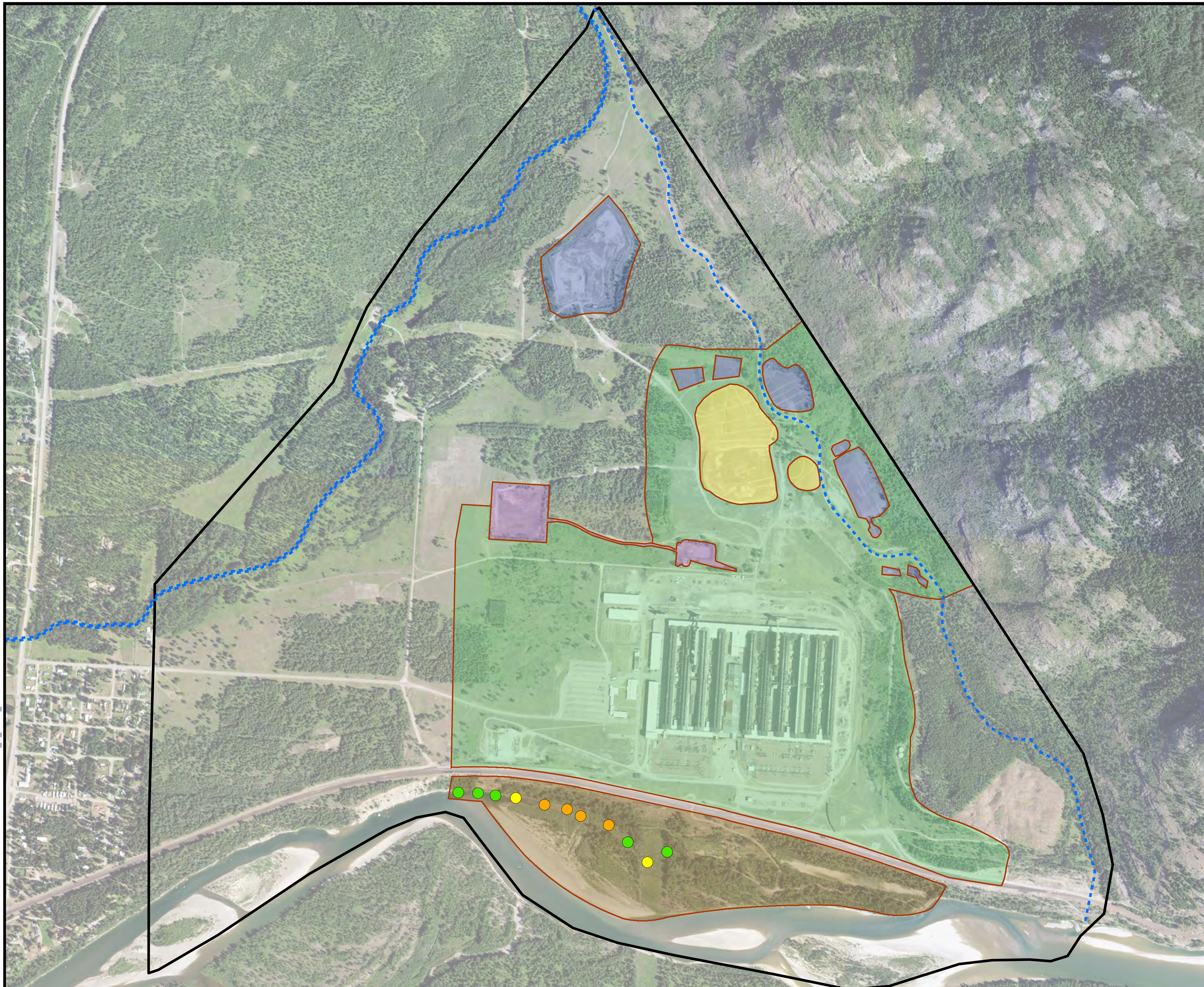

N

CONCENTRATION LEGEND - EA 8 & 9

- ANALYTE NOT DETECTED
- ND - 5.2 (LESS THAN CHRONIC CRITERION PRG)
- 5.2 - 22 (GREATER THAN CHRONIC CRITERION PRG, LESS THAN ACUTE CRITERION PRG)
- >22 (GREATER THAN ACUTE CRITERION PRG)

ALL CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µG/L)

1,000 0 1,000'

Title:

CONCENTRATIONS OF DISSOLVED FREE CYANIDE IN POREWATER – ECOLOGICAL PRG COMPARISON

2000 ALUMINUM DRIVE
COLUMBIA FALLS, MONTANA

Prepared for:

COLUMBIA FALLS ALUMINUM COMPANY, LLC

ROUX

Compiled by: C.S.	Date: 03/13/20	APPENDIX
Prepared by: M.S.R.	Scale: AS SHOWN	I3
Project Mgr: L.J.	Project: 2476.0001Y008	
File: I3. PW_D_Free_Cyanide.mxd		

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