TETRA TECH

FOCUSED FEASIBILITY STUDY
REVISION NO. 2

Operable Unit No.1
North Alcoa Site
East St. Louis, Illinois

April 12, 2012

complex world

CLEAR SOLUTIONS™

Focused Feasibility Study
Revision No. 2

Operable Unit No. 1
North Alcoa Site
East St. Louis, IL

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TABLE OF CONTENTS

TABLE OF CONTENTS i
LIST OF TABLES iii
LIST OF FIGURES iii
LIST OF APPENDICES iv
LIST OF ACRONYMS v
EXECUTIVE SUMMARY ..... ES - 1
1.0 INTRODUCTION 1
1.1 Overview of the RI/FS Process 2
1.2 Relationship to Other Documents 3
1.3 Report Organization 4
2.0 SUMMARY OF REMEDIAL INVESTIGATION REPORT AND RISK ASSESSMENTS 5
2.1 Site History 5
2.2 Remedial Investigation Report 5
2.2.1 Site Characterization 7
2.2.2 Nature and Extent of Contamination 8
2.2.2.1 Surface Soil 9
2.2.2.1.1 Metals 9
2.2.2.1.1.1 IB-1 – Residue Disposal Areas 10
2.2.2.1.1.2 IB-2 – Gypsum Dike Areas 11
2.2.2.1.1.3 IB-3 – Other Areas of Alcoa Activities 11
2.2.2.1.1.4 IB-4 – Other Areas of North Alcoa Site 11
2.2.2.1.2 Fluoride, Cyanide and pH 11
2.2.2.1.3 Organics 12
2.2.2.1.4 Radiological Analyses 15
2.2.2.2 Subsurface Soil 16
2.2.2.2.1 Metals 16
2.2.2.2.1.1 IB-1 – Residue Disposal Areas 17
2.2.2.2.1.2 IB-2 – Gypsum Dike Areas 18
2.2.2.2.1.3 IB-3 – Other Areas of Alcoa Activities 18
2.2.2.2.1.4 IB-4 – Other Areas of North Alcoa Site 18
2.2.2.2.2 Fluoride, Cyanide and pH 18
2.2.2.2.3 Organics 19
2.2.2.3 Sediment 22
2.2.2.3.1 Metals 22
2.2.2.3.2 Fluoride, Cyanide and pH 22
2.2.2.3.3 Organics 23
2.2.2.4 Surface Water 25
2.2.2.4.1 Metals 25
2.2.2.4.1.1 Total Metals 25
2.2.2.4.1.2 Dissolved Metals 26
2.2.2.4.2 Fluoride, Cyanide, Sulfide, and pH 27
2.2.2.4.3 Organics 28
2.2.2.5 Groundwater 29
2.2.2.6 Geotechnical Samples 30
2.2.2.6.1 IB-1 – Residue Disposal Areas 30
2.2.2.6.2 IB-2 – Gypsum Dike Areas 31

2.2.2.6.3 IB-4 – Other Areas of North Alcoa Site 31
2.2.2.7 Agronomic Samples 31
2.2.2.8 Phase 2 Ecological Data Collection 32
2.2.2.8.1 Surface Soil Samples 32
2.2.2.8.2 Vegetation Samples 33
2.2.2.8.3 Terrestrial Invertebrate Samples 34
2.2.2.9 Off-Site Boring Investigation 35
2.3 Baseline Human Health Risk Assessment 35
2.3.1 Human Health External Radiation Risk Uncertainty 37
2.3.2 Respondent Position on Hypothetical Nature of Residential Scenario 37
2.3.3 BHHRA Conclusions 38
2.4 Baseline Ecological Risk Assessment 41
2.4.1 Ecological Risk Assessment for Pond in IB-1b 42
2.5 Surface Water 43
3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS 44
4.0 REMEDIAL ACTION OBJECTIVES 59
5.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES 61
5.1 General Response Actions 61
5.2 Identification of Potential Technologies 61
6.0 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES 63
6.1 RAA-0 No Action 63
6.2 RAA-1 Restricted Access 63
6.3 RAA-2 Containment with Placement of an ARAR-compliant Soil Cover and On-Site Storm Water Management 63
6.3.1 Soil Cover (IB-1 and IB-4a) 65
6.3.2 Soil Cover (IB-2) 66
6.3.3 Surface Water Control/Conveyance (IB-4a) 67
6.3.4 No Action Planned (IB-3c and IB-4b) 67
6.3.5 Backfill/Grading (IB-4d) 68
7.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES 69
7.1 RAA-0 No Action 70
7.2 RAA-1 Restricted Access 71
7.3 RAA-2 Containment with Placement of ARAR-Compliant Soil Cover and On-Site Storm Water Management 71
8.0 COMPARATIVE ANALYSIS OF ALTERNATIVES 75
8.1 Overall Protection of the Human Health and the Environment 75
8.2 Compliance with ARARs 75
8.3 Long-Term Effectiveness and Permanence 75
8.4 Short-Term Effectiveness 75
8.5 Implementability 76
8.6 Cost 76
9.0 REFERENCES 77

LIST OF TABLES

Table 2-1 Summary of the Chemical Composition of Bauxite Residue and Gypsum
Table 2-2 RME and CT Summed Theoretical Excess Lifetime Cancer Risks – Site-wide Scenarios
Table 2-3 RME and CT Summed Noncancer Hazard Summary – Site-wide Scenarios
Table 2-4 Exposure Point Concentration Summary – Operable Unit 1 Surface Soil
Table 2-5 RME Summed Risk Results – Operable Unit 1 Trespasser Scenario
Table 2-6 Summary of Baseline Ecological Risk Conclusions
Table 5-1 Identification of Potential Applicable Technologies and Process Options
Table 8-1 Summary of CERCLA Evaluation Criteria

LIST OF FIGURES

Figure 1-1 Site Location Map
Figure 1-2 Proposed Operable Unit No. 1 Boundary
Figure 2-1 Investigative Blocks
Figure 2-2 Site Topographic Map from February 2005
Figure 2-3 Geologic Cross Sections A-A' and B-B'
Figure 2-4 Property Ownership within Operable Unit No. 1
Figure 2-5 Known Extent of Bauxite Residue and Gypsum
Figure 2-6 Histograms of Selected COPCs in Bauxite Residue
Figure 2-7 Aluminum Results of Sitewide Surface Soil Samples
Figure 2-8 Arsenic Results of Sitewide Surface Soil Samples
Figure 2-9 Lead Results of Sitewide Surface Soil Samples
Figure 2-10 Thallium Results of Sitewide Surface Soil Samples
Figure 2-11 Vanadium Results of Sitewide Surface Soil Samples
Figure 2-12 Fluoride, Cyanide, and pH Results of Sitewide Soil Samples
Figure 2-13 Organics Results of Sitewide Surface Soil Samples
Figure 2-14 Total Radium (Ra-226 & Ra-228) Results in Surface Soil Samples
Figure 2-15 Location and Metals Results of Sitewide Subsurface Soil Samples
Figure 2-16 Fluoride, Cyanide and pH Results of Sitewide Subsurface Soil Samples
Figure 2-17 Organics Results of Sitewide Subsurface Soil Samples
Figure 2-18 Metals Results of Sitewide Sediment Samples

Figure 2-19 Fluoride, Cyanide and pH Results of Sitewide Sediment Samples
Figure 2-20 Organics Results of Sitewide Sediment Samples
Figure 2-21 Total and Dissolved Metal Results of Sitewide Surface Water Samples
Figure 2-22 Fluoride, Cyanide, pH and Sulfate Results of Sitewide Surface Water Samples
Figure 2-23 Organics Results of Sitewide Surface Water Samples
Figure 2-24 Analytical Results of Sitewide Groundwater Samples
Figure 2-25 Locations of Phase 2 Ecological Samples
Figure 2-26 Offsite Investigatory Borings Remedial Investigation
Figure 6-1 RAA-2 Conceptual Design – Plan View
Figure 6-2 RAA-2 Conceptual Design – Cross Section

LIST OF APPENDICES

Appendix A USEPA Baseline Residential, Industrial/Commercial Worker, and Trespasser Risk Calculations
Appendix B ARAR Analysis
Appendix C Radiological Survey Report
Appendix D ProUCL Inputs/Outputs and OU-1 Risk Spreadsheets
Appendix E Summary of Revised Risk Calculations for Pond in IB-1b Using Organic Layer COPC Concentrations
Appendix F Radiation Risk Shielding Calculations
Appendix G Preliminary Engineering Cost Estimates

LIST OF ACRONYMS

AOC	Administrative Order on Consent
ARARs	Applicable or Relevant and Appropriate Standards, Limitations, Criteria, and Requirements
BERA	Baseline Ecological Risk Assessment
BHHRA	Baseline Human Health Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COIs	Chemicals of Interest
COPCs	Chemicals of Potential Concern
COPECs	Constituents of Potential Ecological Concern
ECOIs	Ecological Chemicals of Interest
FEMA	Federal Emergency Management Agency
FS	Feasibility Study
FFS	Focused Feasibility Study
FFS-OU1	Focused Feasibility Study for Operable Unit No. 1
HASP	Health and Safety Plan
IAC	Illinois Administrative Code
IB	Investigative Block
IEPA	Illinois Environmental Protection Agency
IUECA	Illinois Uniform Environmental Covenant Act
MTBE	Methyl-tert-butyl ether
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ORP	Oxidative/Reduction Potential
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU-1	Operable Unit No. 1
PAH	Polynuclear Aromatic Hydrocarbon
PRG	Preliminary Remediation Goals
RAA	Remedial Action Alternative
RAO	Remedial Action Objective
RBCs	Risk-Based Concentrations
RDA	Residue Disposal Area

RfD	Reference Dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RSD	Risk-Specific Dose
RSL	Regional Screening Levels
SOW	Statement of Work
SPL	Spent Potliner
SPT	Standard Penetration Test
SVOC	Semi-volatile Organic Compound
TACO	Tiered Approach to Corrective Action Objectives (35 IAC Part 742)
TBC	To Be Considered
TCLP	Toxicity Characteristic Leaching Procedure
UCL	Upper Confidence Limit
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

This Focused Feasibility Study for Operable Unit No. 1 (FFS-OU1) has been prepared pursuant to the Administrative Order on Consent (AOC) for the North Alcoa Site (the "Site"), East St. Louis, Illinois. The AOC with the United States Environmental Protection Agency (USEPA) requires the Respondents, Alcoa and the City of East St. Louis, to conduct a Remedial Investigation and Feasibility Study (RI/FS) of hazardous substances associated with the former Alcoa operations at the Site.

In the interest of facilitating Site redevelopment, the Respondents and USEPA have agreed that the Site will be subdivided into Operable Units. The geographic extent of Operable Unit No. 1 (OU-1) is shown in Figure 1-1, and includes the bauxite residue impoundments, gypsum areas, and other adjacent areas. The boundaries of OU-1 lie entirely within the municipal limits of the City of East St. Louis and are intended to encompass a contiguous part of the property with common environmental, geotechnical, water management and property ownership attributes that are conducive to redevelopment by a single entity. All property within OU-1 is currently owned only by either the City of East St. Louis or the Alton & Southern Railroad. Land use of OU-1 is zoned industrial, and while there are no specific individual industrial or commercial uses of OU-1 assumed or required for purposes of this report, the area is suitable for a solar project. Numerous economic and regulatory factors beyond CERCLA will determine whether a solar project would actually be constructed in OU-1.

The FS process builds upon site characterization information, the nature and extent of contamination, and the risk to human health and the environment presented in the Draft Remedial Investigation (RI) Report (Alcoa and the City of East St. Louis, 2005a) and the Draft Revised RI Report (Alcoa and the City of East St. Louis, 2009a). The Draft Baseline Human Health Risk Assessment (BHHRA) (Alcoa and the City of East St. Louis, 2005b) and the Draft Baseline Ecological Risk Assessment (BERA) (Alcoa and the City of East St. Louis, 2005c) were submitted on February 15, 2005 and February 17, 2005, respectively. The documents were revised in response to USEPA comments and resubmitted on April 15, 2010 (Alcoa and the City of East St. Louis, 2010a and 2010b). None of these reports have been finalized to date.

Section 2.0 of FFS-OU1 summarizes the 2009 Draft Revised RI Report and 2010 risk assessments and is not repeated in detail in this Executive Summary. Fundamentally, there are two primary waste materials remaining from former Alcoa operations within OU-1:

- Bauxite residue produced from the bauxite ore refining process, which used caustic to separate aluminate liquor from the insoluble bauxite residue ("red mud"); and
- Gypsum produced from the reaction of fluorspar and sulfuric acid to produce hydrofluoric acid, which was used to produce anhydrous aluminum fluoride.

The bauxite residue was initially placed into the former Pittsburg Lake, below current regional grade, and subsequently into three above-grade residue disposal areas (RDAs), impounded by gypsum berms (the Gypsum Area) around the perimeter of the RDAs (Figure 1-2). There is a fourth accumulation of bauxite residue between the three RDAs and the Lake Drive.

The placement of bauxite residue and gypsum basically governs the nature and extent of contamination at the Site. The bauxite residue is composed of relatively insoluble iron silicate

minerals with a variety of naturally occurring trace metals and metalloids. Bauxite residue is alkaline and requires various natural and/or man-made neutralization processes to achieve a circumneutral pH condition suitable for plant growth. The gypsum is composed primarily of calcium sulfate, but also contains trace amounts of minerals and metalloids, including lead. Two samples were collected within OU-1 and analyzed for TCLP metals during the 1996 CERCLA redevelopment study funded by USEPA and conducted by Illinois Environmental Protection Agency (IEPA) (IEPA, 1999). Lead was detected in one sample of gypsum at a concentration greater than the TCLP criteria.

Although slightly acidic pH values were reported in subsurface samples during the RI in areas of IB-2 and IB-3 (average pH of 5.54 and 6.02, respectively), these measurements are not representative of the entire subsurface conditions at the Site. Most of the IB-2 and IB-3 areas are underlain with significant accumulations of alkaline bauxite residue at depth (infilling of the former Pittsburgh Lake). Thus large-scale migration of groundwater in the subsurface is expected to be buffered by the alkaline material, decreasing the mobility of pH-dependent COCs. Therefore the TCLP results are not expected to be representative of the migration potential of metals and metalloids at the Site. Groundwater monitoring data collected during the RI provides evidence that Site metals and metalloids are not being leached to the aquifer.

USEPA agreed that TCLP results are not representative of Site conditions as stated in the USEPA revised ARARs analysis (provided by email from USEPA on March 23, 2012):

> *"The 1996 gypsum dike TCLP leaching test is not representative of site conditions of this land-filled fluorogypsum waste material. The TCLP leaching test is representative of an acidic (low pH) environment; the Alcoa site gypsum waste area has a very high pH (basic). Consequently, contaminants in the gypsum area IB-2 are not believed to present a leaching risk to the surrounding environment, as evident by groundwater monitoring data conducted to date at the site."*

Therefore, the nature and extent of contamination can be summarized by:

1) Maps of the extent of bauxite residue and gypsum (Figure 2-5); and
2) A table (Table 2-1) and figure (Figure 2-6) summarizing the chemical composition of bauxite residue and gypsum.

As requested by USEPA, tables and drawings from the draft RI Report depicting the nature and extent of Chemicals-of-Potential-Concern (COPC) are included in this FFS in Section 2.2.2.

The Draft Revised BHHRA (Alcoa, 2010a) concludes that risk to current receptors (trespassers) at the Site is within the USEPA risk range. During preparation of FFS-OU1, USEPA has directed the Respondents to include the following potential future exposure scenarios in the calculation of baseline risks (i.e., future risks that could occur if no further removal or remediation action is taken):

- Residential exposure on the barren RDAs (IB-1) and Gypsum Areas (IB-2) and the North Wet Area (IB-4a), and

- Industrial worker exposure on the barren RDAs (IB-1) and Gypsum Areas (IB-2) and the North Wet Area (IB-4a).

The Investigative Block (IB) nomenclature is explained in Section 2.2.

USEPA personnel performed baseline risk calculations for potential future residential, industrial, and current trespasser receptors. The USEPA risk calculation work product is included in its entirety in Appendix A. In summary, the USEPA future residential and industrial worker exposure scenarios assume exposure in these areas, using concentrations measured during the RI (i.e., without site improvements), for a duration of 30 years for residential and trespasser receptors, and 25 years for industrial worker scenarios. The USEPA cumulative risk calculations exceed the USEPA risk range of 10^{-4} to 10^{-6} for potential future residential receptors in the RDAs and Gypsum Areas, and potential future industrial workers in the RDAs. The cumulative risks for each scenario and investigation block is summarized below.

Potential Future Exposure Scenario	Type of Risk	IB-1	IB-2	IB-4a
Residential	Carcinogenic	4×10^{-3}	3×10^{-4}	6×10^{-5}
Residential	Non-carcinogenic (HQ) - Child	3	1.56	1.8
Industrial	Carcinogenic	1×10^{-3}	8×10^{-5}	8×10^{-6}
Industrial	Non-carcinogenic (HQ)	0.2	0.08	0.09
Trespasser	Carcinogenic	5×10^{-5}	4×10^{-6}	2×10^{-6}
Trespasser	Non-carcinogenic (HQ) - Adolescent	0.05	0.02	0.03

A discussion of the uncertainty in the risk calculations for the trespasser scenario due to adherence of contamination to clothes and/or skin is provided in Section 2.3.1. The contribution to radiation risk from this mechanism is negligible.

The National Contingency Plan and USEPA guidance require a qualitative assessment of the likelihood of future exposure scenarios included in the BHHRA. The Respondents' assessment of the likelihood of the USEPA potential future scenarios are provided in Section 2.3.2.

The Draft Revised BERA (Alcoa and the City of East St. Louis, 2010b) concludes that although some individual organisms may experience exposure to chemicals that exceed toxicity reference values, risk to populations of non-protected species or individual organisms of special-status species appear to be low. Therefore there are no components of the Remedial Action Alternatives designed to address adverse risk to ecological receptors.

Both the 2010 Draft Revised BHHRA and 2010 Draft Revised BERA assess surface water pathways for the various exposure scenarios evaluated in each assessment. Neither the Draft Revised BHHRA nor the Draft Revised BERA indicate that exposure to chemicals of potential concern (COPCs) in surface water pathways exceed the USEPA risk range for the evaluated receptors.

Applicable or Relevant and Appropriate Requirements (ARARs) are evaluated in Section 3.0 and Appendix B. IEPA has indicated they will require placement of two feet of cover in accordance with 35 IAC 807.305(c) over the bauxite residue and gypsum areas. 40 CFR 192 is also an ARAR.

Remedial action objectives (RAO) are presented in Section 4.0. The BHHRA concludes that if future land use of OU-1 is industrial, then there are areas of IB-2 containing lead that require development of a remedial action objective that is protective of future industrial land workers. Therefore the first RAO for soil in OU-1 is:

> *Prevent future direct contact by humans working in industrial exposure scenarios to soil with lead concentrations characterized by a 95% Upper Confidence Limit of the arithmetic mean of soil samples collected within an investigative block of greater than 800 mg/kg, which is the IEPA screening level for industrial/commercial exposure.*

IEPA has indicated placement of two feet of cover over the bauxite residue and gypsum areas in accordance with 35 IAC 807.305(c) is an ARAR for the Site. Compliance with ARARs is one of the remedial alternative threshold screening criteria; therefore the second RAO for soil in OU-1 is:

> *Prevent future human exposure (absorption, ingestion, and/or external radiation) from contaminants, including naturally occurring radium and other radionuclides found in bauxite residue and gypsum waste exceeding the USEPA baseline risk range of 10^{-4} and 10^{-6} by placement of an ARAR-compliant soil cover in accordance with 35 IAC 807.305(c).*

As stated in the revised ARARs analysis (March 23, 2012) provided by USEPA, bauxite materials found in IB-3 and IB-4 were primarily found at depth below two feet (old Pittsburgh Lake) in site borings and surficial materials are sufficiently stable at present; therefore the two foot cover is not required.

The baseline risk calculations prepared by USEPA discussed above calculated radiological risk for the residential, industrial worker and trespasser receptors. These risk calculations suggest that there may be a potential future risk greater than the USEPA risk range for residential and a full-time industrial worker. Another potential exposure issue to address in the remedial alternatives evaluation is the presence of radium and other radionuclides in the bauxite residue and gypsum. Naturally occurring radiation risk to trespassers under current site conditions is within or below the USEPA risk range. For other exposure scenarios to occur in the bauxite residue areas, site improvements such as a soil cover must be placed to allow access over the residue disposal areas, and the gypsum berms must be regraded; however, as part of the baseline risk assessment, USEPA required baseline residential and industrial exposure scenarios included in Section 2.3 and Appendix A. For the baseline residential and industrial scenarios for IB-1 and the residential scenario of IB-2, summed theoretical excess lifetime cancer risks for potential radiological exposure exceed the EPA's 10^{-4} to 10^{-6} risk range. The baseline industrial scenario of IB-2 and the baseline residential and industrial scenarios of IB-4 are within the EPA risk range. The summed noncancer hazards for young child receptors are somewhat greater than 1 for IB-1, IB-2, and IB-4.

As is generally also the case for chemical constituents, USEPA guidance on establishing cleanup levels for CERCLA sites with radioactive contamination (OSWER 9200.4-18) states that cleanups should generally achieve risk levels in the 10^{-4} to 10^{-6} range (USEPA, 1997b). Therefore the third RAO for soil in OU-1 is:

Prevent human exposure that yields cumulative risk (including radiation risk) exceeding the USEPA risk range of 10^{-4} to 10^{-6} or yields a chemical noncancer hazard index greater than 1.

Three general response actions are considered for these remedial objectives: no action, institutional controls, and containment. The remedial technology for institutional control is access restriction (i.e., environmental easement/restrictive covenant and fencing). The remedial technologies for containment are horizontal and vertical barriers and surface controls (regrading, storm water diversion and collection, and silt fencing). All of these technologies except vertical barriers are applicable to the Site and were used to assemble remedial action alternatives.

Three remedial action alternatives (RAA) were assembled:

- RAA-0 No Action;
- RAA-1 Restricted Access;
- RAA-2 Containment with Placement of an ARAR-Compliant Soil Cover and On-Site Storm Water Management; and

RAA-0 - No Action serves as a baseline against which other alternatives are evaluated. This and all the other alternatives take into account the removal action that has already occurred in the Former SPL Stockpiling Area, which removed principal threat material spent potlining (SPL) for off-site treatment and disposal.

RAA-1 – Restricted access consists of fencing and institutional controls to restrict access.

RAA-2 – Containment with Placement of an ARAR-Compliant Soil Cover and On-Site Storm Water Management employs various containment technologies including placement of a clean soil cover two feet thick, regrading of the gypsum dikes and an environmental easement/restrictive covenant to control future intrusive activities in these areas. The soil cover would be placed over IB-1, -2 and -4a excluding storm water retention areas. Future industrial/commercial activities at the Site would be acceptable based on mitigated risk and geotechnical stability provided by placement of cover material. Soils in the area of IB-3b that historically received runoff from RDA-1 (IB-1a) and containing surficial soil with radium concentrations exceeding the 40 CFR 192 ARAR will be removed or will be covered with a two feet thick ARAR-compliant cover. Placement of the clean soil cover layer over the RDAs and Gypsum Area will result in clean storm water, which will be directed to an on-Site storm water retention pond system consisting of current and newly constructed ponds. On-Site storm water retention ponds will be designed to contain storm water up to the 100-year design storm. In Areas IB-1b and -1c storm water in excess of the 100-year design storm will gravity drain through an overflow spillway and plunge pool to area IB-3b. Storm water in area IB-3b (located in both OU-1 and OU-2) will continue to be managed in the current manner. Surface drainage from Area IB-1a will flow to a retention pond directly west of the area. This retention pond will contain runoff from storms greater than a 100-year return period; if the retention pond should overflow excess water will flow south into IB-3b, where storm water will continue to be managed

in the current manner. A low berm will be constructed on the eastern boundary of OU-1 to further limit surface water runoff to the railroad and other properties.

A conveyance structure will be installed along Lake Drive to manage clean storm water along the right-of-way. The purpose of this storm water conveyance structure is to manage storm water associated with the area along Lake Drive and not to manage storm water from the interior of the Site (i.e., bauxite residue or gypsum areas). Storm water from the area along Lake Drive will not contact waste material at the Site; therefore it will be considered “clean” storm water. All other storm water in OU-1 will continue to be managed in the current manner.

The three RAAs are evaluated in detail relative to the CERCLA criteria in Section 7.0. The comparative analysis of remedial alternatives is provided in Section 8.0 and summarized in Table 8-1.

1.0 INTRODUCTION

This Focused Feasibility Study for Operable Unit No. 1 (FFS-OU1) has been prepared pursuant to the Administrative Order on Consent and Statement of Work (AOC/SOW) to conduct a Remedial Investigation/Feasibility Study (RI/FS) for the North Alcoa Site (the "Site"), East St. Louis (U.S. EPA Docket No. V-W-'03-C-728, signed December 31, 2002). The requirement for conducting a Feasibility Study for the Site is set forth in Section IX 27 D Task IV of the AOC. Alcoa, Inc. (Alcoa) and the City of East St. Louis (the City) are Respondents under the Consent Order with the U.S. Environmental Protection Agency (USEPA).

The RI/FS Work Plan (Alcoa and City of East St. Louis, 2003) provides the background information and risk-based technical approach necessary to design and implement the RI/FS studies, pursuant to the requirements of the AOC/SOW. FFS-OU1 has been prepared in accordance with USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988). Selection of the remedy for OU-1 is based on data collected from the OU-1 area, the results of baseline human health and ecological risk assessments conducted during the RI, and the revised ARARs analysis. The RI report and the risk assessments are draft and the RI for OU-2 has not been finalized.

The geographic scope of the RI/FS is based on a definition of the Site provided in the AOC/SOW (page 4):

> *"Site" or "Facility" or "North Alcoa Site" shall mean the facility as that term is defined at 42 U.S.C. Section 9601(9), which includes the following areas in East St. Louis, Illinois: 1) the property located north of Missouri Avenue, which is approximately bounded by 29th St. to the west, Alton Southern Railroad to the east and Lake Drive to the north; and 2) areas located north of Missouri Avenue where hazardous substances have or may have come to be located from former Alcoa operations.*

The overall Site boundary set forth in the first part of this definition is shown in Figure 1-1.

In the interest of facilitating Site redevelopment, the Respondents and USEPA have agreed that the Site will be subdivided into Operable Units. The geographic extent of Operable Unit No. 1 (OU-1) is shown in Figure 1-2, and includes the bauxite residue impoundments, gypsum areas, and other adjacent areas. The boundaries of OU-1 lie entirely within the municipal limits of the City of East St. Louis and are intended to encompass a contiguous part of the property with common environmental, geotechnical, water management and property ownership attributes that are conducive to redevelopment by a single entity. The OU-1 boundary and the CERCLA Site boundary are coincident along the northern and eastern sides of OU-1. All property within OU-1 is currently owned only by either the City of East St. Louis or the Alton & Southern Railroad. Land use of OU-1 is zoned industrial, and while there are no specific individual industrial or commercial uses of OU-1 assumed or required for purposes of this report, the area has recently been determined to be suitable for limited redevelopment for surface use. Numerous economic and regulatory factors beyond CERCLA will determine whether a future surface use of the Site is feasible. Recently an analysis was completed that suggested a solar project could be constructed in OU-1. Therefore, the use of the term "solar project" in this report is not intended to commit future reuse of the Site, but to represent the type of future use that can include solar or other industrial and/or commercial redevelopment. The analysis for this FFS is for the data from the OU-1 area of the Site.

1.1 Overview of the RI/FS Process

The remedial investigation (RI) serves as the mechanism for collecting data to:

- characterize site conditions;
- determine the nature of the waste; and
- assess potential risk to human health and the environment.

The baseline human health and ecological risk assessments conducted during the RI and the revised ARARs analysis are used to develop Remedial Action Objectives (RAOs). The FS is the mechanism for the development, screening, and detailed evaluation of remedial action alternatives to accomplish the RAOs. The RI and the risk assessments for the entire Site (including OU-2) are draft and have not yet been finalized. To facilitate preparation of these documents, relevant data in the RI and risk assessments are either included herein or incorporated by reference. Additionally, risk calculations provided by USEPA are also included.

The development of remedial alternatives requires:

1) identifying RAOs;
2) identifying potential treatment, resource recovery, and containment technologies that will satisfy these objectives;
3) screening the technologies based on their effectiveness, implementability, and cost; and
4) assembling technologies and their associated containment or disposal requirements into alternatives for the contaminated media at the site or for the operable unit.

As stated in OSWER 9355.3-01, (Section 4.2.1):

> *Remedial action objectives consist of medium-specific or operable unit-specific goals for protecting human health and the environment…and should specify: 1). The contaminant(s) of concern, 2) exposure route(s) and receptor(s), 3) an acceptable contaminant level or range of levels for each exposure route (i.e., a preliminary remediation goal…)…Although the preliminary remediation goals are established on readily available information [e.g., reference doses (RfDs) and risk-specific doses (RSDs)] or frequently used standards (e.g., ARARs), the final acceptable exposure levels should be developed on the basis of the results of the baseline risk assessment and the evaluation of the expected exposures and associated risks for each alternative.*

Once potential alternatives have been developed, it may be necessary to screen out certain options to reduce the number of alternatives that will be analyzed. The screening process is designed to narrow the list of alternatives sent through to the detailed screening step based on effectiveness, implementability, and cost. It is usually done on a general basis and with limited resources, because the information necessary to fully evaluate the alternatives may not be complete at this point in the process.

Detailed analysis is the last phase of the RI/FS process. Once sufficient data are available, alternatives are evaluated in detail with respect to nine evaluation criteria that the USEPA has developed to address the statutory requirements and preferences of Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The nine criteria include:

1) overall protection of human health and the environment;
2) compliance with Applicable or Relevant and Appropriate Standards, Limitations, Criteria, and Requirements (ARARs);
3) long-term effectiveness and permanence;
4) reduction of toxicity, mobility, or volume;
5) short-term effectiveness;
6) implementability;
7) cost;
8) State acceptance; and
9) community acceptance.

The first two criteria are “threshold” criteria, and the selected remedial action alternative must comply with these criteria (although it is possible to obtain a waiver for compliance with an ARAR under certain circumstances). The third through seventh criteria are “primary balancing” criteria and can help distinguish the various alternatives. USEPA is solely responsible for gathering information on and evaluating the last two criteria and therefore they are not considered in this FS. The alternatives are analyzed individually against each criterion and then compared against one another to determine their respective strengths and weaknesses and to identify the key trade-offs that must be balanced for the site. The results of the detailed analysis are summarized so that an appropriate remedy consistent with CERCLA can be selected by USEPA.

1.2 Relationship to Other Documents

The Draft RI Report (Alcoa and the City of East St. Louis, 2005a) was submitted to USEPA on February 22, 2005. USEPA provided written comments on the RI Report on March 22, 2005, and the RI was revised in response to those comments and resubmitted to USEPA on March 17, 2009 (Alcoa and the City of East St. Louis, 2009a). USEPA provided written comments on the Draft Revised RI Report on April 5, 2010 but the document has not yet been finalized. The Baseline Human Health Risk Assessment (BHHRA) (Alcoa and the City of East St. Louis, 2005b) and the Baseline Ecological Risk Assessment (BERA) (Alcoa and the City of East St. Louis, 2005c) were submitted on February 15, 2005 and February 17, 2005, respectively. USEPA provided written comments on the two risk assessments on March 22, 2005, and those documents were revised in response to those comments and resubmitted on April 15, 2010 (Alcoa and the City of East St. Louis, 2010a and 2010b). Like the RI Report, the risk assessments have also not been finalized. FFS-OU1 has been prepared using the information in the Draft Revised RI Report and revised risk assessments (including risk calculations provided by USEPA) and with knowledge of the USEPA comments on those prior reports.

Finalization of the Site-wide RI Report and risk assessments may result in some additional modifications that will need to be reflected in a finalized version of FFS-OU1.

1.3 Report Organization

The report is organized into the following sections:

- Section 2.0 Summary of Remedial Investigation Report and Risk Assessments
- Section 3.0 Applicable or Relevant and Appropriate Requirements
- Section 4.0 Remedial Action Objectives
- Section 5.0 Identification and Screening of Remedial Technologies
- Section 6.0 Development of Remedial Action Alternatives
- Section 7.0 Detailed Analysis of Remedial Alternatives
- Section 8.0 Comparative Analysis of Alternatives
- Section 9.0 References

2.0 SUMMARY OF REMEDIAL INVESTIGATION REPORT AND RISK ASSESSMENTS

This section summarizes the information presented in the 2009 Draft Revised RI Report (Alcoa and the City of East St. Louis, 2009a) and 2010 Draft Revised Human Health and Ecological Risk Assessments (Alcoa and the City of East St. Louis, 2010a and Alcoa and the City of East St. Louis, 2010b, respectively), which provide the foundation for FFS-OU1.

2.1 Site History

Manufacturing processes at the former Alcoa operations, the East St. Louis Works, occurred primarily on the south side of Missouri Avenue, where alumina and aluminum fluoride was produced from bauxite ore (Figure 1-1). The bauxite refining process uses hot sodium hydroxide (caustic) in a pressurized digester to separate the sodium aluminate liquor from the insoluble bauxite residue ("red mud"). From 1944 to 1946, as part of the World War II aluminum supply effort, red mud was sintered in rotary kilns with limestone and soda ash, and returned to the digesters to increase the yield of aluminum oxide. The residue from this process is "brown mud". Both forms of bauxite residue were disposed north of Missouri Avenue. Initially (at the beginning of the twentieth century) the bauxite residue was disposed in the former Pittsburg Lake, and then later in residue disposal areas, contained within gypsum berms. The gypsum was a byproduct of the hydrofluoric acid plant ("the Acid Plant"), which reacted fluorspar with sulfuric acid. Bauxite residue and gypsum are the primary waste products remaining at the North Alcoa Site. There are three large, named residue disposal areas (RDAs) of approximately 40 acres each (Figure 1-1) within the North Alcoa Site. These RDAs are adjacent to one another and form a roughly triangular shape of 120 acres with the three RDAs forming the apexes of the triangle (RDA 1 is the northwest apex; RDA 3 is the northeast apex; and RDA 2 is the south apex). There is a fourth accumulation of bauxite residue between the RDAs and Lake Drive. There were other Alcoa industrial operations south of Missouri Avenue, explained in detail in the Draft Revised RI Report, but these operations play little role in the nature and extent of waste materials north of Missouri Avenue. An exception is the cryolite recovery process, which involved stockpiling of spent potliner (SPL) within the North Alcoa Site prior to processing in operations located south of Missouri Avenue. The SPL stockpiling area (IB-3C) was the subject of an expedited cleanup process. Details of SPL removal are detailed in the Completion Report – Spent Potliner Removal (Alcoa and the City of East St. Louis, 2006). The Former SPL Stockpiling Area is identified on Figure 2-1.

2.2 Remedial Investigation Report

The Draft Revised RI Report documents the site characterization activities for the former Alcoa operations located north of Missouri Avenue. The site was divided into four investigative block (IB) areas (a total of 12 investigative sub-blocks) based on former or current Site land use, habitat, and other similar characteristics. The locations of the four IBs and sub-blocks are shown on Figure 2-1. The following is a list of the Investigative Blocks, and the terminology used in the RI/FS Work Plan (some sub-blocks are identified by property owners at that time, and some parcels have changed ownership). Investigative Blocks and sub-blocks located partially or wholly within OU-1 are listed in bold font.

IB-1 – Residue Disposal Areas

IB-1a – RDA 1 (The Old Pond)

IB-1b – RDA 2 (The Brown Mud Pond)

IB-1c – RDA 3 (The Red Mud Pond)

IB-2 – Gypsum Dike Areas

IB-3 – Other Areas of Alcoa Activities

IB-3a – Brick Works/Childs Property (now owned by John Paule Metal Recycling)

IB-3b – Redevelopment Area (a southern parcel is now owned by John Paule Metal Recycling)

IB-3c – SPL Stockpile Area

IB-4 – Other Areas of North Alcoa Site

IB-4a – North Wet Area

IB-4b – Triangle Wet Area

IB-4c – Ball Fields

IB-4d – Berm Wet Area

IB-4e – Active Commercial Area

As a point of clarification, IB-4 was initially termed "Other Areas of North Alcoa Site" because the review of records and maps conducted during preparation of the RI Work Plan did not identify any specific activities in these areas. Site reconnaissance and site characterization information collected during the RI indicates the presence of bauxite residue in IB-4a, the North Wet Area located between the RDAs and Lake Drive. There are lesser accumulations of residue in the subsurface elsewhere in IB-4, as discussed later.

In order to characterize the nature and extent of contamination on the Site, samples were collected of soil (surface and subsurface), sediment and surface water from 11 of the 12 subareas on the Site. The twelfth subarea, IB-3c, the SPL Stockpile Area was not sampled in Phase 1 of the RI, but test pits were dug to visually identify the extent of wastes. The results of the test pit excavation were reported to the USEPA in Technical Memorandum No. 4 (Alcoa and the City of East St. Louis, 2004d). An SPL Removal Plan was subsequently submitted for the area and presented in the Revised Final Spent Potliner Removal Plan (Alcoa and the City of East St. Louis, 2005d). The SPL Removal Action was performed in March 2006, and the SPL Removal results are presented in the Completion Report (Alcoa and the City of East St. Louis, 2006). A supplemental Field Sampling Plan (Alcoa and the City of East St. Louis, 2007) was prepared, and an investigation was conducted to characterize subsurface conditions following SPL removal. These investigation results are presented in Technical Memorandum 10 (Alcoa and City of East St. Louis, 2009b).

Most of the data were collected during the Phase 1 sampling efforts performed in the Fall of 2003. Additional data needed to reduce uncertainty in the ecological risk assessment were collected as Phase 2 efforts in the Fall of 2004. The sample collection methodology, data validation and presentation of analytical results are included in the Draft Revised RI Report. Key findings of the Draft Revised RI Report are summarized in the sections that follow.

2.2.1 Site Characterization

The Site is composed of three bauxite residue disposal areas generated from the alumina extraction processes as well as other fill materials. These deposits rise up to over 30 feet above the surrounding terrain (Figure 2-2). The dike at RDA-1 has been breached and a deeply incised, dendritic drainage pattern has developed within this area. Low lying areas outside of the RDAs consist of wet areas and uplands with various fill materials present at the surface.

Due to historical flooding and the need to promote development, much of this area has been built up by filling low-lying areas. Therefore, the majority of the surficial soils present in the City of East St. Louis today are fill material. The on-site fill material has been found to contain clay, sand, gravel-sized cinders (from burning coal), limestone fragments, cloth remains and organic material (IEPA, 1997). It is unclear how much of this material is related to former Alcoa operations. In addition to the fill material, bauxite residue and gypsum derived from Alcoa operations are found at the Site. The relationship of the bauxite residue and gypsum dikes to the underlying native geology is shown on cross sections A-A' and B-B' (Figure 2-3). The bauxite residue was initially deposited into low lying areas (e.g., former Pittsburg Lake) and then later into three mud lakes (residue disposal areas), which were contained by the gypsum dikes and a fourth area north of the three mud lakes and south of Lake Drive. The above grade waste impoundments at the Site are not within the boundary of the 100-year floodplain as mapped by the Federal Emergency Management Agency (FEMA) (2003a and 2003b).

The bauxite residue generally consists of fine-grained (generally >90% less than 200 sieve material) red or brown clay/silt material. The material has high moisture content, and below the near surface, it is a semi-solid. The bauxite residue is soft, highly plastic, thixotropic and not suitable as a subgrade for building construction or redevelopment without extensive engineering. Standard Penetration Test (SPT) measurements performed during the collection of geotechnical samples in the residue indicated that the samples were collected over the entire 6-inch sample interval without a single blow count (e.g., the residue could not support the weight of the sampling equipment and thus is termed "zero blow count"). While SPT measurements are primarily used to estimate relative density for granular deposits, the SPT information supports other conclusions that the residue cannot support physical structures or site redevelopment without installation of engineered surficial or soil cover layers. The residue has very poor trafficability when wet and can be difficult to access without special equipment even in dry conditions.

The RDAs have grown over with vegetation in most areas since the plant ceased operations in the 1950s. Vegetated and un-vegetated areas of bauxite residue are readily visible in the aerial photograph of Figure 1-1. The dikes around the RDAs are comprised primarily of gypsum, which was a byproduct from the Acid Plant. The gypsum is coarse- to fine-grained and semi-consolidated due to cementation. Gypsum occurring on the surface is readily visible as a light, whitish area on Figure 1-1. It is also mapped as an investigative block (IB-2) in Figure 2-1.

Annual precipitation for the area averages about 37 inches; however, the driest season is the winter, with only 18% of the annual precipitation occurring in December, January and February. The wettest period of the year is from March through July when 50% of the annual precipitation falls in this 5-month period. Annual snowfall averages about 20 inches.

Regional land use in the vicinity of the Site includes residential and other urban uses, industrial and commercial uses, and parks. The property to the north and east of the Site is mapped as residential or urban land use. The area southwest of the Site and south of Missouri Avenue is

industrial land use while land use within the Site is zoned industrial/commercial by the City of East St. Louis. Frank Holten State Park is east of the Site.

A detailed site ownership map for OU-1, obtained from the county tax assessor's office in 2003, is provided in Figure 2-4. We understand that two entities own property in OU-1. Much of the area was used for storage of bauxite residue and gypsum and is owned by the City of East St. Louis. Alton & Southern Railroad owns rail spurs along the eastern boundary of the Site, as well as inactive right-of-ways south and west of the residue disposal areas. The City of East St. Louis is in the process of evaluating the possibility of transferring ownership of the Alton & Southern Railroad parcels within OU-1 to the City.

Some of the inactive properties have been considered for redevelopment by various entities. A large area between the bauxite residue impoundments and Missouri Avenue was the subject of a CERCLA redevelopment study funded by USEPA and conducted by Illinois Environmental Protection Agency (IEPA) (IEPA, 1999). In 2010, approximately 20 acres of property to the south of OU-1 in the south-central portion of the Site along Missouri Avenue was purchased by John Paule Metal Recycling to house an auto recycling/crushing facility.

2.2.2 Nature and Extent of Contamination

The nature and extent of contamination in OU-1 primarily is governed by the presence or absence of bauxite residue and gypsum. Significant accumulations of these materials occur in defined areas. The gypsum occurs as berm material encompassing the RDAs (and as splitter dikes within the RDAs), and in the eastern part of RDA-2, where the City pushed gypsum over barren residue areas to control dusting. The extent of the gypsum occurring at the surface is shown in Figure 2-5. The bauxite residue also occurs in the subsurface (where used to infill Pittsburg Lake), within the RDAs, and in the North Wet Area (IB-4a). The bauxite residue and gypsum are relatively homogenous in chemical composition due to:

- Uniformity of ore material (the bauxite ore was transported only from the mines at Bauxite, Arkansas and Suriname, South America, and the fluorspar was shipped from the Fluorspar Mining District in southern Illinois);
- Uniformity of process (the bauxite refinery operated with little process change after 1911, and the Acid Plant process was not changed during the history of operations); and
- Transportation of the bauxite residue occurred by slurry pipeline from 1925 until the operations were shut down in 1957 (pumping residue through a long pipeline will further blend and homogenize the residue).

Therefore the nature and extent of contamination within OU-1 can be summarized by:

1) Maps of the extent of residue and gypsum (Figure 2-5); and
2) A table (Table 2-1) and figure (Figure 2-6) summarizing the chemical composition of residue and gypsum.

In an effort to summarize all collected data for the Site as requested by USEPA, this section also presents a summary of the results of the samples collected from the Site during the RI prior

to subdividing the Site into Operable Units. The data are summarized in tables embedded in the following subsections and on attached figures referenced herein. The data summaries include the number of times each constituent was detected in each IB, the average detection and the maximum detection. Data are categorized by the media sampled, the sample depth and by the IB in which they were collected. For the purpose of this discussion, the subareas within each IB have been combined, although pertinent results in some subareas have been extracted and reported separately. The concentrations of the constituents detected in the samples are compared to human health or ecologically based criteria in the companion risk assessments. As requested by the Agency, Regional Screening Levels (RSLs) used to identify COPCs in the BHHRA are provided in the summary tables for soil provided within the text of this Section. For more detailed information, please refer to the tables included in the Draft Revised RI report.

The following sections present the results of the samples by medium (e.g., surface soil, subsurface soil, surface water, sediment groundwater, etc.). Each section is further divided into subsections that present the sample results by analytical suite (e.g., metals, VOCs, SVOCs, etc.).

2.2.2.1 Surface Soil

For the purpose of the BHHRA, surface soil samples are defined as those samples collected within the 0-2 foot below ground surface (bgs) depth interval. The surface soil samples are used in the risk assessment for exposure pathways that involve contact with soil in the absence of excavation activities. The RI included the collection of 137 surface soil samples from the Site. Fifty-six surface soil samples were collected in IB-1, 18 were collected in IB-2, 40 were collected in IB-3 and 23 were collected in IB-4. The following subsections present a summary of the results of the surface soil samples.

2.2.2.1.1 Metals

All 137 of the surface soil samples collected from the Site were analyzed for metals and metalloids. Aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc were detected in the Site surface soil samples. Figures 2-7 through 2-11 provide the locations of the surface soil samples and the metals results for each sample that exceeds their respective Industrial EPA RSLs. The list of detected metals was consistent from one IB to another; however, in general, the concentrations of metals in IB-2 are lower than those detected in the other IBs. Additionally, the metals in IB-1 tend to be slightly higher than in the other IBs. The observed concentrations are consistent with the expected results given the materials deposited in each IB. The following table provides a summary of the metals detected in the surface soil samples collected in each IB.

		Range of Metals Detections											
Metals	RSL[1] (mg/kg)	IB-1 (mg/kg)			IB-2 (mg/kg)			IB-3 (mg/kg)			IB-4 (mg/kg)		
		No.	Avg	Max	No.	Avg	Max	No.	Avg	Max	No.	Avg	Max
Aluminum	99,000	56	62370	127,000	18	7513	61,100	40	34815	96,400	23	68397	135,000
Antimony	410	38	3.74	9.46	4	3.06	4.62	18	2.76	11	13	1.96	5.16
Arsenic	1.6	56	23.7	76.2	9	11.9	43.7	40	14.1	31.8	23	22	48.5
Barium	19,000	56	101	794	18	129	292	40	157	404	23	155	578
Cadmium	810	39	4	23.7	17	0.98	7.25	34	3.19	29.4	16	1.86	8.29
Chromium	1400	56	479	1,100	18	34.4	306	40	166	978	23	57.3	138
Cobalt	30	52	2	12.8	6	1.14	2.69	40	4.86	9.79	23	3.13	9.91
Copper	4100	56	14	41.7	18	12.7	138	40	59.1	738	23	23.6	84.8
Lead	1000	56	143	1,290	18	690	1,230	40	274	2,330	23	113	1,050
Manganese	2300	56	328	1,480	18	37.5	259	40	290	607	23	671	2,110
Mercury	31	56	0.293	0.91	18	0.21	0.657	40	0.263	1.53	23	0.198	0.688
Nickel	2000	56	7.37	23.2	15	3.21	25	40	17.1	65.1	23	12.5	60.9
Selenium	510	20	5.44	16	3	3.12	3.58	20	1.75	6.55	14	2.93	15.3
Silver	510	37	1.85	3.23	12	0.32	0.597	23	0.978	2.74	6	1.41	2.95
Thallium	8.2	28	5.82	19.8	1	10.4	10.4	20	2.97	8.79	13	3.76	7.3
Vanadium	520	56	637	1,220	17	91.3	950	40	174	813	23	147	419
Zinc	31000	53	49	227	18	73	370	40	198	701	23	152	1,210

(1) EPA Regional Screening Levels. RSLs based on noncarcinogenic effects are divided by 10 per EPA Region 3 guidance.

2.2.2.1.1.1 IB-1 – Residue Disposal Areas

Fifty-six surface soil samples were collected in IB-1. Due to the similarities of the materials, all of the RDAs in IB-1 were combined in the summary. Aluminum was present in higher concentrations than any of the other detected metals. Given that the residue in IB-1 is residual material from the alumina extraction process, aluminum was expected to dominate the metals present in the residue. Arsenic, barium, chromium, copper, lead, manganese, mercury, nickel and vanadium were also detected in all of the surface soil samples collected in IB-1. Additionally, cobalt and zinc were detected in relatively low concentrations in nearly all of the surface soil samples collected in IB-1. Mercury was detected in all surface soil samples collected in IB-1.

Evaluation of the surface soil data for each of the three IB-1 areas indicates that the range of detected concentrations of aluminum, lead and zinc are similar in each of the three IB-1 subareas. Lead appears to have high outlying concentrations in borings 1aUP016 and 1cUP020. Review of the boring logs for these borings indicates that gypsum dike material is present throughout the entire depth of 1aUP016 and from the surface to 4 feet deep in 1cUP020. These materials are more consistent with those found in IB-2 and are located immediately adjacent to IB-2 areas.

2.2.2.1.1.2 IB-2 – Gypsum Dike Areas

Eighteen surface soil samples were collected in IB-2. Aluminum was detected in all 18 samples collected in IB-2; however, the range of detections is significantly lower than in IBs 1, 3, and 4. Barium, chromium, copper, lead, manganese, mercury, and zinc were detected in all of the surface soil samples collected in IB-2. Additionally, cadmium, nickel and vanadium were detected in nearly all of the surface soil samples collected in IB-2. As mentioned above, the concentrations of metals detected in IB-2 tend to be somewhat lower than in IB-1. The table in Section 2.2.2.1.1 provides the range of detections for each metal.

2.2.2.1.1.3 IB-3 – Other Areas of Alcoa Activities

Forty surface soil samples were collected in IB-3. Surface soil samples were collected from IBs 3a and 3b. The subareas in IB-3 were combined for the purpose of summarizing the data. Aluminum was present in all 40 of the surface soil samples collected in IB-3. The range of detections was lower than in IBs 1 and 4, but higher than in IB-2. Arsenic, barium, chromium, cobalt, copper, lead, manganese, mercury, nickel, vanadium and zinc were also detected in all of the samples collected in IB-3. With the exception of zinc, these metals were detected in concentrations similar to or lower than those in IB-1. Zinc was detected in concentrations that were somewhat higher than in the surface soil samples collected in IB-1. Cadmium was detected in 34 of the 40 samples collected in IB-3 in concentrations similar to those observed in IB-1. The table in Section 2.2.2.1.1 provides the range of detections for each metal.

Further evaluation of the surface soil samples in each subarea indicates that arsenic, chromium, lead, selenium, thallium, vanadium and zinc are present in similar concentrations in each area. Cadmium appears to be higher in subarea 3a than in subarea 3b. There is no clear reason for the difference in the cadmium concentrations between the two subareas.

2.2.2.1.1.4 IB-4 – Other Areas of North Alcoa Site

Twenty-three surface soil samples were collected in IB-4. The surface soil samples were collected from IB-4a and IB-4c. The IB-4 areas were combined for the data summary presented above; however, because IB-4c is actively used as a recreational area, the areas were considered separately in the human health risk assessment. Aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc were detected in the surface soil samples collected in IB-4.

2.2.2.1.2 Fluoride, Cyanide and pH

Soil pH, fluoride and total cyanide were analyzed in all of the surface soil samples collected at the Site. Figure 2-12 presents the results of the pH, fluoride and cyanide analyses on the Site map. A summary of the detections for each of these parameters is presented in the following table.

		Range of Detections											
Wet Chemistry	**RSL[(1)] (mg/kg)**	**IB-1 (mg/kg)**			**IB-2 (mg/kg)**			**IB-3 (mg/kg)**			**IB-4 (mg/kg)**		
		No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
pH (s.u.)	--	56	8.35	12	18	5.59	7.6	40	6.45	12.5	23	4.86	11.8
Fluoride	6100(a)	56	55.7	419	18	49	156	40	42.1	244	23	45.9	171
Cyanide	2000(b)	23	4.65	29.4	4	9.1	21.4	11	1.23	6.4	8	1.31	5.6

(1) EPA Regional Screening Levels. RSLs based on noncarcinogenic effects are divided by 10 per EPA Region 3 guidance.
(a) RSL for Fluorine, which is soluble form of Fluoride, and form on which RfD is based.
(b) RSL for free Cyanide conservatively used for total cyanide.

The pH of the surface soil in IB-1 ranged from 7.3 to 12.0. IB-3 and IB-4 showed similar pH ranges, except the low end of the pH range and the average pH were lower than in IB-1. The pH of the surface soil in IB-2 was closer to neutral with a pH range from 4.6 to 7.6. Given that the alumina was extracted in a caustic process and the gypsum material in IB-2 was produced in an acidic process, the pH results appear to be consistent with the residues deposited in each of the areas.

Fluoride was detected in all of the surface soil samples collected at the Site. The fluoride concentrations in IB-1 were higher than the concentrations in the other IBs. IB-2 had the lowest maximum concentration of the IBs. The fluoride at the Site was processed in the Acid Plants, which produced the gypsum deposited in IB-2. It appears that fluoride was not a significant component of the Acid Plant waste stream (gypsum) since the highest concentrations in the surface soils occurred in IBs 4a, 1b, 3b, and 1c in ascending order of concentration. None of the fluoride concentrations exceeded the human health screening value, and it was not identified as a human health COI in surface soil. The ecological risk assessment screening identified fluoride as a COI in surface soil in all IBs. As a result, fluoride was further evaluated in the Phase 2 RI. The results of the Phase 2 investigation are presented in Section 2.2.2.8 below.

Cyanide was detected in approximately one-third of the surface soil samples collected at the Site. The detected cyanide concentrations ranged from 0.24 milligrams per kilogram (mg/kg) to 29.4 mg/kg. Cyanide was detected less frequently in IB-2 than in the other IBs; however, the detection limit was elevated. The frequency of cyanide detection was highest in IB-1 and the majority of the detected concentrations exceeding 10 mg/kg were also in IB-1. None of the cyanide concentrations exceeded the human health screening value, and it was not identified as a COI in surface soil. The ecological risk assessment screening identified cyanide as a COI in surface soil in all IBs. As a result, cyanide was further evaluated in the Phase 2 RI. The results of the Phase 2 investigation are presented in Section 2.2.2.8 below.

2.2.2.1.3 Organics

Seventeen surface soil samples collected at the Site were analyzed for organics. Of the samples selected for organics analysis, all were analyzed for volatile organic compounds (VOCs). Figure 2-13 presents the results of the VOCs that exceed their respective Industrial EPA RSLs on the Site map. The following table presents the frequency of detection for the VOCs in surface soil samples.

		Range of VOC Detections											
Compounds	**RSL[(1)] (mg/kg)**	**IB-1 (µg/kg)**			**IB-2 (µg/kg)**			**IB-3 (µg/kg)**			**IB-4 (µg/kg)**		
		No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg.**	**Max**	**No.**	**Avg**	**Max**
Benzene	1.1	1	2	2	ND			ND			ND		
Ethylbenzene	5.7	1	2	2	ND			ND			ND		
Toluene	500	1	9	9	ND			ND			ND		
Xylene	60	1	9	9	ND			ND			3	3	5
Acetone	6100	ND			ND			1	25	25	ND		
Carbon Disulfide	67	ND			ND			1	1	1	ND		
MTBE	--	1	24	24	ND			ND			ND		
Methylene Chloride	11	ND			ND			4	10	16	2	4.5	6

(1) EPA Regional Screening Levels. RSLs based on noncarcinogenic effects are divided by 10 per EPA Region 3 guidance.
ND indicates not detected.

VOCs were detected infrequently in IBs 1, 3 and 4. No VOCs were detected in IB-2. Benzene, ethylbenzene, toluene, xylene and methyl-tert-butyl ether (MTBE) were detected in one sample each in IB-1. Acetone, carbon disulfide and methylene chloride were detected in samples collected in IB-3. Xylene and methylene chloride were detected in IB-4. The concentrations of the VOCs detected in the surface soil samples were below the regional screening level, and the VOCs are not COPCs in surface soils for human or ecological receptors.

Seventeen surface soil samples were analyzed for semi-volatile organic compounds (SVOCs). Figure 2-13 presents the results of the SVOCs on the Site map. The following table presents a summary of the SVOC results for each IB.

		Range of SVOC Detections											
Compounds	**RSL[(1)]**	**IB-1**			**IB-2**			**IB-3**			**IB-4**		
	(mg/kg)	**(µg/kg)**			**(µg/kg)**			**(µg/kg)**			**(µg/kg)**		
		No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
1,1' Biphenyl	5100	ND			ND			1	75	75	ND		
2,4,5-Trichlorophenol	6200	ND			ND			1	45	45	ND		
2-Methylnaphthalene	410	ND			ND			20	1963	9,200	ND		
Benzylaldehyde	10000	ND			ND			1	47	47	ND		
Bis(2-ethylhexyl)phthalate	120	4	415	660	1	140	140	2	140	150	2	149	200
Carbazole	--	ND			ND			2	535	970	ND		
Dibenzofuran	--	ND			ND			2	350	370	ND		
PAHs													
Acenaphthene	3300	ND			ND			30	1464	7,400	ND		
Acenaphthylene	3300(a)	ND			ND			17	934	4,000	ND		
Anthracene	17000	ND			ND			38	197	1,800	ND		
Benzo(a)anthracene	2.1	ND			ND			39	700	7,100	ND		
Benzo(a)pyrene	0.21	ND			ND			39	763	8,900	ND		
Benzo(b)fluoranthene	2.1	ND			ND			39	660	6,600	ND		
Benzo(k)fluoranthene	21	ND			ND			39	362	3,500	ND		
Benzo(g,h,i)perylene	1700	ND			ND			39	1085	14,000	ND		
Chrysene	210	ND			ND			39	680	7,100	ND		
Dibenz(a,h)anthracene	0.21	ND			ND			29	107	1,200	ND		
Fluoranthene	2200	ND			ND			39	1517	16,000	ND		
Fluorene	2200	ND			ND			29	123	520	ND		
Indeno(1,2,3-cd)pyrene	2.1	ND			ND			39	672	8,900	ND		
Naphthalene	20	ND			ND			2	445	500	ND		
Phenanthrene	1700	ND			ND			39	1025	8,100	ND		
Pyrene	1700	ND			ND			39	1474	15,000	ND		

(1) EPA Regional Screening Levels (RSL, 2008). RSLs based on noncarcinogenic effects are divided by 10 per EPA Region 3 guidance.
(a) RSL for surrogate chemical Acenaphthene.
ND indicates not detected.

In general, the data showed sporadic detections of some SVOCs in the surface soil. Bis(2-ethylhexyl) phthalate was detected in all of the IBs. 1,1-Biphenyl, 2,4,5-trichlorobenzene, 2-methylnaphthalene, benzylaldehyde, carbazole and dibenzofuran were detected infrequently in IB-3 only.

The polynuclear aromatic hydrocarbons (PAHs) were detected more frequently than the other SVOCs. As the above table shows, PAHs were detected only in IB-3. The human health and ecological risk assessments will discuss the relevance of the detections, however, given the concentrations, only benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene and indeno(1,2,3- cd)pyrene in IB-3 were identified as COPCs for human health (i.e., concentrations exceeded the regional screening levels). The ecological screening did not identify SVOCs as COIs.

PCBs were analyzed in 17 surface soil samples collected at the Site. The surface soil sample results showed PCB Aroclors 1254 and 1260 present on the Site. The following table presents a summary of the PCB detections in surface soils at the Site.

		Range of PCB Detections											
Compounds	**RSL[(1)] (mg/kg)**	**IB-1 (µg/kg)**			**IB-2 (µg/kg)**			**IB-3 (µg/kg)**			**IB-4 (µg/kg)**		
		No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
PCB-1254	0.74	1	13	13	1	71	71	2	22	32	ND		
PCB-1260	0.74	2	11	12	ND			2	41.5	61	1	7.8	7.8

(1) EPA Regional Screening Levels. RSLs based on noncarcinogenic effects are divided by 10 per EPA Region 3 guidance.
ND indicated not detected.

The observed PCB concentrations are well below any screening value, and PCB is therefore not considered to be a COPC for human or ecological receptors on the Site.

2.2.2.1.4 Radiological Analyses

Sixty-two surface soil samples, including two duplicates, were collected from the residue in IB-1a, IB-1b, IB-1c and IB-2 for radiological analyses during the RI (September 2004). The radiological samples were submitted to Severn Trent Laboratories, Inc. in St. Louis, Missouri for radium-226 analysis by gamma spectroscopy. Radium-226 was detected in 46 of the 62 samples in concentrations ranging from 0.19 picocuries per gram (pCi/g) to 9.7 pCi/g. The radiological results are presented graphically on Figure 2-14. As discussed in Technical Memorandum No. 7 (Alcoa and the City of East St. Louis, 2004e), these data are compared to the criteria of 10 pCi/g for unrestricted use of phosphogypsum found at 40 CRF 61 Subpart R. None of the samples exceeded this criterion.

The laboratory reported concentrations of lead-210, potassium-40, radium-226, radium-228, and uranium-238 that exceeded the USEPA Preliminary Remediation Goals (PRGs) for residential soil. Lead-210 was detected in two samples in concentrations ranging from 6 pCi/g to 11.0 pCi/g. Potassium-40 was detected in all samples analyzed in concentrations ranging from 0.79 pCi/g to 11.4 pCi/g. Radium-228 was detected in 38 samples in concentrations ranging from 0.64 pCi/g to 40.0 pCi/g. Uranium-238 was detected in 23 samples in concentrations ranging from 0.56 pCi/g to 28.3 pCi/g. Figure 2-14 illustrates the results from the radiological investigation for total radium (radium-226 and radium-228). Total radium concentrations ranged from 0.15 pCi/g to 45.1 pCi/g. These results are discussed further in the BHHRA. The PRGs are qualitative cleanup levels for residential soil and were used to determine nature and extent of contamination based on the results of the RI. Site-specific data should be calculated to evaluate remedial options for soils exceeding the PRG in this industrial soil application. There has been no radon testing at the Site to date.

A radiological survey was performed at the Site on November 14-18, 2011. The goal of the survey was to evaluate site conditions with respect to external radiation levels and evaluate radioactive material concentrations in surface and subsurface soils. A summary of field activities and results are summarized in the Radiological Survey Report in Appendix C.

In general, gamma radiation levels exhibit logical patterns. The RDAs contain the highest radiation levels, and outside the RDAs, levels are much lower with elevated levels primarily limited to low-lying areas west of RDA-1 that historically received runoff from the breached dike of RDA-1. Gamma radiation levels are presented as Figure 4 of Appendix C.

All soil samples collected during this investigation, as well as in the previous RI investigation, had Ra-226 concentrations less than 15 pCi/g above background, and soil samples of materials other than bauxite residue had Ra-226 concentrations less than 5 pCi/g above background. Surface and subsurface soil sample results are presented in Table 1A and 1B of Appendix C.

2.2.2.2 Subsurface Soil

For the purpose of the BHHRA, subsurface soil samples are defined as samples collected in the depth interval from two to ten feet below the ground surface. The subsurface soil samples are used in the risk assessment for exposure pathways that involve contact with soil during excavation activities that may allow exposure to the receptors considered. The RI included the collection of 137 subsurface soil samples from the Site. Sixty-one subsurface soil samples were collected in IB-1, 11 were collected in IB-2, 43 were collected in IB-3 and 22 were collected in IB-4. The laboratory reported seven additional subsurface soil samples or specific analytical suites, which were subsequently removed from the data set for various reasons. Most of these samples were either duplicated due to shipping or laboratory errors, or were analyzed for parameters not called for in the SAP. The results of these samples were provided to the USEPA but were not included in the data summaries that follow. Figure 2-15 presents the locations of the subsurface soil samples on a plan view map. Figure 2-3 presents the waste material thicknesses as derived from subsurface boring cross sections. The following sections present a summary of the results of the subsurface soil samples.

2.2.2.2.1 Metals

Aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium and zinc were detected in the subsurface soil samples collected on the Site. Figure 2-15 provides the locations of the surface soil samples and the metals results for each sample. The list of detected metals was consistent from one IB to another; however, as with the surface soil samples, in general, the concentrations of metals in IB-2 are lower than the metals detected in the other IBs. Additionally, the metals in IB-1 tend to be slightly higher than in the other IBs. With regard to comparison of the surface and subsurface soil results, the metals detected in IBs 1 and 2 tend to be similar to slightly higher in the deeper intervals than in the shallower intervals; however, the nature of the material appears to be the same throughout. A comparison of the surface and subsurface soils in IBs 3 and 4 shows that metals concentrations in the shallower intervals tend to be higher than in the deeper interval. The following table provides a summary of the metals detected in the subsurface soil samples.

		Range of Metals Detections											
Metals	RSL[(1)] (mg/kg)	IB-1 (mg/kg)			IB-2 (mg/kg)			IB-3 (mg/kg)			IB-4 (mg/kg)		
		No.	Avg.	Max	No.	Avg.	Max	No.	Avg.	Max	No.	Avg.	Max
Aluminum	99,000	61	64,868	96,200	11	9665	32,200	43	37,944	98,400	22	66,871	109,000
Antimony	410	35	4.2	31.4	1	4.07	4.07	10	1.76	3.41	8	1.85	3.58
Arsenic	1.6	60	32.8	170	9	13	66.7	42	14	73.5	22	25	60.4
Barium	19,000	61	116	274	11	125	273	43	178	294	22	155	354
Cadmium	810	40	1.63	9.52	7	0.484	1.61	33	1.33	5.58	13	0.595	1.45
Chromium	1400	61	361	947	11	14.6	42.6	43	82.3	445	22	64.1	128
Cobalt	30	57	2.52	48.2	8	3.56	14.5	42	4.99	13.4	22	3.16	10.1
Copper	4100	61	19	243	11	11.4	33.4	43	27.1	190	22	9.76	29.5
Lead	1000(a)	61	103	1,280	11	603	2,250	43	116	612	22	83.9	335
Manganese	2300	61	435	2,380	11	263	1,660	43	381	2,050	22	440	1,960
Mercury	31	60	0.315	0.757	11	0.129	0.61	43	0.159	0.935	21	0.315	2
Nickel	2000	61	7.66	52.1	10	8.37	35.6	43	15.8	36.3	22	8.33	28.6
Selenium	510	38	7.8	181	3	5.22	13.3	14	2.04	5.09	10	2.56	12.5
Silver	510	41	2.44	7.52	4	0.482	0.819	17	1.16	3.61	8	1.75	3.88
Thallium	8.2	34	10.2	195	4	3.08	7.09	28	2.18	4.74	11	2.34	3.22
Vanadium	520	61	531	1,190	11	50.3	326	43	109	412	22	165	304
Zinc	31000	60	21	88.7	11	35.3	92.5	43	118	1,140	22	44.2	158

(1) EPA Regional Screening Levels. RSLs based on noncarcinogenic effects are divided by 10 per EPA Region 3 guidance.

The following subsections provide a summary of the constituents detected for each IB and comparative evaluations of the data between the subareas in each IB.

2.2.2.2.1.1 IB-1 – Residue Disposal Areas

Sixty-one subsurface soil samples were collected in IB-1. Due to the similarities of the materials, all of the RDAs in IB-1 were combined in the summary. Aluminum was present in higher concentrations than any of the other detected metals. Given that the residue in IB-1 is residual material from the alumina extraction process, aluminum was expected to dominate the metals present in the residue. Barium, chromium, copper, lead, manganese, nickel and vanadium were also detected in all of the subsurface soil samples collected in IB-1. Additionally, arsenic, cobalt, mercury and zinc were detected in nearly all of the subsurface soil samples collected in IB-1.

Evaluation of the subsurface soil data for each of the three IB-1 areas indicates that the range of detected concentrations of aluminum, arsenic, lead, vanadium and zinc are similar in each of the three IB-1 subareas. Lead appears to have a high outlying concentration in boring 1aUP016 relative to the remainder of the IB-1 subsurface soil data set. Review of the boring log for this boring indicates that gypsum dike material is present throughout the entire depth. This material is more consistent with that found in IB-2, and is located immediately adjacent to IB-2 in the southwestern corner of IB-1a. Chromium and thallium appear to be similar in IB-1a and IB-1b,

and somewhat higher in IB-1c. Manganese concentrations appear somewhat higher in IB-1b as compared to 1a and 1c.

2.2.2.2.1.2 IB-2 – Gypsum Dike Areas

Eleven subsurface soil samples were collected in IB-2. Aluminum was detected in all 11 subsurface soil samples collected in IB-2; however, the range of detections is significantly lower than in IBs 1, 3, and 4. Barium, chromium, copper, lead, manganese, mercury, vanadium and zinc were detected in all of the subsurface soil samples collected in IB-2. Additionally, arsenic, cobalt, cadmium and nickel were detected in nearly all of the subsurface soil samples collected in IB-2. The occurrence of these constituents is similar to that of the surface soil samples. As mentioned above, the concentrations of metals detected in IB-2 tend to be somewhat lower than in IB-1. The table in Section 2.2.2.2.1 provides the range of detections for each metal.

2.2.2.2.1.3 IB-3 – Other Areas of Alcoa Activities

Forty-three subsurface soil samples were collected in IB-3. Subsurface soil samples were collected from both IBs 3a and 3b. The subareas in IB-3 were combined for the purpose of summarizing the data. Aluminum was present in all 43 of the subsurface soil samples collected in IB-3. The range of detections was similar to that in IB-1 and lower than in IB-4. Barium, chromium, copper, lead, manganese, mercury, nickel, vanadium and zinc were also detected in all of the samples collected in IB-3. Arsenic was detected in 42 of 43 samples in IB-3. Most of the metals were detected in concentrations similar to or lower than those in IB-1. Cadmium and cobalt were detected in nearly all of the IB-3 samples in concentrations similar to those observed in IB-1. The table in Section 2.2.2.2.1 provides a summary of the results for each metal.

2.2.2.2.1.4 IB-4 – Other Areas of North Alcoa Site

Twenty-two subsurface soil samples were collected in IB-4. The subsurface soil samples were collected from both IB-4a and IB-4e. Subsurface soil samples were collected at eight locations in area IB-4e during the RI (locations 4eUP001-4eUP008). Subsurface soil samples were not collected beneath the Ball Fields (IB-4c) because as discussed in the RI Work Plan, potential direct contact to surface soils was the potentially complete exposure pathway evaluated in the risk assessment. The IB-4 areas were combined for the data summary presented above. Aluminum, arsenic, barium, chromium, cobalt, copper, lead, manganese, nickel, vanadium and zinc were detected in the all of the subsurface soil samples collected in IB-4. Mercury was detected in 21 of the 22 samples collected. The subsurface soil results are presented on Figure 2-15. As discussed in Section 2.2.2 and shown on Figure 2-5, portions of IB-4 contain bauxite residue in the subsurface.

2.2.2.2.2 Fluoride, Cyanide and pH

Soil pH, fluoride and total cyanide were analyzed in all of the subsurface soil samples collected at the Site. Figure 2-16 presents the results of the pH, fluoride and cyanide subsurface soil samples. A summary of the results of detections for each of these parameters is presented in the following table.

		Range of Detections											
Wet Chemistry	**RSL[(1)] (mg/kg)**	**IB-1 (mg/kg)**			**IB-2 (mg/kg)**			**IB-3 (mg/kg)**			**IB-4 (mg/kg)**		
		No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
pH (s.u.)	--	61	8.98	12.2	11	5.54	8.3	43	6.02	12.4	22	9.77	12.4
Fluoride	6100[(a)]	61	78.3	624	11	46.5	148	43	42.1	206	22	52	125
Cyanide	2000[(b)]	22	32.1	143	5	1.47	3.8	6	5.83	12.7	8	5.03	22.8

(1) EPA Regional Screening Levels. RSLs based on noncarcinogenic effects are divided by 10 per EPA Region 3 guidance.
(a) RSL for Fluorine, which is soluble form of Fluoride, and form on which RfD is based.
(b) RSL for free Cyanide conservatively used for total cyanide.

The pH of the subsurface soil in IB-1 ranged from 7.7 to 12.2 with an average of 8.98. IB-4 showed a similar pH range with a slightly higher pH of 8.6 at the low end of the range and a higher average at 9.77. IB-3 had a similar pH at the top end of the range, but had a significantly lower low-end pH at 4.5 and a lower average at 6.02. The pH of the subsurface soil in IB-2 was closer to neutral with a pH range from 4.8 to 8.3 and an average of 5.54. These results mirror the results of the surface soil samples.

Fluoride was detected in all (in IB-3) of the subsurface soil samples collected at the Site. The fluoride concentrations in IB-1 were higher than the concentrations in the other IBs. IB-4 had the lowest maximum concentration of the IBs. Evaluation of the data within each subarea indicates that the highest concentrations were observed in IB-1c Comparison of the concentrations of the fluoride at the Site to the human health screening criteria indicates it is not considered to be a COI in subsurface soils.

Cyanide was detected in approximately one-third of the subsurface soil samples collected at the Site. The detected cyanide concentrations ranged from 0.23 milligrams per kilogram (mg/kg) to 143 mg/kg. Cyanide was detected in similar frequencies in all of the IBs. Comparison of the concentrations of cyanide at the Site to the human health screening criteria indicates that it is not considered to be a COI in subsurface soils.

2.2.2.2.3 Organics

Fifty-three subsurface soil samples collected at the Site were analyzed for organics. Seven of these were collected in IB-1, one was collected in IB-2, 41 were collected in IB-3 and four were collected in IB-4e. Of the samples selected for organics analysis, 18 were analyzed for VOCs. Figure 2-17 presents the locations and results of the subsurface soil samples analyzed for VOCs. The following table presents a summary of the results of the VOCs in subsurface soil samples.

		Range of VOC Detections											
Compounds	**RSL(1) (mg/kg)**	**IB-1 (µg/kg)**			**IB-2 (µg/kg)**			**IB-3 (µg/kg)**			**IB-4 (µg/kg)**		
		No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
Ethylbenzene	29	ND			ND			ND			2	10900	13,000

		Range of VOC Detections											
Toluene	4600	ND			ND			ND			2	4550	5,700
Xylene	260	ND			ND			ND			2	20000	24,000
Acetone	61000	1	25	25	ND			1	12	12	2	42.5	47
Chloroform	1.5	ND			ND			1	2	2	2	2	2
Isopropylbenzene	1100	ND			ND			ND			2	1750	2,100
MTBE		ND			1	3	3	ND			ND		
Methylene Chloride	54	2	9	9	ND			4	7.5	13	2	18	18

(1) EPA Regional Screening Levels. RSLs based on noncarcinogenic effects are divided by 10 per EPA Region 3 guidance.
ND indicates not detected.

VOCs were detected infrequently in IBs 1, 2, 3, and 4. Ethylbenzene, toluene, xylene, acetone, chloroform, isopropylbenzene and methylene chloride were detected in two samples each in IB-4. Acetone was detected in one sample in IBs 1 and 3. Methylene chloride was detected in two samples in IB-1 and one sample in IB-3. Chloroform was detected in one sample in IB-3 and MTBE was detected in one sample in IB-2. The concentrations of the VOCs detected in the subsurface soil samples were below the applicable screening criteria, and the VOCs are not COPCs in subsurface soils.

Fifty-three subsurface soil samples were analyzed for SVOCs. Figure 2-17 presents the locations and results of the subsurface soil samples analyzed for SVOCs. The following table presents a summary of the SVOC results for each IB.

		Range of SVOC Detections											
Compounds	**RSL[(1)] (mg/kg)**	**IB-1 (µg/kg)**			**IB-2 (µg/kg)**			**IB-3 (µg/kg)**			**IB-4 (µg/kg)**		
		No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
1,1' Biphenyl	5100	ND			ND			ND			2	30000	36,000
2,4,5-Trichlorophenol	6200	ND			ND			1	53	53	ND		
2-Methylnaphthalene	410	ND			ND			10	1140	4,500	1	320	320
4-Nitrophenol	--	ND			ND			ND			1	310	310
Bis(2-ethylhexyl)phthalate	120	2	560	1,000	ND			1	12,000	12,000	1	120	120
Carbazole	--	ND			ND			1	220	220	2	22,000	26,000
Dibenzofuran	--	ND			1	45	45	1	140	140	2	120,000	130,000
Di-n-butylphthalate	--	ND			ND			1	160	160	ND		
N-nitrosodiphenylamine	--	ND			ND			ND			2	10,200	13,000
Phenol	--	ND			ND			ND			2	56	58
PAHs													
Acenaphthene	3300	ND			ND			24	1141	9,900	ND		
Acenaphthylene	3300[(a)]	ND			ND			9	592	1,900	ND		
Anthracene	17000	ND			ND			29	190	3,500	2	29.5	46
Benzo(a)anthracene	2.1	ND			ND			31	583	14,000	2	153	220
Benzo(a)pyrene	0.21	ND			ND			30	685	16,000	2	170	240

		Range of SVOC Detections											
Compounds	RSL[1] (mg/kg)	IB-1 (µg/kg)			IB-2 (µg/kg)			IB-3 (µg/kg)			IB-4 (µg/kg)		
		No.	Avg	Max	No.	Avg	Max	No.	Avg	Max	No.	Avg	Max
Benzo(b)fluoranthene	2.1	ND			ND			30	680	16,000	2	176	260
Benzo(k)fluoranthene	21	ND			ND			30	341	7,900	2	92	130
Benzo(g,h,i)perylene	1700	ND			ND			34	791	20,000	2	200	260
Chrysene	210	ND			ND			30	697	16,000	2	156	220
Dibenz(a,h)anthracene	0.21	ND			ND			19	186	3,100	2	32.5	47
Fluoranthene	2200	ND			ND			35	1075	25,000	2	315	460
Fluorene	2200	ND			ND			23	194	2,100	1	6.3	6.3
Indeno(1,2,3-cd)pyrene	2.1	ND			ND			29	573	13,000	2	142	190
Naphthalene	20	ND			ND			2	1510	2,900	ND		
Phenanthrene	1700	ND			ND			36	774	12,000	2	174	260
Pyrene	1700	ND			ND			32	1284	29,000	2	275	380

(1) EPA Regional Screening Levels. RSLs based on noncarcinogenic effects are divided by 10 per EPA Region 3 guidance.
(a) RSL for surrogate chemical Acenaphthene.
ND indicates not detected.

In general, 1,1-biphenyl, 2,4,5-trichlorophenol, 4-nitrophenol, carbazole, dibenzofuran, di-n-butylphthalate, n-nitrosodiphenylamine and phenol were detected infrequently on the Site. 2-Methylnaphthalene was detected in 10 samples collected in IB-3 and one sample collected in IB-4 in concentrations ranging from 120 to 4,500 mg/kg. Bis(2-ethylhexyl) phthalate was detected infrequently in IBs 1, 3 and 4. Based on screening against the human health criteria, none of these constituents were identified as COPCs in subsurface soils.

The PAHs were detected only in IBs 3 and 4. IB-3 was the only area where PAHs were present in concentrations exceeding the human health screening criteria. Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene were identified as COPCs in IB-3.

PCBs were detected in two of the subsurface soil samples collected in IB-3. PCBs were not detected in IBs 1, 2, or 4. The detected concentrations were less than the human health screening criteria, and therefore, PCBs are not considered to be COPCs on the Site. Figure 2-17 presents the locations and results of the subsurface soil samples analyzed for PCBs. The following table presents a summary of the PCB results for subsurface soils.

		Range of PCB Detections											
Compounds	RSL[1] (mg/kg)	IB-1 (µg/kg)			IB-2 (µg/kg)			IB-3 (µg/kg)			IB-4 (µg/kg)		
PCB-1248	--	ND			ND			1	370	370	ND		
PCB-1254	0.74	ND			ND			1	28	28	ND		
PCB-1260	0.74	ND			ND			2	86.5	150	ND		

(1) EPA Regional Screening Levels. RSLs based on noncarcinogenic effects are divided by 10 per EPA Region 3 guidance.
ND indicates not detected.

2.2.2.3 Sediment

Sixty-one sediment samples were collected from the Site. Twenty-nine of the sediment samples were collected in IB-1, 10 were collected in IB-3 and 22 were collected in IB-4. IB-2 does not contain wet areas or standing water and no sediment samples were collected there. The following subsections present a summary of the sediment data collected at the Site.

2.2.2.3.1 Metals

Aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium and zinc were detected in the sediment samples collected on the Site. Figure 2-18 provides the locations of the sediment samples and the metals results for each sample. The list of detected metals was consistent from one IB to another; and the concentration ranges were similar. The following table provides a summary of the metals detected in the sediment samples.

	Range of Metals Detections								
Metals	**IB-1 (mg/kg)**			**IB-3 (mg/kg)**			**IB-4 (mg/kg)**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
Aluminum	29	81748	119,000	10	51350	192,000	22	53398	123,000
Antimony	ND			6	3.45	5.31	3	2.65	3.34
Arsenic	29	23.1	38.7	10	61.7	141	22	46.7	119
Barium	29	106	189	10	202	441	22	126	176
Cadmium	6	1.28	2.25	9	4.62	16.5	21	1.73	4.45
Chromium	29	895	1,310	10	112	371	22	138	776
Cobalt	29	3.24	8.74	10	7.82	19.5	22	3.24	6.92
Copper	29	44.1	159	10	90.6	337	22	27.8	95.7
Lead	29	151	568	10	171	695	22	248	976
Manganese	29	296	528	10	395	546	22	279	851
Mercury	29	0.269	0.55	10	0.267	1.14	22	0.215	0.563
Nickel	29	12.8	43.4	10	38.6	105	22	13.1	24
Selenium	17	4.73	8.72	8	3.13	11.3	19	3.95	11.6
Silver	8	2.65	3.79	4	2.24	5.85	2	1.24	1.89
Thallium	10	4.21	8.0	1	6.15	6.15	1	3.11	3.11
Vanadium	29	870	1,270	10	230	1,170	22	184	451
Zinc	29	216	1,030	10	519	2,620	22	239	879

ND indicates not detected.

2.2.2.3.2 Fluoride, Cyanide and pH

Sediment pH, fluoride and total cyanide were analyzed in all of the sediment samples collected at the Site. Figure 2-19 provides the results of the sediment samples analyzed for pH, fluoride, and cyanide on the Site map. The following table provides a summary of the results of these parameters in sediment samples.

	Range of Detections								
Wet Chemistry	**IB-1 (mg/kg)**			**IB-3 (mg/kg)**			**IB-4 (mg/kg)**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
pH (s.u.)	29	7.66	10.2	10	8.13	10.7	22	7.31	11.7
Fluoride	29	77.5	373	10	465	2,790	22	75.2	205
Cyanide	5	0.786	1.3	6	22.9	53.6	10	3.58	8.9

The pH values in IB-1 ranged from 6.6 to 10.2. The average pH in IB-1 was 7.66; however, this value was pulled down by the pH in IB-1b, which had an average of 7.27. IB-1a and IB-1c had average sediment pH values of 10.03 and 8.57 respectively. The difference is believed to be related to the presence of a significant amount of vegetation surrounding the surface water in IB-1b, which appears to keep the pH circumneutral. Similar conditions appear to be present in IB-4b, which also has an average pH that is circumneutral at 6.75. IB-4a and IB-4d have higher average pHs at 9.85 and 8.85 respectively.

Fluoride was detected in all of the IBs in concentrations ranging from 14.9 to 2,790 mg/kg. The highest concentrations of fluoride were detected in IB-3b, with two samples exceeding 1,000 mg/kg. The human health risk assessment will further assess the significance of the fluoride detected in sediment. Cyanide was detected in sediment samples all of the IBs in concentrations ranging from 0.25 to 53.6 mg/kg. IB-3b was the only area where total cyanide in sediment exceeded 10 mg/kg, with three samples ranging from 27.9 to 53.6 mg/kg. Cyanide was identified as a COPC in sediment only in IB-3.

2.2.2.3.3 Organics

Nine sediment samples collected at the Site were analyzed for organics. Of the samples selected for organics analysis, all were analyzed for VOCs. Figure 2-20 presents the locations and results of the sediment samples analyzed for VOCs. The following table provides a summary of the results for the VOCs in sediment samples.

	Range of VOC Detections								
Compounds	**IB-1 (µg/kg)**			**IB-3 (µg/kg)**			**IB-4 (µg/kg)**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
Benzene	ND			ND			1	2.0	2.0
Toluene	ND			ND			1	2.0	2.0
Xylene	2	4.0	6.0	ND			ND		
Acetone	1	33	33	ND			ND		
MTBE	ND			1	5.0	5.0	2	9.5	16
Methylene Chloride	2	5.0	6.0	ND			ND		

ND indicates not detected.

VOCs were detected infrequently in IBs 1, 3, and 4. Benzene, toluene, xylene, acetone, MTBE and methylene chloride were detected in at least one of the three IBs. Xylene, acetone and methylene chloride were detected in samples collected in IB-1. MTBE was detected in one sample in IB-3 and benzene, toluene and MTBE were detected in IB-4. The concentrations of the VOCs detected in the sediment samples were below the applicable screening criteria, and the VOCs were not identified as COPCs in the sediment samples.

Nine sediment samples were analyzed for SVOCs. Figure 2-20 presents the locations and results of the sediment samples analyzed for SVOCs. The following table presents a summary of the SVOC results for each IB.

	Range of SVOC Detections								
Compounds	**IB-1 (µg/kg)**			**IB-3 (µg/kg)**			**IB-4 (µg/kg)**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
2-Methylnaphthalene	ND			D			1	550	550
Bis(2-ethylhexyl)phthalate	1	790	790	ND			ND		
Dibenzofuran	1	79	79	ND			1	230	230
PAHs									
Acenaphthene	1	130	130	ND			ND		
Anthracene	1	110	110	ND			1	95	95
Benzo(a)anthracene	1	130	130	D			2	220	320
Benzo(a)pyrene	1	87	87	ND			2	200	300
Benzo(b)fluoranthene	1	140	140	1	93	93	3	204	390
Benzo(k)fluoranthene	ND			ND			1	150	150
Benzo(g,h,i)perylene	1	77	77	ND			2	141	210
Chrysene	1	130	130	1	71	71	3	210	370
Dibenz(a,h)anthracene	ND			ND			1	65.0	65
Fluoranthene	1	370	370	1	90	90	3	310	630
Fluorene	1	150	150	ND			ND		
Indeno(1,2,3-cd)pyrene	ND			ND			2	141	220
Naphthalene	ND			ND			1	180	180
Phenanthrene	1	660	660	ND			3	500	1,000
Pyrene	1	330	330	1	110	110	3	340	640

ND indicates not detected.

The SVOCs were detected relatively infrequently with 11 PAHs and bis(2ethylhexyl)phthalate and dibenzofuran detected in one sample in IB-1, four PAHs detected in one sample in IB-3 and 13 PAHs, 2-methylnaphthalene and dibenzofuran detected in IB-4.

PCBs were detected in sediment samples collected in IBs 1, 3 and 4. The PCB Aroclors detected included 1254 and 1260. Figure 2-20 presents the locations and results of the

sediment samples analyzed for PCBs. The following table presents a summary of the PCBs detected in sediments at the Site.

	Range of PCB Detections								
	IB-1 (µg/kg)			IB-3 (µg/kg)			IB-4 (µg/kg)		
	No.	Avg	Max	No.	Avg	Max	No.	Avg	Max
PCB-1254	3	66.0	89	1	70	70	1	21	21
PCB-1260	2	58.5	71	1	32	32	1	20	20

The concentrations of PCBs detected were below the human health screening criteria, and PCB was not identified as a COPC in sediment samples.

2.2.2.4 Surface Water

Thirty-eight surface water samples were collected from IBs 1, 3, and 4 on the Site. No surface water was present in IB-2. Fifteen surface water samples were collected in IB-1, four were collected in IB-3 and 20 were collected in IB-4. All of the surface water samples were analyzed for total and dissolved metals, pH, fluoride, total cyanide, sulfate and TDS. Turbidity was measured in the field. Additionally, five samples were analyzed for VOCs and five were analyzed for SVOCs.

2.2.2.4.1 Metals

The surface water samples were analyzed for both total and dissolved (filtered) metals. Figure 2-21 provides the locations of the surface water samples and both the total and dissolved metals results for each sample. The following subsections present the results of the total and dissolved metals in surface water at the Site.

2.2.2.4.1.1 Total Metals

Total aluminum, antimony, arsenic, barium, cadmium, calcium, chromium, cobalt, copper, lead, magnesium, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc were detected in the surface water samples collected on the Site. The list of detected metals was consistent from one IB to another with the exception of mercury, which was not detected in surface water in IB-3. The following table provides a summary of the total metals results in the surface water.

	Range of Total Metals Detections								
Metals	**IB-1 (mg/l)**			**IB-3 (mg/l)**			**IB-4 (mg/l)**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
Aluminum	14	41.2	208	4	1.14	2.04	20	37.4	156
Antimony	15	0.001	0.0049	4	0.002	0.0041	20	0.003	0.0092
Arsenic	10	0.037	0.0893	4	0.015	0.0281	19	0.097	0.203
Barium	5	0.067	0.228	4	0.026	0.0402	20	.008	0.0152
Cadmium	11	0.013	0.0295	4	0.001	0.0016	3	0.001	0.0025
Calcium	15	73.3	187	4	212	473	20	98.8	434
Chromium	11	1.07	3.79	2	0.005	0.0059	8	0.008	0.0121
Cobalt	7	0.003	0.0061	2	0.002	0.0029	5	0.003	0.0037
Copper	15	0.011	0.0329	4	0.017	0.0285	20	0.01	0.0248
Lead	15	0.049	0.204	4	0.019	0.0317	20	0.011	0.0418
Magnesium	15	3.72	7.16	4	5.12	12.8	20	0.479	1.29
Manganese	15	0.366	0.798	4	0.077	0.106	20	0.02	0.0543
Mercury	2	0.0002	0.00017	ND			1	0.0003	0.00034
Nickel	15	0.007	0.0226	4	0.08	0.0278	20	0.007	0.0192
Selenium	15	0.012	.0895	4	0.006	0.0085	20	0.019	0.0409
Silver	10	0.002	0.0048	2	0.002	0.0035	6	0.0003	0.00046
Thallium	5	0.0001	0.00012	2	0.0000375	0.000038	8	0.00004	0.00011
Vanadium	15	0.899	3.16	4	0.017	0.0358	20	0.146	0.426
Zinc	13	0.028	0.0882	3	.067	0.101	20	0.026	0.0825

ND indicates not detected.

2.2.2.4.1.2 Dissolved Metals

Dissolved aluminum, antimony, arsenic, barium, cadmium, calcium, chromium, cobalt, copper, lead, magnesium, manganese, nickel, selenium, silver, thallium, vanadium, and zinc were detected in the surface water samples collected on the Site. The list of detected metals was consistent from one IB to another throughout the Site. The following table provides a summary of the dissolved metals results in the surface water samples.

	Range of Dissolved Metals Detections								
Metals	**IB-1 (mg/l)**			**IB-3 (mg/l)**			**IB-4 (mg/l)**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
Aluminum	11	2.48	6.84	4	1.07	.72	20	35.4	149
Antimony	15	0.001	0.0047	4	0.00	0.0039	20	0.003	0.0084
Arsenic	9	0.025	0.0673	3	0.016	0.0309	18	0.101	0.213
Barium	15	0.013	0.0381	4	0.02	0.0221	20	0.005	0.0134
Cadmium	10	0.0003	0.00083	4	0.0007	0.0013	14	0.0003	0.00059
Calcium	15	60.6	88	4	219	463	20	100	445
Chromium	10	0.041	0.062	1	0.004	0.0043	5	0.004	0.0047
Cobalt	8	0.002	0.0039	3	0.003	0.0036	4	0.003	0.0042
Copper	15	0.004	0.0157	4	0.015	0.0197	20	0.013	0.0242
Lead	13	0.001	0.0019	4	0.005	0.0067	20	0.004	0.0094

	Range of Dissolved Metals Detections								
Metals	**IB-1 (mg/l)**			**IB-3 (mg/l)**			**IB-4 (mg/l)**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
Magnesium	15	2.44	7.11	4	4.92	12	16	0.527	1.29
Manganese	15	0.159	0.606	4	0.066	0.108	20	0.013	0.0527
Mercury	ND			ND			ND		
Nickel	15	0.002	0.0049	4	0.018	0.0266	20	0.007	0.0186
Selenium	15	0.012	0.0874	4	0.004	0.0065	20	0.018	0.0389
Silver	7	0.0001	0.00026	2	0.001	0.002	4	0.0001	0.00014
Thallium	1	0.000033	0.000033	1	0.000053	0.000053	14	0.00004	0.000057
Vanadium	15	0.296	1.23	4	0.009	0.0112	20	0.144	0.418
Zinc	15	0.011	0.0193	3	0.040	0.0705	15	0.017	0.0683

ND indicates not detected.

The dissolved metals results showed concentrations that were generally lower than the total metals. Mercury was not detected in the dissolved metals samples, but was detected in total metals samples collected in IB-1 and IB-4. Additionally, comparison of the total and dissolved metals results generally showed a larger difference in samples with high turbidity values. The higher metals concentrations in the total metals analyses appear to be driven by the particulate matter in the water.

2.2.2.4.2 Fluoride, Cyanide, Sulfide, and pH

Water pH, fluoride, total cyanide, sulfate, TDS and turbidity were analyzed in all of the surface water samples collected at the Site. Figure 2-22 provides the results of the surface water samples analyzed for pH, fluoride, cyanide sulfate, TDS and turbidity on the Site map. The following table presents a summary of the detections in surface water samples.

	Range of Detections								
Wet Chemistry	**IB-1**			**IB-3**			**IB-4**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
pH (s.u.)	15	7.82	9.9	4	7.90	9.3	20	6.80	11.4
Fluoride (mg/l)	15	14.3	55.2	4	151	302	20	27.2	43.5
Cyanide (mg/l)	ND			2	7.45	9.8	11	0.138	0.73
Sulfate (mg/l)	15	298	633	4	1723	3,550	20	2055	3,920
TDS (mg/l)	15	1013	2,430		4003	5,700	20	4159	6,210
Turbidity (NTU)	15	4260	17,100	4	17.2	26.9	20	38.9	170

ND – Indicates not detected.

The pH of the surface water ranged from 5.8 to 11.4 in IB-4; however, all but one sample, collected in IB-4b and its duplicate had pH values above 8.3. The IB-4b sample had a pH of 5.8. This mirrors the sediment sample results for this area. The pH values in IBs 1 and 3 were closer to neutral, with average pH values of 7.82 and 7.90 respectively.

Fluoride was detected in the surface water samples in concentrations ranging from 2.3 to 302 mg/l. In IBs 1 and 4, the maximum fluoride concentration was 55.2 mg/l. The higher fluoride concentrations were detected in IB-3b with two of the four samples collected in the area showing concentrations of 283 and 302 mg/l.

Cyanide was detected in IB-4 in low concentrations ranging from 0.083 and 0.73 mg/l. In IB-3, cyanide was detected in two samples at concentrations of 5.1 and 9.8 mg/l. Cyanide was not detected in surface water in IB-1.

Sulfate was detected in all of the surface water samples collected at the Site. The sulfate concentrations ranged from 5.5 to 3,920 mg/l. The sulfate concentrations in IB-1c were significantly lower than in the other IBs ranging from 5.5 to 6.2 mg/l. Sulfate in IB-1a and 1b was approximately two orders of magnitude higher, and IBs 3b, 4a, 4b, and 4d were between one and three orders of magnitude higher than the samples from IB-1c.

TDS concentrations in surface water ranged from 299 to 6,210 mg/l. The TDS concentrations in IB-1c were significantly lower than in the other IBs ranging from 299 to 530 mg/l. TDS in IBs 1a, 1b, 3b, 4a, 4b, and 4d ranged from 1,040 to 6,210 mg/l.

The turbidity in the surface water samples ranged from 1.7 nephelometric turbidity units (n.t.u.) to 17,100 n.t.u. The turbidity of the samples collected in IB-1c was higher than any of the other samples collected from the Site. Surface water samples collected in IB-1b had the lowest turbidity of the samples collected on the Site.

The human health and ecological risk assessments further assess the significance of the water pH, fluoride, total cyanide, sulfate, TDS and turbidity detected in surface water.

2.2.2.4.3 Organics

Five surface water samples collected at the Site were analyzed for organics. Of the samples selected for organics analysis, all were analyzed for VOCs. Figure 2-23 presents the VOC results on the Site map. The following table presents for a summary of the detections of VOCs in the surface water samples.

	Range of VOC Detections								
Compounds	**IB-1 (µg/l)**			**IB-3 (µg/l)**			**IB-4 (µg/l)**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
Acetone	3	5.43	6.8	ND			1	9.6	9.6
Carbon Disulfide	1	1	1.0	ND			2	0.55	0.9
MEK	2	1.35	1.5	ND			1	.7	1.7

ND – Indicates not detected.

Acetone, carbon disulfide and methylethyl ketone (MEK) were detected in samples collected in IB-1 and IB-4. No VOCs were detected in the samples collected in IB-3. The concentrations of VOCs detected in the surface water samples were slightly above the respective detection limits. VOCs were not identified as COPCs in surface water.

Of the samples selected for organics analysis, all were analyzed for SVOCs. Figure 2-23 presents the SVOC results on the Site map. The following table presents the frequency of detection for the SVOCs in the surface water samples.

	Range of SVOC Detections								
Compounds	**IB-1 (µg/l)**			**IB-3 (µg/l)**			**IB-4 (µg/l)**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
Bis(2-ethylhexyl)phthalate	ND			ND			1	32	32
Phenol	ND			ND			1	1.0	1.0

ND indicates not detected.

Bis(2-ethylhexyl)phthalate and phenol were detected in one sample each in IB-4. No other SVOCs were detected and no SVOCs were detected in IBs 1 and 3. The SVOC detections in IB-4 were only slightly above the detection limit. No SVOCs were identified as COPCs in surface water.

2.2.2.5 Groundwater

The potentiometric surface of the American Bottoms Aquifer is generally around 20 ft-bgs in the vicinity of the Site. Four monitoring wells (MW-1 through MW-4; Figure 2-24) were installed around the perimeter of the Site to obtain groundwater samples and groundwater levels. A fifth, existing well (Upchurch MW-2S) was also used to collect a groundwater sample. MW-1 is located on the eastern perimeter of the Site and wells MW-2, MW-3 and MW-4 are located along the northwestern perimeter of the Site. The groundwater levels measured on July 26, 2004 indicate that groundwater flows from southeast to northwest across the Site. MW-1 is located up gradient of the Site, while MW-2, MW-3 and MW-4 are located down gradient of the Site. The Upchurch property is located at the northwestern corner of the Site and MW-2S is located approximately 200 feet from MW-2.

Groundwater samples were collected from the five monitoring wells in July 2004 and analyzed for alkalinity, total and amenable cyanide, chloride, fluoride, sulfate, TDS, gross alpha/beta and gamma spectroscopy. Additionally, the groundwater samples were analyzed for both total and dissolved metals including antimony, arsenic, cadmium, chromium, iron, lead, manganese, mercury, molybdenum, selenium, thallium and uranium (total only). Field parameters included pH, conductivity, oxidative/reductive potential (ORP), dissolved oxygen, and temperature. The groundwater chemistry results of the samples are tabulated and presented on Table 4-6 in the Draft Revised RI (Alcoa, 2009a). The locations of the monitoring wells, including the sample results and the spatial variations in groundwater chemistry are presented on Figure 2-24.

The field parameters were measured to monitor the progress of well purging during sampling. The final values obtained from the wells prior to sample collection were as follows: pH measurements of groundwater samples ranged from 6.71 in MW-2 to 7.89 in well MW-4. The conductivity of the groundwater samples ranged from 966 micromhos per centimeter (µmhos/cm) in well MW-1 to 3,626 µmhos/cm in well MW-3. ORP values of groundwater samples ranged from -96 electron volts (ev) in well MW-2 to -245 ev in well MW-1. Dissolved oxygen values of groundwater samples ranged from 0.03 mg/l in well MW-3 to 0.14 mg/l in well MW-2S. The water temperature values ranged from 15.59 degrees Celsius (°C) in MW-1 to 17.76 °C in MW-2. The groundwater samples collected from monitoring wells during the RI are

circumneutral, and do not exhibit the high pH values characteristic of caustic as would be expected if leachate from residue were impacting groundwater.

The results of the groundwater samples showed detections for all of the parameters analyzed except mercury and antimony (Figure 2-24). Additionally, chromium and lead were detected in the total sample, but not in the dissolved sample. The pH values of the groundwater samples are circumneutral and do not exhibit the high pH values characteristic of caustic. Figure 2-24 presents the locations and analytical results of the groundwater samples.

2.2.2.6 Geotechnical Samples

Eighty-eight geotechnical samples were collected from borings in the RI. These samples were analyzed for water content (84 samples), Atterberg limits (53 samples), soil classification (53 samples), compression (four samples), dry unit weight (31 samples), a sieve test (78 samples) and permeability (five samples). Sixty-one geotechnical samples were collected from IB-1, 25 were collected from IB-2 and two were collected from IB-4a. No geotechnical samples were collected from IB-3. The locations of the geotechnical samples are presented on Figure 2-3 of the Draft Revised RI report. The purpose of the geotechnical samples was to provide data on soil properties that may be needed for the development and screening of remedial alternatives. A summary of the results of the geotechnical samples is presented below for each IB.

2.2.2.6.1 IB-1 – Residue Disposal Areas

Sixty-one geotechnical samples were collected in IB-1. These samples were analyzed for water content (57 samples) Atterberg limits (45 samples), soil classification (45 samples), compression (two samples), dry unit weight (25 samples), a grain size (52 samples) and permeability (five samples). These samples were collected primarily from the residue and were very fine-grained in nature.

The water content is calculated by dividing the weight of water in the sample by the weight of dry solids. The water content of the samples collected in IB-1 ranged from 29 to 123 percent. As would be expected, the water content of the shallow samples was generally less than that of the deeper samples.

The percent passing a #200 sieve in IB-1 ranged from 10.7 to 99.9. The Atterberg limits results showed liquid limits ranging from 32 to 112 percent moisture, the plastic limits ranged from 17 to 84 percent moisture and the plastic indices ranged from zero to 53. Atterberg limits varied widely throughout the samples and were often related to the content of fine-grained materials. Samples comprised predominantly of fine-grained material generally had high Atterberg limits. In general, where the material was classified as sand, the Atterberg limits test was performed on finer-grained portions of the sample (i.e., clay or silt bands within the sand matrix). With the exception of borings 1bUP003 and 1bUP005, the in-situ water content of the samples exceeded the liquid limits, which, in theory, suggests that the soils have zero strength. Given that the alumina extraction process changed over time and that there was variability in the deposition of the waste from the process, certain areas of the RDAs appear to have significantly more stable soil than others. The reported soil classifications for soils in IB-1 ranged from CL to MH.

The results of the permeability samples from IB-1 ranged from 3.8×10^{-7} to 2.0×10^{-6} centimeters per second (cm/sec). These samples had between 62 and 99 percent passing a #200 sieve, and were classified as MH to ML. The measured permeabilities are consistent with the material types observed and geotechnical measurements of bauxite at other facilities.

2.2.2.6.2 IB-2 – Gypsum Dike Areas

Twenty-five geotechnical samples were collected from IB-2. Seven of these were analyzed for Atterberg limits and soil classification, two were subjected to a compression test, four were tested for dry unit weight and all 25 were analyzed for water content and subjected to a sieve test. The water content of the samples collected in IB-2 ranged from 13 to 58 percent. The water content in the IB-2 samples was significantly lower than in the IB-1 samples.

The percent passing a #200 sieve ranged from 10.0 to 99.9 percent. The Atterberg limits results in IB-2 showed liquid limits ranging from 39 to 73 percent moisture, the plastic limits ranged from 25 to 46 percent moisture and the plastic indices ranged from zero to 48. In general, where the material was classified as sand, the Atterberg limits test was performed on finer-grained portions of the sample (i.e., clay or silt bands within the sand matrix). Five of the seven samples tested for Atterberg limits had in-situ water contents lower than the liquid limits; four of these had water contents above the plastic limit.

The reported soil classifications for soils in IB-2 ranged from CH to MH. It should be noted that in samples with less than 50% passing the #200 sieve (five samples), the soil classification is not representative of the material as a whole. The material in IB-2 is generally hard, cementicious material and was characterized by the geotechnical lab as being similar to slag, containing large, angular grains of gravel size.

2.2.2.6.3 IB-4 – Other Areas of North Alcoa Site

Two geotechnical samples were collected in IB-4. These samples were analyzed for water content (2 samples) Atterberg limits (1 sample), soil classification (2 samples), dry unit weight (2 samples) and subjected to a sieve test (2 samples). The content of these samples was primarily bauxite residue and they were very fine-grained in nature. The water content of the samples collected in IB-4 was 54 and 74 percent. The sample that was 54 percent water was a surface soil sample collected from zero to 2 feet in depth. The sample with a water content of 74 percent was collected from 9-11 feet in depth.

The percent passing a #200 sieve in IB-1 ranged from 90.3 percent (shallow sample) to 99.5 percent (deep sample). Atterberg limits were only run on the deep sample and the liquid limit was 63 percent moisture, the plastic limit was 45 percent moisture and the plastic index was 18. The in-situ water content of the deep sample exceeded the liquid limits, meaning that the soil has zero strength. The shallow sample was listed as non-plastic. The reported soil classification for the shallow sample was CH.

2.2.2.7 Agronomic Samples

One hundred and thirty-nine samples were collected from IBs 1, 2, and 4 for agronomic parameters. No agronomic samples were collected from IB-3. The agronomic samples were collected from three depth intervals on the Site including zero to one ft-bgs, one to two ft-bgs, and nine to 11 ft-bgs. The agronomic parameters included nitrogen, sulfur, calcium, magnesium, sodium, potassium, boron, zinc, manganese, copper, iron, phosphorus, soil pH, water content, and soil bulk density in IBs 1, 2, and 4, and nitrate, sulfate, cation exchange capacity (CEC) and exchangeable sodium capacity (ESP) in IBs 1 and 4. The locations of the agronomic samples are presented on Figure 2-3 of the Draft Revised RI report. The following

table provides a summary of the data including the number of samples analyzed in each IB and the range of detections for each parameter.

	Range of Detections for Agronomic Parameters								
Parameters	**IB-1 (mg/kg)**			**IB-2 (mg/kg)**			**IB-4 (mg/kg)**		
	No.	**Min**	**Max**	**No.**	**Min**	**Max**	**No.**	**Min**	**Max**
Nitrogen	118	49	2276	17	26	355	4	152	218
Sulfur	118	501	206757	17	1336	205755	4	16701	21141
Calcium	118	61080	362520	17	5368	217129	4	201066	293373
Magnesium	118	187	17613	17	5	4701	4	3488	3813
Sodium	118	1027	368675	17	50	4998	4	39173	279677
Potassium	118	3	2039	17	39	2618	4	1045	1521
Boron	118	4	269	17	1	381	4	122	136
Zinc	118	32	1181	17	20	454	4	79	184
Manganese	118	23	7359	16	3	462	4	783	1174
Copper	118	18	1087	17	15	400	4	36	73
Iron	118	2817	265025	17	145	185068	4	59544	83216
Phosphorus	118	7	3416	17	3	1184	4	1754	2611
Nitrate	83	2	26	NA			4	6	10
Sulfate	118	168	304	NA			4	840	2247
CEC (meq/100g)	118	2.4	76.3	NA			4	77.5	90.9
ESP (%)	118	4.38	59.43	NA			4	7.52	19.96
pH (s.u.)	118	7.3	10.6	17	5.9	7.9	4	10.4	10.5
Water Content (%)	118	2.4	41.7	17	1.33	30.01	4	26.72	35.77
Bulk Density	118	1.01	2.62	17	1.46	2.41	4	1.41	1.71

2.2.2.8 Phase 2 Ecological Data Collection

Ninety-one samples were collected from IBs 1, 2, and 3 to assess the uptake of Site-related metals into plant and terrestrial invertebrate tissues as outlined in the Phase 2 Ecological Field Sampling Plan (Alcoa, 2004e). These samples consisted of 31 surface soil, 32 plant tissue and 28 terrestrial invertebrate samples that were collected from IB-1a, IB-1b, IB-1c, IB-2, and IB-3b on of the Site. The locations of the samples are presented on Figure 2-25.

The purpose of the Phase 2 data collection was to reduce the uncertainty in the assessment of ecological risk described in the BERA. The evaluation of the Phase 2 data is presented in the ecological risk assessment. The results of the samples collected as part of the Phase 2 data collection are presented in the following subsections.

2.2.2.8.1 Surface Soil Samples

Thirty one surface soil samples were collected from the Site as part of the Phase 2 ecological data collection. The samples were analyzed for cadmium, chromium (total and hexavalent), lead, selenium, vanadium, zinc, cyanide, fluoride and pH. The chromium VI data were all rejected by the data validator due to extremely low matrix spike recovery. The documentation of the data validation for the chrome VI samples is provided in Appendix F of the Draft Revised RI

report. The fluoride data is also suspect because of the variability observed between the Phase 1 and 2 data. The Phase 2 fluoride concentrations were significantly lower than the Phase 1 data. The following table provides a summary of the results.

	Range of Constituents Detected in Phase 2 Surface Soil Samples								
Parameters	**IB-1**			**IB-2**			**IB-3**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
Cadmium (mg/kg)	16	6.2	10.7	5	4.23	7.6	10	3.84	10
Chromium (mg/kg)	16	683	1,900	5	99.1	216	10	180	413
Lead (mg/kg)	16	382	3,650	5	873	1360	10	278	1,110
Selenium (mg/kg)	12	3.33	5.7	4	3.03	5.1	10	3.18	17
Vanadium (mg/kg)	16	7.36	1,270	5	278	631	10	243	898
Zinc (mg/kg)	16	143	756	5	153	307	10	328	1,290
Fluoride (mg/kg)	16	10.1	33.8	5	3.86	4.7	10	7.85	23.1
Cyanide (mg/kg)	4	5.08	9.7	3	3.03	5.9	5	11.3	53.2
pH (s.u.)	16	6.96	9.2	5	7.49	7.8	10	7.71	8.8

The metals concentrations detected in the Phase 2 surface soil samples were similar to those detected in the Phase 1 surface soil samples. The maximum lead detection in IB-1 was higher than the previous maximum; however, the next highest lead concentration in IB-1 was 1,040 mg/kg, and all of the other lead concentrations were less than 200 mg/kg. The maximum detection of zinc was higher in IB-3 than in the Phase 1 RI; however, all of the other zinc concentrations in IB-3 were within the range of the Phase 1 data. The metals detected in these samples will not be directly evaluated in the human health risk assessment because the Phase 1 effort yielded a statistically adequate data set for human health risk assessment. The ranges of detections are similar to those of the Phase 1 data and the samples were collected in support of the ecological evaluation.

The Phase 2 surface soil sample results for pH, fluoride and cyanide are also presented in the above table. The pH ranges of the samples were generally similar to those in Phase 1. The average pH in IB-1 was nearly neutral at 6.96, IB-2 was slightly above neutral at 7.49, and IB-3 was also slightly above neutral at 7.71. Cyanide was detected in 12 of the 31 Phase 2 samples within the ranges observed in the Phase 1 RI in IB-1 and IB-2. The maximum detection of cyanide in IB-3 was approximately one order of magnitude higher than the maximum in the Phase 1 RI. This result appears to be a high outlier; the other concentrations observed in IB-3 in the Phase 2 investigation were less than 1.0 mg/kg.

2.2.2.8.2 Vegetation Samples

Thirty-two samples were collected of vegetation growing in IB-1, IB-2, and IB-3. The vegetation samples were analyzed for cadmium, chromium (total only), lead, selenium, vanadium, zinc, cyanide and fluoride. The following table provides a summary of the results.

	Range of Constituents Detected in Phase 2 Vegetation Samples								
Metals	**IB-1 (mg/kg)**			**IB-2 (mg/kg)**			**IB-3 (mg/kg)**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
Cadmium	14	0.3	1.7	5	0.386	0.95	10	0.263	0.53
Chromium	17	1.83	5.0	5	1.31	2.6	10	0.688	1.7
Lead	17	3.95	41.5	5	19.7	42.3	10	1.4	1.8
Selenium	17	1.44	1.8	5	1.38	1.7	10	1.5	2.0
Vanadium	13	1.76	5.5	5	8.34	3.1	6	0.375	0.46
Zinc	17	59.6	234	5	62.9	98.8	10	45.4	94.5
Fluoride	17	1054	2,050	5	514	1,060	10	922	1,270
Cyanide	1	0.75	0.75	1	0.94	0.94	ND		

ND indicates not detected.

All of the metals except cadmium and vanadium were detected in all of the samples collected. Cadmium was detected in all but three samples and vanadium was detected in all but eight samples. Cadmium, lead and zinc all appear to have one high outlying concentration in the sample set from IB-1. Sample 1bVG002 had cadmium, chromium, and lead concentrations at 1.7, 41.5, and 234 mg/kg respectively. All of these concentrations are nearly one order of magnitude higher than the next highest concentration in the data set for IB-1.

The Phase 2 vegetation sample results for cyanide are also presented in the above table. Cyanide was detected in only one sample in each of IB-1 and IB-2. The cyanide detections were only slightly above the detection limit.

2.2.2.8.3 Terrestrial Invertebrate Samples

Twenty-eight terrestrial invertebrate samples were collected from the Site during Phase 2. These included 14 samples from IB-1, five from IB-2 and nine from IB-3. The terrestrial invertebrate samples were analyzed for cadmium, chromium (total only), lead, selenium, vanadium, zinc, cyanide and fluoride. The results of the terrestrial invertebrate samples collected for the ecological evaluation are presented on Table 4-11 of the Draft Revised RI. The following table provides a summary of the analytical results.

	Range of Constituents Detected in Phase 2 Invertebrate Samples								
Metals	**IB-1 (mg/kg)**			**IB-2 (mg/kg)**			**IB-3 (mg/kg)**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
Cadmium	13	0.362	0.92	5	1.05	2.2	9	0.61	1.4
Chromium	14	51.5	191	5	94.3	241	9	27.8	102
Lead	14	5.03	34.4	5	86	260	9	1.15	2.9
Selenium	14	0.428	0.79	4	0.478	0.98	9	0.539	1.1
Vanadium	14	7.22	33.2	4	8.15	22.2	6	0.386	1.7
Zinc	14	84.9	161	5	124	195	9	87.3	128
Fluoride	4	75.7	99.7	1	14.7	14.7	2	136	210

	Range of Constituents Detected in Phase 2 Invertebrate Samples								
Metals	**IB-1 (mg/kg)**			**IB-2 (mg/kg)**			**IB-3 (mg/kg)**		
	No.	**Avg**	**Max**	**No.**	**Avg**	**Max**	**No.**	**Avg**	**Max**
Cyanide	5	4.58	10.5	1	2.1	2.1	3	2.77	3.8

The metals results for the terrestrial invertebrates had detections of all of the metals analyzed. Chromium, lead and zinc were detected in all of the samples analyzed. Cadmium and selenium were detected in all but one sample each, and vanadium was detected in all but four samples.

The Phase 2 terrestrial invertebrate sample results for fluoride and cyanide are also presented in the above table. Fluoride and cyanide were detected at a relatively low frequency in the invertebrate samples. Fluoride was detected in seven of the 28 samples and cyanide was detected in nine of the 28 samples.

2.2.2.9 Off-Site Boring Investigation

The off-site boring investigation was performed to verify the location of bauxite residue placement and other fill materials at the northwestern perimeter of the Site and within the footprint of the former Pittsburg Lake. Historically, fill was placed in the former Pittsburg Lake, but the geographic extent of the lake was not accurately defined in the early 20th century when infilling occurred. This information is germane to the definition of the Site Boundary as set forth in the AOC. The borings were placed in the residential area to the north of Lake Drive and in two parallel lines along the southern property line of the adjacent residences and along the Louisiana Boulevard/Lake Drive right of way to the north of the residences (Figure 2-24). The borings were documented in accordance with Tetra Tech SOP No. 4: Supervision of Exploratory Borings, using a detailed lithologic log. The field procedures were conducted in accordance with the drilling and logging procedures outlined in sections 2.6.2.2 and 2.6.2, respectively, of the Field Sampling Plan in Appendix G-2 of the RI/FS Work Plan (Alcoa and the City of East St. Louis, 2003). No samples were collected for chemical analysis. The results of the investigation indicate that residue is present in the four borings nearest the Site (Borings 4cUP014, 4cUP015, 4cUP016, and 4cUP017) between at least two and eight feet deep. No observable bauxite residue was present in the other six borings. It should be noted that the borings containing residue were all within the Site as defined by the AOC.

Based on the results of the off-site boring investigation, the residue may be present on the southern portion of the residential properties but does not appear to extend as far northward as Louisiana Blvd. All of the residue observed in the borings along the northwestern corner of the Site was greater than two feet in depth. Figure 2-5 presents the limit of the bauxite residue in the area.

2.3 Baseline Human Health Risk Assessment

The primary objective of the BHHRA is to evaluate the possible risks associated with chemicals of potential concern (COPCs) in environmental media on human receptors to help guide future risk management decisions at the Site. Baseline human health risks were evaluated for current conditions of the Site and potential future conditions of several areas of the Site where activities other than baseline activities could be reasonably expected.

The Draft Revised BHHRA submitted to the USEPA on April 15, 2010 has not been finalized. During preparation of FFS-OU1, USEPA has directed the Respondents to include the following potential future exposure scenarios in the calculation of baseline risks (i.e., future risks that could occur if no further removal or remediation action is taken):

- Residential exposure on the barren RDAs (IB-1) and Gypsum Areas (IB-2) and the North Wet Area (IB-4a),
- Industrial worker exposure on the barren RDAs (IB-1) and Gypsum Areas (IB-2) and the North Wet Area (IB-4a), and
- Trespasser exposure on the barren RDAs (IB-1) and Gypsum Areas (IB-2) and the North Wet Area (IB-4a).

USEPA personnel performed these baseline risk calculations, and Appendix A provides the USEPA work product modified on the basis of a technical meeting between the USEPA and Alcoa representatives, and Alcoa's understanding of applicable assumptions. The USEPA future residential, industrial worker, and trespasser exposure scenarios assume exposure in these areas, using concentrations measured during the RI (i.e., without site improvements), for a duration of 30 years for residential receptors, 25 years for industrial worker, and 30 years for trespasser (i.e., that trespasser is local resident). The trespasser exposure scenario would consist of two hours per day to the 95% UCL for 20 days per year. The exposure duration would be 10 years for the adolescent plus 20 years for an adult. I was assumed that 100% of the individual's daily intake would occur during this 2 hour time frame. The calculated chemical and radiological risks for the residential, industrial worker, and trespasser receptors are presented in Appendix A. The cumulative risks for each scenario and investigative blocks are summarized below.

Potential Future Exposure Scenario	Type of Risk	IB-1	IB-2	IB-4a
Residential	Carcinogenic	4×10^{-3}	3×10^{-4}	6×10^{-5}
Residential	Non-carcinogenic (HQ) - Child	3	1.56	1.8
Industrial	Carcinogenic	1×10^{-3}	8×10^{-5}	8×10^{-6}
Industrial	Non-carcinogenic (HQ)	0.2	0.08	0.09
Trespasser	Carcinogenic	5×10^{-5}	4×10^{-6}	2×10^{-6}
Trespasser	Non-carcinogenic (HQ) - Adolescent	0.05	0.02	0.03

This analysis indicates that the risks associated with the trespasser scenario are within the USEPA risk range of 10^{-6} to 10^{-4} and the noncarcinogenic HI is lower than 1 for IB-1, IB-2, and IB-4a. A residential scenario may be associated with risks that exceed the USEPA risk range for IB-1 and IB-2 and potentially for unacceptable noncarcinogenic effects for a child residential receptor for all three areas. These risk calculations also suggest that there may be risk greater than the USEPA risk range for a full-time industrial receptor for IB-1.

2.3.1 Human Health External Radiation Risk Uncertainty

The trespasser risk calculations presented above are based on a 2 hour per day exposure time. A review comment by the agency on the risk calculations concerned whether a 2 hour per day exposure time would underestimate risk to the trespasser if contaminated material adhered to the clothes and/or skin, resulting in continued exposure after the trespasser left the site, and potentially transfer the material to other individuals, pets or objects. The uncertainty in the risk calculation associated with this issue is discussed below.

External radiation is highly dependent upon proximity to significant quantities of radioactive material. The amount of material that may become adhered to a trespasser's skin or clothing is limited. For children, the skin adherence factor is 0.04 mg/cm^2 and for adults, it is 0.011 mg/cm^2. Even assuming adherence to 100% of the skin, which is more conservative than used for dermal absorption calculations, to account for "dirty clothes" does not result in significant total mass.

An evaluation of the dose and risk received from such material was made based on the study by Kowalczik (2008) assessing the dose from radioactive skin contamination of a child. The annual risk was calculated to be $4x10^{-11}$. Thirty years of exposure at this level equates to a total risk of $1x10^{-9}$. This number is conservative since the adult skin adherence factor is lower and the dose from skin contamination is also lower due to the increased depth below the skin of critical organs. Transfer to other individuals, pets, or objects would be a fraction of the material on the trespasser and thus contribute even less risk; therefore the incremental risk associated with adherence of contaminated material to clothes and/or skin is negligible.

2.3.2 Respondent Position on Hypothetical Nature of Residential Scenario

The Respondents maintain the position that future residential or industrial land use is not reasonably anticipated given geotechnical considerations of the RDA substrate. Future residential land use also is not likely given the industrial zoning of the site and the commitment of the City to ensure no future residential development. Therefore, a residential scenario can only be considered as a hypothetical condition and is not realistic for OU-1.

With regard to geotechnical considerations (as discussed in Section 2.2.1), the bauxite residue is soft, highly plastic, thixotropic and not suitable as a subgrade for building construction or site redevelopment without extensive engineering. The residue has very poor trafficability when wet and can be difficult to access without special equipment even in dry conditions. Thus, solely based on geotechnical reasons there is effectively no likelihood that future residential or industrial land use on bauxite residue can occur without first creating a stable geotechnical platform that would accommodate roads and buildings. Typically this will require placement of a cover material over the bauxite residue, such as a cohesive earthen material (i.e., silty clay). The recent Test Strip Program demonstrated that placement of a two foot soil cover does allow access of equipment needed for future Site redevelopment. Placement of a soil cover layer that meets IEPA landfill cover requirements will result in different exposure point concentrations than those used in Appendix A. IEPA requires placement of clean soil as the landfill cover. The steep side slopes of the gypsum dikes likewise prevent site reuse as currently configured without reshaping and regrading the material. Therefore, there is virtually no likelihood that the future risk calculations provided in Appendix A represent reasonable future exposure scenarios.

Furthermore, the City of East St. Louis has zoned OU-1 as industrial land use, which prohibits residential land use. Finally, independent of and in addition to the remedy selected by USEPA, Alcoa plans to negotiate with the City of East St. Louis for placement of deed restrictions and/or

other durable covenants on property within OU-1 that would both specifically prohibit residential land use within OU-1 and disturbance of the residue and gypsum.

Based on these facts, the Respondents consider USEPA's inclusion of an on-Site residential scenario for OU-1 as part of the FS process unrealistic by Site-specific considerations. Furthermore, including this scenario is not supported in the National Contingency Plan or in USEPA Risk Assessment Guidance. For example, the U.S. Congress mandates in The National Contingency Plan (40 CFR 430 (d)(4)) that:

> *(4) Using the data developed under paragraphs (d)(1) and (2) of this section, the lead agency shall conduct a site-specific baseline risk assessment to characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to ground water or surface water, releasing to air, leaching through soil, remaining in the soil, and bioaccumulating in the food chain. The results of the baseline risk assessment will help establish acceptable exposure levels for use in developing remedial alternatives in the FS, as described in paragraph (e) of this section.*

Additionally, the preamble to the National Contingency Plan (55 FR 8711) states:

> *In general, the baseline risk assessment will look at a future land use that is both reasonable, from land use development patterns, and may be associated with the highest (most significant) risk, in order to be protective. These considerations will lead to the assumption of residential use as the future land use in many cases. Residential land use assumptions generally results in the most conservative exposure estimates. The assumption of residential land use is not a requirement of the program but rather is an assumption that may be made, based on conservative but realistic exposures, to ensure that remedies that are ultimately selected for the site will be protective. An assumption of future residential land use may not be justifiable if the probability that the site will support residential use in the future is small.*

USEPA has published various guidance documents concerning baseline risk assessments and future land use considerations. OSWER Directive 9355.0-30 (Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions) states:

> *When exposures based on reasonable future land use are used to estimate risk, the NCP preamble states that the ROD "should include a qualitative assessment of the likelihood that the assumed future land use will occur" (55 Fed. Reg. at 8710).*

As stated above, for geotechnical reasons future residential or industrial land use cannot occur on the waste materials without first placing a soil bridging layer on the waste and reconfiguring the steep side slopes of the impoundments. Thus there is realistically no likelihood that the assumed future land use will occur directly on the bauxite residue or gypsum.

2.3.3 BHHRA Conclusions

The USEPA baseline risk calculations are provided in Appendix A. The methodology and conclusions of the Draft Revised BHHRA are provided below.

In the BHHRA, maximum concentrations of chemicals in soil, sediment, and surface water were compared against conservative screening criteria (e.g., U.S. EPA Regional Screening Levels or RSLs) to identify COPCs for the quantitative risk assessment. Industrial RSLs were used as

screening criteria for on-Site exposure scenarios based on current and probable future land use. Residential soil RSLs were also used to identify COPCs for potential off-Site migration. Potentially complete and significant exposure pathways were identified in the Exposure Assessment of the Draft Revised BHHRA.

Exposure assumptions were identified in the RI/FS Work Plan, and these were used in the risk assessment to quantify exposure for complete exposure pathways for the various receptors. The Draft Revised BHHRA concludes that the Site is within or below the USEPA risk range for current receptors under the baseline scenarios evaluated as part of this risk assessment. The current exposure scenario for IB-1 and IB-2 evaluated in the BHHRA considers only a trespasser, and these results are within acceptable risk targets. The exposure frequency that is assumed in the BHHRA for a trespasser (20 day/year) is considered to be a conservative estimate given the site-specific condition. The RDAs are not easily accessible and a good distance from the OU-1 perimeter, and there has been little evidence of any onsite trespassing and no evidence of regular trespassing within the extent of OU-1.

The BHHRA indicates there are potential future risks to industrial/commercial receptors if there were to be direct contact with gypsum containing lead at concentrations in excess of 800 mg/kg. IB-specific receptor risk and noncancer hazards are presented in Tables 2-2 and 2-3, respectively. As indicated previously, USEPA baseline calculations are provided in Appendix A and indicate potential for risk outside the USEPA risk range for hypothetical residential exposure scenarios for IB-1 and IB-2 and future industrial workers in IB-1.

It should be noted that a portion of IB-3 is within the OU-1 boundary, while the rest of IB-3 is part of OU-2 that will be addressed at a future time. The trespasser risk to the OU-1 area of IB-3 is evaluated in the FFS in the following manner. IB-3 surface soil samples that are within the OU-1 boundary have been identified, and summary statistics of key non-radiological COPCs (i.e., arsenic, vanadium, and a number of the carcinogenic PAHs) were calculated for this dataset (see Appendix D for the sample list and ProUCL output for these calculations). The 95% UCL for the IB-3 OU-1 surface soil samples can be compared to those of IB-1, IB-2, and the RI definition of IB-3, as shown in Table 2-4. The 95% UCLs calculated for IB-3 within OU-1 are lower than the respective 95% UCLs for the RI IB-3 dataset in all cases but one. The exception was the nearly equivalent result for arsenic (16.2 vs. 16.9 mg/kg for RI IB-3 vs. IB-3 OU-1 datasets, respectively).

Given the generally lower 95% UCLs (which become the EPCs of the risk characterization), the corresponding summed theoretical excess lifetime cancer risks and non-cancer HIs are expected to be lower for the IB-3 OU-1 dataset than for the RI IB-3 dataset. Furthermore, since the RI estimate cancer risk results of the IB-3 trespasser are lower than 10^{-6} and the trespasser HI is less than one, the IB-3 OU-1 assessment of the trespasser also is expected to indicate acceptable risk. This is demonstrated in Table 2-5 in which the COPC-specific risk results for IB-3 OU-1 are compared with the RI risk results for IB-1, IB-2, and IB-3 (drawn from the BHHRA risk tables, which have been included in this FFS in Appendix D). The IB-3 OU-1 risk results were calculated by taking the ratios of the COPC-specific EPCs of the IB-3 OU-1 and RI IB-3 datasets and multiplying the RI COPC-specific cancer risks and His by the respective EPC ratio. For IB-3 OU-1, the resulting summed theoretical lifetime excess cancer risk is $4x10^{-7}$ and the summed HI is 0.004. Therefore, current trespassing is also acceptable for the IB-3 OU-1 area. Under the future solar field development, surface soil will be covered and not available for direct contact by trespassing receptors.

Radionuclides

Risk from radionuclides from IB-1 and IB-2 was included in the BHHRA discussion above. Data on radionuclides in IB-3 was not available until after preparation of the BHHRA. Radionuclide concentration data collected during the November 2011 radiological survey (Appendix C) found that concentrations in IB-3 were similar to or less than those in IB-1 and IB-2. Since the IB-3 radionuclide soil samples were not random, but directed at locations to support the gamma survey, statistical analysis of the soil samples is not relevant. However, maximum radionuclide concentrations are associated with un-diluted residue and where present, IB-3 generally contains diluted bauxite residue. Therefore, the associated radiological risks are less than those calculated for IB-1, which were determined to be within the USEPA risk management range for a trespasser.

Groundwater

The Draft Revised BHHRA evaluated the groundwater exposure pathway, including: 1) physical completeness of the exposure pathway (verification of the effectiveness of the institutional control and a survey for existing wells) and 2) presence of chemicals of interest (COIs) in groundwater at concentrations that may pose potential risk. Data collected as part of the groundwater investigation at the Site indicates that groundwater has been minimally impacted from activities at the Site. During the risk assessment and based on information contained in Technical Memoranda No. 2 and No. 3 (*Effectiveness of the City of East St. Louis Groundwater Ordinance as an Institutional Control* and *Status of Existing Water Wells*, respectively), it was concluded that current and future use of groundwater is an incomplete exposure pathway and impacted groundwater is not likely to affect surface water in the future (Alcoa and the City of East St. Louis, 2004b and c). An industrial well was identified at the Upchurch property (IB-4e), and potential incidental exposure of an industrial worker to groundwater from this well was also within acceptable risk estimates.

Much of the waste bauxite residue and gypsum materials are underlain by significant accumulations of bauxite residue at depth (infilling of the former Pittsburgh Lake). Thus large-scale migration of groundwater in the subsurface is expected to be buffered by the alkaline residue decreasing the mobility of pH-dependent COCs. Although TCLP data collected in OU-1 during the 1996 CERCLA redevelopment study (IEPA, 1999) is not representative of site conditions as stated in the March 23, 2012 revised ARARs analysis provided by USEPA, by comparing TCLP results to groundwater monitoring data collected during the RI, it is evident that Site metals and metalloids are not being leached to the aquifer; therefore there are not significant issues with leaching of site materials to groundwater.

USEPA provided the following information on the groundwater pathway in a letter to Alcoa and the City dated July 22, 2011 (USEPA, 2011):

> *"Based on information generated to date about groundwater quality at the site and the nature of the bauxite residue materials, any needed remedial action for the site groundwater will not be precluded by the bauxite residue impoundment remedial action. Based on current information, EPA envisions that the future groundwater remedial action at the site would consist of a pathway exclusion demonstration and an appropriate, durable, and enforceable institutional control (IC). One mechanism to consider is the Illinois [Uniform] Environmental Covenant Act, which has been successfully used at CERLCA sites in Illinois. The current information indicates that groundwater under the*

bauxite residue materials is not anticipated to be the subject of any future remedial action other than the pathway elimination and IC remedy described above."

2.4 Baseline Ecological Risk Assessment

The Draft Revised BERA was submitted April 15, 2010 but has not been finalized. The BERA assesses ecological risks in the baseline and future conditions at the Site, only part of which contains OU-1. Risks are evaluated for the list of Ecological Chemicals of Interest (ECOIs) that was identified in the RI/FS Work Plan (Alcoa and the City of East St. Louis, 2003).

Historically, no significant ecological resources were present at the Site during operations. Currently, invasive species have populated the Site but do not appear to represent a significant wildlife habitat resource for the area. The Site is a relatively small fragment of low quality habitat dominated by invasive species typical of disturbed sites. It is near, but physically disconnected from, the much larger semi-contiguous remnant of higher quality habitat that includes Frank Holten State Park, Horseshoe Lake State Park and a corridor in the Harding Ditch Area that connects East St. Louis to the Mississippi River. Species observed on-Site include typical urban wildlife. More wide-ranging species such as waterfowl, small birds and mammals such as whitetail deer and coyote may occasionally visit the Site. A breeding colony of black-crowned night heron, little blue heron and snowy egret is reportedly located within one mile of the Site, however, none of these species have been observed on-Site (although the RIFS Work Plan did not identify the requirement to conduct a specific survey for black-crowned night heron, such as nocturnal surveillance). The Site does not represent critical habitat for either threatened or endangered species, or special-status species.

Management goals are used to identify the goals of the Site in terms of ecological risk. The ecological risk management goal used to design the BERA data collection and evaluation process was (Alcoa and the City of East St. Louis, 2010b):

- The post-remedy condition of the Site will not result in significant adverse effects on local wildlife populations, including state-endangered bird species from the nearby Alorton Rookery.

The RDAs (IB-1) were subdivided into three sub-areas (IB-1a, IB-1b, and IB-1c) and each was evaluated separately due to different habitats and potentially different exposures. As requested by the agency, IB-2 was evaluated only for receptors that might occasionally cross the area since it is essentially barren and represents no viable ecological habitat and provides no food source for receptors. Within IB-3, only IB-3b is assessed because it represents the only area of ecological habitat in that investigative block. Within IB-4, only IB-4a is within the boundaries of OU-1.

The Draft Revised BERA evaluates potential risks to a range of receptors representing wide-ranging avian and mammalian carnivores (red-tailed hawk and coyote), herbivores (whitetail deer), small birds (American robin) and mammals (deer mouse). Risks to receptors that utilize primarily wet habitats (muskrat and mallard) were also evaluated along with risks to the black-crowned night heron. The objective of evaluating risks to the semi-aquatic habitats is to determine whether the wet areas on the Site might currently present risk to the local populations of waterfowl. The assessment of risk was limited to the terrestrial wildlife receptors that could either inhabit the Site as part of their home range or transiently move through the Site.

Populations of aquatic species were not included as an assessment endpoint to be evaluated in the BERA due to the lack of quality habitat and the isolated nature of the wet areas at the Site.

Constituents of Potential Ecological Concern (COPECs) were identified using standard USEPA screening procedures (USEPA, 1997a). Ecological risks posed by exposure to COPECS were for wide-ranging receptors on a Site-wide basis and an IB-by-IB basis for receptors with small ranges. No unacceptable risk to local populations of wide-ranging upland receptors (represented by whitetail deer, coyote, and red-tailed hawk) are predicted. When reasonable assumptions of area use are used in the exposure calculations, no risk is estimated for wide-ranging semi-aquatic receptors.

Risks also were assessed to small home range mammalian and bird receptors (represented by the deer mouse and American robin; Table 4-3 of the BERA). Table 2-6 summarizes the BERA conclusions for specific receptors and Site investigative blocks. Some low-level risks are predicted for such individual small-home range receptors, but local populations are not at unacceptable levels of risk.

In summary, although some individual organisms may experience exposure to COPECs that exceed toxicity reference values (i.e., hazard quotient of greater than unity), neither populations of non-protected species, or individuals of special-status species appear to be at risk.

This assessment of baseline conditions is also predicted for reasonable future scenarios. Some areas of the Site are considered candidates for future commercial or industrial development. Either of these future landscape scenarios likely would remove the limited ecological habitat currently present in IB-3b. One of the future options for the barren residue areas of IB-1 and IB-4a is implementation of a cover system that would also support industrial site redevelopment, such as a solar project, or to regrade the RDAs and Gypsum Area. If either of the containment cover alternatives is implemented, the Site will not be managed as ecological habitat, and closure is not intended to enhance local populations of receptors.

2.4.1 Ecological Risk Assessment for Pond in IB-1b

Risk calculations were prepared for various ecological receptors potentially present in the IB-1b pond area, which is currently covered by stands of phragmites and a small open water pond area. Ecological risk calculations provided to USEPA on January 5, 2012 used analyses of bauxite residue collected during the RI as the EPC in the HQ calculations. The LOAEL HQs for some receptors exceeded a value of one for chromium, vanadium, and/or zinc. This calculation did not account for the vegetative layer that covers the bauxite residue in the pond area. Observations made during the test strip program indicated that the vegetative mat was on the order of six inches in some areas. Therefore additional sampling was conducted to obtain the information needed to provide more representative EPC data for the HQ calculations and to reduce uncertainty in the Site-specific risk calculations.

Samples of organic material covering the base of the wet area, both currently inundated and non-inundated, were collected within the IB-1b pond in March 2012. Samples were analyzed for chromium, vanadium, and zinc. Sample results are presented in Table 1, Appendix E. The measured COPC concentrations in the organic layer are considerably lower than COPC concentrations measured in the sediment/residue reported in the Draft Revised BERA (Alcoa, Inc. and the City of East St. Louis, 2010b). A summary of the estimated exposure and resulting HQ calculations using the mean and 95% organic layer samples is provided in Table 2, Appendix E. All LOAEL HQs were less than 1.0 for all COPC/receptor pairs. Therefore risks to the aquatic and semi-aquatic receptors potentially utilizing the IB-1b pond (if allowed to remain

as a water treatment feature without additional cover) are considerably lower than originally predicted in the Draft Revised BERA regardless of assumed Site use by the receptors.

2.5 Surface Water

Both the Draft Revised BHHRA and Draft Revised BERA assess surface water pathways for the various exposure scenarios evaluated in each assessment. Neither the Draft Revised BHHRA nor the Draft Revised BERA indicate that exposure to COPCs in surface water pathways exceed the USEPA risk range for the evaluated receptors.

3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

One of the FS evaluation criteria is compliance of the remedy with applicable or relevant and appropriate requirements (ARARs):

> *"Compliance with the applicable or relevant and appropriate requirements (ARARs) of other environmental laws is a cornerstone of CERCLA. To avoid simply displacing the contamination at a site from one medium (i.e., air, soil, water) into another, identification of ARARs is the major prerequisite for setting cleanup goals, selecting the remedy, and determining how to implement the remedy while assuring protection of human health and the environment." (USEPA, 1992)*

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site (Section 300.5 of the NCP, 55 FR at 9914). Relevant and appropriate requirements mean those cleanup standards that address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited (Section 300.5 of the NCP, 55 FR at 9914). Advisories, guidance and policies may help USEPA define and develop protective remedies and interpret laws. These policies and guidance, known as "to be considered" (TBCs) are not potential ARARs because they are not promulgated.

ARARs are divided into the three categories:

- **Chemical-specific requirements** – health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values,
- **Location-specific requirements** – restrictions placed on the types of activities that can be conducted or on the concentration of hazardous substances that can be present solely because of the location where they will be conducted; and
- **Action-specific requirements** – technology or activity-based requirements or limitations on actions taken with respect to hazardous wastes.

USEPA provided the following revised ARAR analysis by email on March 23, 2012:

I. ARARs Introduction

This ARARs analysis evaluates each of the potential landfill waste cover and closure ARARs within each of the four identified areas addressed in the Focused Feasibility Study (FFS): IB-1 (bauxite residue area); IB-2 (fluorogypsum area); IB-3 and IB-4 (not all of IB-3 and IB-4 are in the OU-1 footprint). This analysis also evaluates each of the potential waste cover and closure ARARs for four pond areas existing within IB-1a, IB-1b, and IB-4a. In Part 1, Section A below identifies the potential ARARs; Section B analyzes each potential ARAR for the identified area;

Section C provides a discussion of the requirement imposed by each ARAR proposed through this analysis. Part II addresses potential landfill and waste cover, closure and post-closure care ARARs for the pond areas within IB-1a, IB-1b and IB-4b. Part III provides an evaluation of surface water management ARARs.

Site Background Information

The Alcoa plant operated from 1902 until the late 1950s, and by the mid-1960s, most of the production facilities had been demolished and the land had been sold or otherwise transferred. Alcoa transferred the property containing OU1 to the Southwest Regional Port District in 1961. OU1 contains three residue disposal areas of approximately 40 acres each, designated as IB-1a, IB-1b and IB-1c, and a fourth smaller area that was also used for disposal of some residue (within IB-4a). Four areas exist within the OU1 footprint that have been used for surface water collection/management seepage ponds. Two of these are located in IB-1a and IB-1b and two are located within IB-4a.

A. Potential landfill and waste cover, closure and post-closure care ARARs :

35 Illinois Administrative Code (IAC) 807.305

35 IAC 807.305 provides the cover material, thickness and compaction requirements for sanitary landfills.

35 IAC 807.502

35 IAC 807.502 imposes requirements to attain specified landfill closure standards to maintain the performance of the cover.

35 IAC 811

Applies to landfills that, among other things, had accepted waste after September 18, 1990. 35 IAC 811 provides standards for operating, covering and closing sanitary landfills at Subpart A, inert waste landfills at Subpart B, and putrescible and chemical waste landfills at Subpart C.

RCRA Subtitle C

RCRA Subtitle C specifies standards for operating, covering and closing a hazardous waste landfill.

40 C.F.R. Part 192

40 C.F.R. Part 192 specifies standards for the stabilization, disposal and control of uranium and thorium mill tailings.

B. Analysis by Disposal Area

1. Bauxite (Red Mud) Area (IB-1)

35 IAC 807.305

The requirements of 35 IAC 807.305 are not applicable to the North Alcoa Site bauxite residue landfill area IB-1 because the landfill ceased operations prior to the rule, but 35 IAC 807.305 is relevant and appropriate, even though the landfill ceased operations prior to the rule, since the State of Illinois requires this provision for landfills that ceased operations prior to the rule. For purposes of 35 IAC Part 807, the North Alcoa Site bauxite (red mud) residue is a solid waste which, pursuant to 415 ILCS 5/3.535, is defined to include waste from mining operations.

35 IAC 807 applies to solid waste landfills that, among other things, cease operations prior to September 18, 1990, and initiate closure by September 18, 1992. See 35 IAC 814, Subpart E. Although disposal of waste within IB-1 ceased prior to September 18, 1990, Alcoa failed to initiate closure by September 18, 1992. However, 35 IAC 807 was not in effect at the time of this landfill disposal operation. At that time, there were similar Illinois Department of Public Health land disposal regulations in effect. 35 IAC 807 is identified because this is the earliest set of Illinois landfill regulations that are still in effect. Therefore, 35 IAC 807 is not applicable.

The daily and intermediate landfill cover requirements provided by 35 IAC 807.305 (a) and (b) are not relevant and appropriate requirements for IB-1 because Illinois has not consistently required the application of these daily covers, prior to a final cover, for landfills that ceased operations prior to September 18, 1990 and failed to initiate closure by September 18, 1992.

Illinois has precedent for selecting and consistently applying 35 IAC 807.305(c) as the relevant and appropriate cover requirement for historical landfills that ceased operations prior to September 18, 1990 and failed to initiate closure by September 18, 1992, unless: (1) the landfill exhibits groundwater contamination or (2) the landfill cover is not sufficiently protective.

Both groundwater contamination at the Site and concerns regarding the stability of the bauxite waste and its cover have been identified. (See Phase 2 geotechnical report (March 2012)). The record documents groundwater contamination consisting of fluoride exceeding MCL standards. In addition, the Focused Feasibility Study documents that the bauxite red mud is "soft, highly plastic, thixotrophic and not suitable for building construction or redevelopment without extensive engineering."

Exceedances of MCLs have been identified for fluoride. Fluoride is not a primary MCL and any slight exceedances of the MCL for fluoride have also been evaluated in the site risk assessment. The preliminary conclusions from the risk analysis for groundwater data (this has not been finalized) do not indicate risks exceeding EPA's target risk range, even when considering a residential ingestion exposure scenario. Preliminary risk analyses for residential ingestion of manganese slightly exceed EPA's risk range but they did not exceed the associated MCL. Area residents are currently connected to the municipal water supply and a groundwater ordinance exists prohibiting any new well installations in the area. As part of the final site remedy selection, an institutional control component will be considered that would require that this existing ordinance be appropriately updated to ensure long term reliability and viability in preventing any future exposure to groundwater in the area. In addition to any necessary updates of this ordinance, the final remedy at the site may require an environmental covenant under the Illinois Uniform Environmental Covenants Act to ensure the groundwater pathway is excluded.

The 35 IAC 807(c) landfill cover has been evaluated with a pilot engineering and field study to evaluate the long term stability and protectiveness of the proposed cover system and to help determine whether an alternative landfill cover will be necessary to attain long-term stability and protectiveness. This engineering analysis is summarized in a Phase 2 geotechnical study (January 2012). The Phase 2 geotechnical study report documents, based on all data collected between August 2011 and January 2012, that the proposed two foot cover is stable, both during placement as well as during several months of monitoring, and will provide the requisite protectiveness.

The Phase 2 geotechnical study concludes that, in addition to implementing an operation and maintenance plan, a cover complying with the 35 IAC 807(c) requirements can be constructed that would remain stable in the long term and would be sufficiently protective. (See January 18, 2012 letter and Phase 2 geotechnical report). The O&M plan will include regular inspections and requirements for maintenance and repair of any issues that would impact stability or protectiveness, such as areas of subsidence or erosion, of the landfill cover identified during these inspections.

Based on this analysis, 35 IAC 807.305(c) is relevant and appropriate for IB-1. If the selected and implemented cover remedy should fail to remain stable and protective over the long term with implementation of routine maintenance and repair, a new or modified landfill cover remedy may be selected and implemented.

35 IAC 807.502

The requirements of 35 IAC 807.502 are not applicable to the North Alcoa Site bauxite (red mud) residue landfill area IB-1 since Alcoa failed to initiate closure by September 18, 1992. 35 IAC 807.502 is relevant and appropriate to provide standards for landfill closure where a 35 IAC 807.305 landfill cover requirement is selected as the relevant and appropriate requirement.

35 IAC 811

In general, 35 IAC Part 811 applies to solid waste landfills that operate after September 18, 1990. 35 IAC 811 is not applicable to the Alcoa Site bauxite (red mud) residue because disposal of bauxite residue was discontinued well before the effective date of this regulation. For purposes of 35 IAC Part 811, the North Alcoa Site bauxite (red mud) residue is a solid waste which, pursuant to 415 ILCS 5/3.535, is defined to include waste from mining operations.

Illinois has precedent selecting and consistently applying 35 IAC Part 811 as the relevant and appropriate cover requirement for historical landfills that ceased operations prior to September 18, 1990, failed to initiate closure by September 18, 1992, and where: (1) the landfill exhibits groundwater contamination or (2) the 35 IAC 807.305(c) landfill cover is not sufficiently protective.

The 35 IAC 807 analysis above is applicable to the 35 IAC 811 analysis here regarding groundwater contamination at the Site, stability of the bauxite waste and correspondingly protectiveness of the 35 IAC 811 cover. So long as the 35 IAC 807.305(c) cover is sufficiently protective of human health and the environment, 35 IAC 811 is relevant but not appropriate for IB-1.

RCRA Subtitle C

The Alcoa Site bauxite (red mud) residue is a solid waste but RCRA Subtitle C is not applicable because the bauxite residue is not considered a RCRA hazardous waste. Solid waste from the extraction, beneficiation, and processing of ores and minerals is excluded from the definition of hazardous waste under the Bevill Amendment (section 3001(b) (3) (A) (ii) of RCRA) and 40 C.F.R. Section 261.4(b) (7). This exemption does not, however, affect CERCLA jurisdiction over the bauxite (red mud) residue where this material contains hazardous substances that could pose a threat to human health and the environment.

In particular, RCRA provides that Bevill wastes shall be "subject only to regulation under other applicable provisions of Federal or State law in lieu of" Subtitle C. 42 U.S.C. 6921(b) (3) (A). Even though RCRA Subtitle C is not applicable, the requirements found in RCRA Subtitle C may be relevant and appropriate on a case by case basis. See also, 55 Fed. Reg. 8666 (March 8, 1990). If the bauxite (red mud) residue area contains hazardous substances that have been or threaten to be released and pose a threat to human health and the environment, then a CERCLA relevant and appropriate analysis may select a RCRA Subtitle C hazardous waste cover requirement. Since a release or threat of release of hazardous substances to the environment (e.g., soil, groundwater, and surface water) has been documented at IB-1, the RCRA Subtitle C requirements may be relevant and appropriate to the IB-1 remedy.

C. *Where RCRA Subtitle C is consistent with an EPA-authorized State hazardous waste cover requirement, EPA identifies the EPA-authorized State requirement for purposes of*

the ARAR. Therefore, the requirement of 35 IAC Part 811, Subpart C would apply if RCRA Subtitle C requirements were found to be relevant and appropriate to a site.

D. *The Alcoa Site bauxite (red mud) residue is a solid waste and RCRA Subtitle C is considered relevant, but RCRA Subtitle C is not applicable and is not appropriate. The bauxite residue is not considered a RCRA hazardous waste because solid waste from the extraction, beneficiation, and processing of ores and minerals is excluded from the definition of hazardous waste under the Bevill Amendment. See, RCRA Section 3001(b)(3)(A)(ii), 42 U.S.C. §6901(b)(3)(A)(ii), and 40 C.F.R. §261.4(b)(7). This exemption does not, however, affect CERCLA jurisdiction over the bauxite residue where this material contains hazardous substances. Although RCRA Subtitle C is considered relevant since the bauxite residue contains hazardous substances, it is not considered appropriate to the remedial action contemplated for the Alcoa Site.*

E. *In particular, RCRA provides that Bevill wastes shall be "subject only to regulation under other applicable provisions of Federal or State law in lieu of" Subtitle C. 42 U.S.C. 6921(b)(3)(A). Even though RCRA Subtitle C is not applicable, the requirements found in RCRA Subtitle C may be relevant and appropriate on a case-by-case basis. See also, 55 Fed. Reg. 8666 (March 8, 1990). If the bauxite residue area contains hazardous substances that have been or threaten to be released to the environment, then a CERCLA relevant and appropriate requirement analysis may select a RCRA Subtitle C hazardous waste cover requirement. Since a release or threat of a release of hazardous substances to the environment (e.g., soil, groundwater, and surface water) has been documented at IB-1, the RCRA Subtitle C requirements may be relevant and appropriate to the circumstances of the release.*

F. *Section 300.400(g)(2) of 40 C.F.R., provides eight criteria to evaluate whether a requirement, such as RCRA Subtitle C, "addresses problems or situations sufficiently similar to the circumstances of the release or remedial action contemplated, and whether the requirement is well suited to the site, and therefore is both relevant and appropriate." Based on the criteria of 40 C.F.R. §300.400(g)(2)(i), the RCRA Subtitle C requirement is not well suited to the Alcoa site. Specifically, a significant purpose of a multilayer RCRA Subtitle C cover is to prevent infiltration of surface waters through the waste to the groundwater. Due to waste remaining in contact with groundwater, and the documented necessity for on-site storm water control, the RCRA Subtitle C cover requirement is not well suited to this site, and would impair the on-site storm water control. In addition and consistent with 40 C.F.R. §300.400(g)(2)(viii), there is no current or potential use for subsurface waters at this site. Based on this analysis, RCRA Subtitle C is relevant but not appropriate for IB-1.*

G. *The record documents that this Site must provide on-site storm water control; off-site storm water control is not viable since there is no nearby direct discharge location and the local sewer system will not accept this flow. The pilot engineering study demonstrates that an alternative landfill cover, 35 IAC 807.305(c), will provide long term stability, will be sufficiently protective of direct contact threats, and would provide for on-site storm water control.*

40 C.F.R. Part 192

Part 192 of 40 C.F.R. is not considered applicable to the Alcoa Site bauxite (red mud) residue because the bauxite material at the site resulted from the disposal of residuals from an

aluminum smelting operation and not from uranium or thorium mill tailings. However, this provision is relevant to any area on the site where material remaining in place would exceed the 5 pCi/g of radium in soil concentration standard. Should this level be found within the bauxite area, this provision would require a landfill cover and a land use restriction prohibiting building on the site. The Site's land use restrictions may allow enclosed structures only where both appropriate radon mitigation measures are taken and measures are taken to prevent unacceptable levels of radon decay products in the enclosed structures. This mandate is a health based standard and applies to combined level of radium 226 and 228 because this risk is additive. As the combined levels of radium 226 and 228 exceed this standard in the bauxite, this regulation is relevant and appropriate and a cover and land use restrictions are required where the standard is exceeded.

Based on this analysis, the proposed landfill cover and closure ARARs controlling the IB-1 remedy is 40 C.F.R. Part 192 and based on the Phase 2 geotechnical study (the proposed two foot cover will be stable and protective in the long term), 35 IAC 807.305(c) and 35 IAC 807.502.

Conclusion as to IB-1

So long as 35 IAC 807.305(c) and 807.502 remain sufficiently protective of human health and the environment, the proposed landfill cover and closure ARARs controlling the IB-1 remedy are 40 C.F.R. Part 192, 35 IAC 807.305(c) and 35 IAC 807.502. The pilot engineering study demonstrated that the 35 IAC 807.305(c) cover will remain sufficiently protective and stable over the long term, and is relevant and appropriate for IB-1.

2. IB-3 and IB-4

The site investigations, as summarized in the FFS, show that the bauxite materials found in IB-3 and IB-4 were primarily found at depths below two feet in site borings and that surficial materials are sufficiently stable at present.

35 IAC 807.305

As discussed in Section B.1, 35 IAC 807 is not applicable to the North Alcoa Site. However, Illinois has precedent for selecting and consistently applying 35 IAC 807.305(c) as the relevant and appropriate cover requirement for landfills that ceased operations prior to September 18, 1990 and failed to initiate closure by September 18, 1992, unless: (1) the landfill exhibits groundwater contamination or (2) the 35 IAC 807.305(c) landfill cover is not sufficiently protective.

Exceedances of MCLs have been identified for fluoride. Fluoride is not a primary MCL and any slight exceedances of the MCL for fluoride have also been evaluated in the site risk assessment. The preliminary conclusions from the risk analysis for groundwater data (this has

not been finalized) do not indicate risks exceeding EPA's target risk range, even when considering a residential ingestion exposure scenario. Preliminary risk analyses for residential ingestion of manganese slightly exceed EPA's risk range but they did not exceed the associated MCL. Area residents are currently connected to the municipal water supply and a groundwater ordinance exists prohibiting any new well installations in the area. As part of the final site remedy selection, an institutional control component will be considered that would require that this existing ordinance be appropriately updated to ensure long term reliability and viability in preventing any future exposure to groundwater in the area. In addition to any necessary updates of this ordinance, the final remedy at the site may require an environmental covenant under the Illinois Uniform Environmental Covenants Act to ensure the groundwater pathway is excluded.

The FFS concludes that, in addition to implementing an operation and maintenance plan, a cover complying with the 35 IAC 807.305(c) requirements can be constructed in IB-3 and IB-4 that would remain stable in the long term and would be sufficiently protective. Based on this analysis, 35 IAC 807.305(c) is relevant and appropriate for areas within IB-3 and IB-4 that contain waste at the surface.

35 IAC 807.502

The requirements of 35 IAC 807.502 are not applicable to the North Alcoa Site IB-3 and IB-4 since Alcoa failed to initiate closure by September 18, 1992. 35 IAC 807.502 is relevant and appropriate to provide standards for closure where a 35 IAC 807.305 cover requirement is selected as the relevant and appropriate requirement.

35 IAC 811

As discussed in Section B.1, 35 IAC 811 is relevant but not appropriate for IB-3 and IB-4.

RCRA Subtitle C

Bauxite waste residue in the Alcoa Site IB-3 and IB-4 is a solid waste but RCRA Subtitle C is not applicable because the bauxite residue is not considered a RCRA hazardous waste. Solid waste from the extraction, beneficiation, and processing of ores and minerals is excluded from the definition of hazardous waste under the Bevill Amendment (section 3001(b) (3) (A) (ii) of RCRA) and 40 C.F.R. Section 261.4(b) (7). This exemption does not, however, affect CERCLA jurisdiction over the bauxite (red mud) residue where this material contains hazardous substances that could threaten human health or the environment. Even though RCRA Subtitle C is not applicable, it may be considered relevant and appropriate on a case by case basis. (See 55 Fed. Reg. 8666 (March 8, 1990). If the bauxite (red mud) residue area contains hazardous substances, then RCRA Subtitle C may be relevant and appropriate.

Groundwater contamination at the Site and waste instability concerns at IB-3 and IB-4 are addressed in the preceding discussion of 35 IAC Part 811. Based on this analysis, RCRA Subtitle C is relevant but not appropriate to waste at IB-3 and IB-4.

40 C.F.R. Part 192

Part 192 of 40 C.F.R. is not considered applicable to the Alcoa Site bauxite (red mud) residue because the bauxite material at the site resulted from the disposal of residuals from an aluminum smelting operation and not from uranium or thorium mill tailings. However, this provision is relevant to any area on the site where material remaining in place would exceed the 5 pCi/g radium in soil concentration standard. Should this level be found within the bauxite area, this provision would require a cover and a land use restriction prohibiting building on the site. The Site's land use restrictions may allow enclosed structures only where both appropriate radon mitigation measures are taken and measures are taken to prevent unacceptable levels of radon decay products in the enclosed structures. This standard is a health based standard and applies to combined level of radium 226 and 228 because this risk is additive. As the combined levels of radium 226 and 228 exceed this standard in the bauxite, this regulation is relevant and appropriate and a cover and land use restrictions are required where the standard is exceeded.

Conclusions as to IB-3 and IB-4

Based on this analysis, the proposed cover and closure ARARs controlling the IB-3 and IB-4 remedy are 35 IAC 807.305(c), 35 IAC 807.502, and 40 C.F.R. Part 192.

3. Fluorogypsum Area IB-2

35 IAC 807.305

Requirements of 35 IAC 807.305 are not applicable to the North Alcoa Site gypsum landfill area IB-2, but 35 IAC 807.305 is relevant and appropriate. For purposes of 35 IAC Part 807, fluorogypsum waste in the North Alcoa Site landfilling area IB-2 is a solid waste which, pursuant to 415 ILCS 5/3.535, is defined to include waste from mining operations.

35 IAC 807 applies to solid waste landfills that, among other things, cease operations prior to September 18, 1990, and initiate closure by September 18, 1992. See 35 IAC 814, Subpart E. Although disposal of waste within IB-2 ceased prior to September 18, 1990, Alcoa failed to initiate closure by September 18, 1992. Additionally, 35 IAC 807 was not in effect at the time of this landfill disposal operation. At that time, there were similar Illinois Department of Public Health land disposal regulations in effect. 35 IAC 807 is identified because this is the earliest set of Illinois landfill regulations that remain effective. Therefore, 35 IAC 807 is not applicable.

The daily and intermediate landfill cover requirements provided by 35 IAC 807.305 (a) and (b) are not relevant and appropriate requirements for IB-2 because Illinois has not consistently required these daily covers, prior to a final cover, for landfills that ceased operations prior to September 18, 1990 and failed to initiate closure by September 18, 1992.

Illinois has precedent for selecting and consistently applying 35 IAC 807.305(c) as the relevant and appropriate cover requirement for landfills that ceased operations prior to September 18, 1990 and failed to initiate closure by September 18, 1992, unless: (1) the landfill exhibits groundwater contamination or (2) the 35 IAC 807.305(c) landfill cover is not sufficiently protective.

Groundwater contamination concern exists at this site, with fluoride levels in groundwater exceeding MCLs. The record does not identify any significant concern with the long term stability of a cover over the fluorogypsum wastes.

Analytical results of 1996 Illinois EPA sampling indicated TCLP exceedances in the gypsum dike. This TCLP testing was completed before the RI was started and was designed to determine if there was a potential environmental concern at the site worthy of further investigation. The 1996 gypsum dike TCLP leaching test is not representative of site conditions of this land-filled fluorogypsum waste material. The TCLP leaching test is representative of an acidic (low pH) environment; the Alcoa site gypsum waste area has a very high pH (basic). Consequently, contaminants in the gypsum area IB-2 are not believed to present a leaching risk to the surrounding environment, as evidenced by groundwater monitoring data conducted to date at the site.

While there are documented exceedances of the groundwater MCL for fluoride at the site, these levels do not pose a risk to human health or the environment, as presented in site risk calculations. In addition, there is an existing groundwater ordinance prohibiting groundwater extraction and use at the Alcoa Site. As part of the final site remedy selection, an institutional control component will be considered that would require that this existing ordinance be appropriately updated to ensure long term reliability and viability in preventing any future exposure to groundwater in the area. In addition to any necessary updates of this ordinance, the final remedy at the site may require an environmental covenant under the Illinois Uniform Environmental Covenants Act to ensure the groundwater pathway is excluded. Based on this analysis, 35 IAC 807.305(c) is relevant and appropriate for IB-2.

35 IAC 807.502

The requirements of 35 IAC 807.502 are not applicable to the North Alcoa Site fluorogypsum residue landfill area IB-2 since Alcoa failed to initiate closure by September 18, 1992. 35 IAC 807.502 is relevant and appropriate to provide standards for landfill closure where a 35 IAC 807.305 landfill cover requirement is selected as the relevant and appropriate requirement.

35 IAC 811

In general, 35 IAC Part 811 applies to solid waste landfills that operate after September 18, 1990. 35 IAC 811 is not applicable to the Alcoa Site fluorogypsum residue because disposal of gypsum residue was discontinued well before the effective date of this regulation. For purposes of 35 IAC Part 811, the North Alcoa Site gypsum residue is a solid waste which, pursuant to 415 ILCS 5/3.535, is defined to include waste from mining operations.

Illinois has precedent for selecting and consistently applying 35 IAC Part 811 as the relevant and appropriate cover requirement for landfills that ceased operations prior to September 18, 1990, failed to initiate closure by September 18, 1992, and where: (1) the landfill exhibits groundwater contamination or (2) the 35 IAC 807.305(c) landfill cover would not be sufficiently protective.

Fluoride and manganese groundwater contamination concern exists at this site, and is addressed in the discussions above. The record does not identify any significant concern with the long term stability of a cover over the fluorogypsum wastes.

Analytical results of Illinois EPA sampling performed in 1996 indicated TCLP exceedances in the gypsum dike. This TCLP testing was completed before the RI was started and was designed to determine if there was a potential environmental concern at the site worthy of further investigation. The 1996 gypsum dike TCLP leaching test is not representative of site conditions of this homogeneous land-filled fluorogypsum waste material (See Alcoa's Technical Memorandum - TCLP and TACO ARARs – July 2011). The TCLP test is representative of an acidic (low pH) environment; the Alcoa site gypsum waste area has a very high pH (basic). Consequently, contaminants in the gypsum area IB-2 are not believed to present a leaching risk to the surrounding environment, as evidenced by groundwater monitoring data conducted to date at the site.

While there are documented exceedances of the groundwater MCL for fluoride at the site, these levels do not pose a risk to human health or the environment, as presented in site risk calculations. In addition, there is an existing groundwater ordinance prohibiting groundwater extraction and use at the Alcoa Site. Therefore 35 IAC 811 is relevant but not appropriate for IB-2, so long as 35 IAC 807.305(c) remains protective of human health and the environment.

RCRA Subtitle C

Fluorogypsum is a solid waste but is not considered RCRA hazardous waste. "Fluorogypsum from hydrofluoric acid production" is specifically identified as waste that is excluded from the definition of hazardous waste pursuant to 40 C.F.R. § 261.4(b) (7) (ii) (C) and (ii) (J) respectively and 35 Ill. Admin. Code 721.104(b) (7). This exemption does not, however, affect CERCLA jurisdiction over the fluorogypsum where these materials contain hazardous substances that if released could threaten human health or the environment Even though RCRA Subtitle C is not applicable, it may be considered relevant and appropriate on a case by case basis. (See 55

Fed. Reg. 8666 (March 8, 1990). If the fluorogypsum area contains hazardous substances, then RCRA Subtitle C may be relevant and appropriate for containment or off-site disposal, regardless of its hazardous waste status.

Analytical results of 1996 Illinois EPA sampling indicated TCLP exceedances in the gypsum dike. This TCLP testing was completed before the RI was started and was designed to determine if there was a potential environmental concern at the site worthy of further investigation. The 1996 gypsum dike TCLP leaching test is not representative of site conditions of this land-filled fluorogypsum waste material. (See Alcoa's Technical Memorandum - TCLP and TACO ARARs – July 2011, as submitted by Tetra Tech on behalf of Alcoa). The TCLP leaching test is representative of an acidic (low pH) environment; the Alcoa site gypsum waste area has a very high pH (basic). Consequently, the technical memorandum concludes that contaminants in the gypsum area IB-2 do not present a leaching risk to the surrounding environment, as evidenced by groundwater monitoring data conducted to date at the site.

While there are documented exceedances of the groundwater MCL for fluoride at the site, these levels do not pose a risk to human health or the environment, as presented in site risk calculations. In addition, there is an existing groundwater ordinance prohibiting groundwater extraction and use at the Alcoa Site. Based on this analysis, RCRA Subtitle C is relevant but not appropriate to fluorogypsum in IB-2, so long as 35 IAC 807.305(c) remains protective.

40 C.F.R. Part 192

Part 192 of 40 C.F.R. is not considered applicable to the Alcoa Site IB-2 fluorogypsum area because the fluorogypsum material at the site did not result from uranium or thorium mill tailings. However, this provision is relevant to any area on the site where material remaining in place would exceed the 5 pCi/g radium in soil concentration standard. Should this level be found within the fluorogypsum area, this provision would require a landfill cover and a land use restriction prohibiting building on the site. The Site's land use restrictions may allow enclosed structures only where both appropriate radon mitigation measures are taken and measures are taken to prevent unacceptable levels of radon decay products in the enclosed structures. This standard is a health based standard and applies to combined level of radium 226 and 228 because this risk is additive. As the combined levels of radium 226 and 228 exceed this standard in the bauxite, this regulation is relevant and appropriate and a cover and land use restrictions are required where the standard is exceeded.

Conclusions as to IB-2

Based on this analysis, the proposed landfill cover and closure ARARs controlling the IB-2 remedy are 35 IAC 807.305(c), 35 IAC 807.502 and 40 C.F.R. Part 192.

C. Requirements of the Proposed ARARs

35 IAC 807.305(c)

Final Cover - a compacted layer of not less than two feet of suitable material shall be placed over the entire surface of each portion of the final lift not later than 60 days following the placement of refuse in the final lift, unless a different schedule has been authorized in the Operating Permit." Although 35 IAC 807.305(c) does not define "suitable, compacted material," Illinois has consistently applied the standard for "suitable material" to an uncontaminated, cohesive soil that can be compacted.

35 IAC 807.502

35 IAC 807.502 requires an operator of a waste management site to close the site in a manner which:

a) minimizes the need for further maintenance, and;

b) controls, minimizes, or eliminates post-closure release of waste, waste constituents, leachate, contaminated rainfall, or waste decomposition products to the groundwater or surface waters or to the atmosphere to the extent necessary to prevent threats to human health or the environment." The responsible parties are required to take whatever actions are necessary during construction of the cover and after construction, to ensure the full thickness of the cap, as required by 35 IAC 807, remains in place.

40 C.F.R. Part 192

40 C.F.R. Part 192 requires a cover and a land use restriction prohibiting building on the site to prevent unacceptable levels of radon decay products in enclosed structures. It is anticipated that any cover applied above would comply with this cover requirement.

II. Potential landfill and waste cover, closure and post-closure care ARARs for the Pond Areas within IB-1a, IB-1b, and IB-4a

Areas within the OU1 footprint that have been used in the past, and are being considered in the remedy alternatives for surface water collection/management seepage ponds. Two of these are located in IB-1a and IB-1b and two are located within IB-4a. The preliminary design, as presented in the FFS Report (February 2012), proposes using ponds in IB-1a, IB-1b and IB-4a to manage onsite stormwater after the remedy is implemented. These areas are part of the current site stormwater management system and will be enhanced and reconfigured as part of the final remedial design. The FFS retains these areas for long term surface water management.

The records for these four ponds document that they have not been, and are not now, used as surface impoundments. A surface impoundment is, pursuant to 40 CFR 260.10 and the corresponding Illinois regulations at 35 IAC Subtitle G, Chapter I, Subchapter c, Part 720, a topographic depression designed to hold an accumulation of liquid wastes. The record documents that these four ponds hold and manage only the surface stormwater flow. Since these four ponds only manage surface stormwater, they are not "surface impoundments" subject to the 40 CFR Part 260 requirements for the surface impoundment management and closure.

Applying the landfill ARARs, a two foot cover would be required over the pond soils and subsoils. However, the record documents that implementing a two foot cover over the pond soils and subsoils, pursuant to 35 IAC 807.305(c) is relevant but not appropriate at this Site.

The Response to Comments letter – OU1 Field Test Strip and Test Load Program Report, January 18, 2012, documents that the pond surfaces cannot support the equipment necessary to place the 35 IAC 807.305(c) two foot cover over the soils within the ponds. In addition, applying the ARAR's two foot cover requirement to the ponds would substantially reduce the Site's stormwater control capacity, and present an unacceptable flooding risk to nearby properties (Post Construction Pond Memo letter dated January 25, 2012).

The record documents evaluation of liners in the ponds that would provide equivalent or better performance to the 35 IAC 807.305(c) ARAR and concluded that this option was not constructible (See January 25, 2012 letter). The performance standard for 35 IAC 807.305(c) is to provide direct contact threat protection which is at least as protective as the protection afforded by 35 IAC 807.305(c). Alcoa's evaluation concluded that the pond areas include organic material over soft residue that has not yet formed a significant crust to support surficial weight. As such, access to the area for heavy equipment would be more impractical than for other areas of the site and would require a bridging layer even for low ground pressure access. Placement of materials thinner that the ARAR soil cover would be impractical due to the increased traffic required to place such materials that may cause areas of liquification that would lead to cover instability. Access to install required drainage trenches would be similarly impractical (See January 25, 2012 letter).

III. Surface Water Management ARARs

As with any remedy that includes capping, surface water management is an issue that must be addressed in the design of the remedy as well as in the ARARs analysis. The options considered for managing surface waters accumulating onsite include offsite discharge to a surface water body such as a stream or a river via an NPDES permit, offsite discharge to a publicly owned treatment works (POTW), discharge onsite to evaporation ponds, or discharge onsite to the groundwater, either through injection or seepage ponds.

Due to the Site's lack of a nearby surface water body with available capacity, offsite discharge is not viable. The nearest surface water body that could accept the onsite stormwater is located

at Frank Holten State Park, immediately to the northeast of the site. Park representatives confirmed that there is insufficient capacity at the park to receive the stormwater from the site (See January 25, 2012 letter).

The East St Louis Water Treatment Plant (POTW) was not willing to accept the Site's surface water discharges. There are significant concerns in the City about flooding as well as the unknown conditions of the infrastructure near the Site. The POTW cited concerns regarding the capacity of its sewer system near the Site. Any plans for Site discharge to the City sewer system in the area would require a comprehensive analysis of the integrity of the sewers to determine if site discharges could cause adverse impacts to the system as a whole. It would also require a large scale improvement project analyzing the entire system and repairs necessary to correct structural deficiencies before any consideration could be given to accepting Site stormwater (See January 25, 2012 letter).

A. Potential Surface Water ARARs applicable to OU1 are:

35 IAC Section 309 specifies the substantive and procedural requirements of a NPDES permit.

35 IAC Section 304 specifies the water quality standards for storm water runoff.

B. Surface Water ARARs Analysis

The surface water impoundments onsite are regarded as treatment works and not as "waters of the State". Any discharge from the impoundments would require an NPDES permit in accordance with 35 IAC Section 309.102(a) and Section 12(f) of the Illinois Environmental Protection Act, or must meet the substantive requirements of the NPDES program, if exempt under Section 121(e). As these impoundments are or will be entirely located onsite, they must meet the substantive requirements of NPDES, which is an applicable requirement for any discharge component.

Storm water runoff would be regulated on a water quality basis. Requirements under 35 IAC 304 that would be applicable for these impoundments, as they would be regulated in the same manner as an out of service ash pond would be for total suspended solids TSS). Metals in the discharge would be regulated by 35 IAC 302.

C. Requirements of the Proposed ARARs

35 IAC Section 309 requires an application for a permit, or if exempt from the requirement to obtain a permit, then the substantive requirements for any discharge.

35 IAC Section 304 requires a storm water discharge plan and limits any storm water discharge.

4.0 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are used to develop remedial action alternatives and specify:

- The contaminant(s) of concern,
- Exposure route(s) and receptor(s), and
- An acceptable contaminant level or range of levels for each exposure route (i.e., a preliminary remediation goal).

The BHHRA concludes that if future land use of OU-1 is industrial, then there are areas of IB-2 containing lead that require development of a RAO that is protective of future industrial land workers.

Therefore the first RAO for soil in OU-1 is:

> *Prevent future direct contact by humans working in industrial exposure scenarios to soil with lead concentrations characterized by a 95% Upper Confidence Limit of the arithmetic mean of soil samples collected within an investigative block of greater than 800 mg/kg, which is the USEPA screening level for industrial/commercial exposure.*

IEPA has indicated placement of two feet of cover over the bauxite residue and gypsum areas in accordance with 35 IAC 807.305(c) is an ARAR for the Site. Compliance with ARARs is one of the remedial alternative threshold screening criteria; therefore the second RAO for soil in OU-1 is:

> *Prevent future human exposure (absorption, ingestion, and/or external radiation) from contaminants, including naturally occurring radium and other radionuclides found in bauxite residue and gypsum waste exceeding the USEPA baseline risk range of 10^{-4} to 10^{-6} by placement of an ARAR-compliant soil cover in accordance with 35 IAC 807.305(c).*

The baseline risk calculations prepared by USEPA calculated chemical and radiological risk for the residential, industrial worker, and trespass receptors. These risk calculations suggest that there may be a potential future risk greater than the USEPA risk range for hypothetical residential and full-time industrial workers. USEPA guidance on establishing cleanup levels for CERCLA sites with radioactive contamination (OSWER 9200.4-18) (USEPA, 1997b) states that cleanups should generally achieve risk levels in the 10^{-4} to 10^{-6} range. Therefore the third RAO for soil in OU-1 is:

> *Prevent human exposure that yields cumulative risk (including radiation risk) exceeding the USEPA risk range of 10^{-4} to 10^{-6} or yields a chemical noncancer hazard index greater than 1.*

Calculations that estimate the potential radiation risk associated with each remedial alternative are presented in Appendix F, and discussed in the detailed analysis of each alternative. Risks to remediation workers during implementation of the selected remedy will be addressed by Health and Safety Plans prepared pursuant to the Remedial Action Work Plan.

5.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

The following sections identify and screen technologies potentially suitable to address the remedial objectives identified in Section 4.0. Principal threat material requiring treatment and disposal off-Site (spent potlining material) has been previously performed as a USEPA-approved removal action (Alcoa and the City of East St. Louis, 2006).

5.1 General Response Actions

The following General Response Actions are considered in this FS:

- No action;
- Institutional controls; and
- Containment and institutional controls.

A No Action Alternative is required by the NCP in order to establish baseline conditions and potential costs at the site.

Institutional controls may be required to further protect against potential exposure in the future. Institutional controls typically consist of access and use restrictions, and for this OU would require compliance with the Illinois Uniform Environmental Covenant Act (IUECA).

Containment is a remedy for low-level threat metals-in-soil waste. Containment minimizes exposure to the impacted material via engineered controls.

5.2 Identification of Potential Technologies

Potential technologies associated with each General Response Action were identified and evaluated for the applicability to site-specific conditions and remedial objectives. Technologies determined to be potentially applicable to the Site were evaluated against three criteria: effectiveness, implementability, and cost. Table 5-1 lists the General Response Actions and associated technologies that would be applicable for satisfying the remedial objectives. As indicated in Table 5-1, the remedial technologies for containment are as follows:

- Horizontal barriers;
- Vertical barriers; and
- Surface controls.

Horizontal barriers can be designed to satisfy two criteria: reduce or eliminate direct contact to impacted surface material; or reduce or eliminate downward migration of contaminants. Technologies designed solely to reduce risks associated with direct contact are typically less complex and less costly than those designed to control downward migration and usually consist

of soil covers that generally are vegetated or are integrated in site redevelopment. The soil cover can be derived from a variety of sources, ranging from appropriately sized borrow material from on- or off-Site sources to creation of an in-place cover by amending bauxite residue with various neutralizing and soil-building components. Horizontal contact barriers can also be created by site redevelopment (e.g., construction of parking lots, buildings, etc.) but would require additional engineering for use on low-strength bauxite residue material.

Because control of the groundwater pathway is not a remedial objective for OU-1, horizontal or vertical barriers technologies designed to control or eliminate downward migration of contaminants are not considered further. Horizontal barriers designed to reduce risks associated with direct contact are applicable to the site, thus a soil cover is a potentially applicable technology.

Surface controls are typically associated with control of storm water. Implementation of storm water controls is required to mitigate horizontal migration of barren residue or gypsum. Storm water control technologies include:

- Regrading, covering and/or revegetating surface soils to minimize erosion and control the rate and direction of storm water run-off;
- Storm water diversion and collection areas; and
- Silt fencing (used on a short-term basis during construction).

In general, surface controls are considered applicable to the Site. During construction activities and as part of the final remedy selected for the site it is likely that some combination of many different types of storm water controls will be utilized at the Site.

As indicated in Table 5-1, a limited number of technologies are considered applicable to the Site. Each of the technologies identified will be incorporated into the alternatives described in Section 6.0, thus there is no need to provide an additional, detailed screening of technologies in an attempt to minimize the number of options considered.

6.0 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

Three site-wide remedial action alternatives (RAAs) were developed utilizing the technologies identified in Section 5.0 to satisfy the RAOs identified in Section 4.0:

- RAA-0 No Further Action;
- RAA-1 Restricted Access; and
- RAA-2 Containment with Placement of an ARAR-compliant Soil Cover and On-Site Storm Water Management.

6.1 RAA-0 No Action

The no further action alternative is retained to serve as a baseline against which other alternatives are evaluated. Under this alternative, no further remedial actions or additional institutional controls are implemented.

6.2 RAA-1 Restricted Access

The restricted access alternative consists of physical and institutional controls via easement/restrictive covenant to prohibit access to the bauxite residue areas and to gypsum containing greater than 800 mg/kg lead and areas that exceed the USEPA risk range of 10^{-4} to 10^{-6}. A fence restricting access would be constructed around the area comprised of IB-1, IB-2, and IB-4a. Institutional controls would be created by implementing durable environmental easement/restrictive covenants compliant with IUECA for these areas. This alternative would not comply with the Illinois solid waste regulation 35 IAC 807.305(c) final cover ARAR of a two foot cover layer. O&M activities would include monitoring of fencing and repair/replacement as needed.

6.3 RAA-2 Containment with Placement of an ARAR-compliant Soil Cover and On-Site Storm Water Management

In RAA-2, an ARAR-compliant two foot thick soil layer will be placed over the bauxite residue (IB-1 and -4a) and gypsum (IB-2). This layer will also create a working platform providing the geotechnical stability needed for subsequent industrial site redevelopment, including potentially a solar project. The gypsum area would be regraded to provide a sustainable slope, and covered with a two foot thick soil layer to prevent contact with gypsum. As stated in the revised ARARs analysis (March 23, 2012) provided by USEPA, bauxite materials found in IB-3 and IB-4 were primarily found at depth below two feet (old Pittsburgh Lake) in site borings and surficial materials are sufficiently stable at present; therefore the two foot cover is not required except in the area west of RDA-1 (IB-1a) where the 40 CFR 192 ARAR is exceeded in surficial soil. O&M activities will include periodic monitoring of the soil cover, and repair as needed.

Storm water within IB-1 will be managed in storm water basins designed to contain the 100-year storm water event. Storm water within IB-1a will drain to a retention pond at the western end of IB-1a. A clean storm water conveyance structure will be installed in drainage along Lake Drive to manage storm water along the right-of-way. This conveyance will drain to the existing storm

water pond located in the northeast corner of the site (i.e., southwest of the intersection of Lake Drive and the rail road). Based on available topographic mapping and field observations, the existing drainage along Lake Drive is isolated by topography from other IB-4a storm water drainage areas, which are located at a higher elevation, perched on bauxite residue. Additional topographic mapping will be integrated into final design to assure that the storm water conveyance structure along Lake Drive and the existing storm water pond in the northeast corner of the Site will not manage storm water runoff from IB-4a bauxite residue or gypsum areas after closure. All other storm water in OU-1 will continue to be managed in the current manner. Each investigation block within OU-1 would be addressed as follows:

IB-1a – Grading and backfilling in eroded areas, placement of a two foot thick soil cover layer in remaining areas (excluding storm water management areas);

IB-1b – Grading, placement of a two foot thick soil cover layer (excluding storm water management areas);

IB-1c – Grading, placement of a two foot thick soil cover layer;

IB-2 – Place gypsum as subsurface fill where appropriate in OU-1, regrade dikes, and placement of a two foot thick soil cover layer over remaining surficial gypsum;

IB-3b – Install surface water drainage system, construct low berm on eastern boundary of OU-1 to further limit surface water runoff to railroad, and remove soil or place ARAR-compliant cover in the area that historically received runoff from RDA-1 (IB-1a) and contains surficial soil with radium concentrations exceeding the 40 CFR 192 ARAR.

IB-3c – Details of SPL removal are detailed in the Completion Report – Spent Potliner Removal (Alcoa and the City of East St. Louis, 2006). Areas exceeding radiological risk based criteria will be remediated in accordance with the revised ARARs analysis;

IB-4a – Grading, placement of a two foot thick soil cover layer over bauxite residue and gypsum (excluding storm water management areas), and upgrade clean storm water conveyance structure along Lake Drive;

IB-4b – Areas exceeding radiological risk based criteria will be remediated in accordance with the revised ARARs analysis; and

IB-4d – Backfill/grading, placement of a two foot thick soil cover layer.

Prior to implementing the IB-specific remedial actions, site preparation activities will include installation of security fencing and preparation of access roads and staging areas. A pre-design field investigation to fill remaining engineering data gaps may be implemented as part of the final design preparation.

Figure 6-1 presents a plan view of the conceptual design of RAA-2. Figure 6-2 presents a schematic (not-to-scale) cross-section of RAA-2. The detailed components of RAA-2 are described below. The activities would be designed and implemented to comply with ARARs. ARARs are discussed in Section 3.0 and summarized in Appendix B. RAA-2 complies with the cover ARAR outlined in 35 IAC 807.305(c).

6.3.1 Soil Cover (IB-1 and IB-4a)

A two foot thick soil cover layer will be constructed over the RDAs. The soil cover layer will be designed to also meet the geotechnical strength requirements for future redevelopment on soft bauxite residue. The soil cover layer soil typically will consist of a cohesive silty clay material, as defined by the United Soil Classification System (USCS) as ML or CL. The material will be free of trash, ice, snow, tree stumps, and other unsuitable and deleterious materials. It shall be of such a nature and character that it can be readily compacted with a reasonable effort using only the equipment required for placement (dozer). The soil cover material will meet the residential Tier 1 requirements found at 35 IAC 742.

The soil cover layer will be placed in lifts having a loose thickness such that when compacted or graded, the lifts will result in a thickness of two feet. Fill material will not be placed on surfaces that are frozen, or contain heavy frost or ice. The cover layer soil will be placed from a stable working area and generally progress inward toward the center of the RDAs. The soil will be pushed forward in an upward tumbling action so as not to impact directly on the residue. Soil will be placed using low ground pressure equipment (maximum contact pressure of ±5 psi).

Soil compaction will be accomplished by “tracking” the surface of the fill material with the equipment used in the placement. The final surface will be tracked by the placement equipment. This method of compaction will likely produce a higher degree of compaction at the surface of the bridging layer than at the base. Long-term stability of the bridging layer will be evaluated during the final design process.

Based on site observations during the Field Test Strip and Test Load Program, the following general sequence is anticipated to be used for bridge placement:

1. Edge areas will be cleared and prepared for access traffic, ideally including roadways accessible to over-the-road sources. This will limit the necessity for staging material and multiple handling of material on the site.
2. Central residue areas to be bridged, likely not including the 1B pond area, will be cleared of vegetation by removal of most woody vegetation and significant accumulations of grass, reeds, and debris. No attempt at grubbing or stump removal is anticipated to be beneficial in light of the risk of disturbing of the residue crust.
3. Bridge material, likely from the Dupo quarry or similar suitable material from elsewhere, will be stockpiled around the edges of the central residue areas.
4. Bridge material will be loaded in off-road trucks, pan-scrappers, or other similar vehicles and placed by dumping over the central residue areas. This operation will likely occur on relatively broad fronts, so that the lateral spreading and related rutting observed in the narrow test strips will be less likely to occur.
5. Over-the-road trucks (single unit, tandem axle) if found able to negotiate the bridge, may enable combining steps 1, 3, and 5 for greater efficiency.
6. Smaller off-road trucks, loader, or lighter/lower pressure equipment may be used in areas if required.
7. Trucks or other equipment dumping the bridge material will operate in as dispersed a manner as practicable, so as to limit traffic over any on location and to provide compactive benefit of tires or tracks over a wide area.
8. Bridge material will be spread and tracked in using small to medium, low pressure dozers such as D-4 to D-6 size.

9. The bridge surface will be bladed or rolled smooth at the close of each work day to reduce infiltration of rainwater.
10. Moisture adjustment of the bridge may be required to control dust (by adding water) and/or to dry the material following wetting by tilling or other methods. If bridge materials are significantly wetted by heavy rain, the work may be suspended to allow drying. Work during rainy periods or periods of cool, humid weather is likely to have longer drying times.
11. The existing residue surface appears to generally have positive drainage toward the middle of the ponds, though at relatively low gradients. The surface of the bridge will attempt to mimic this gradient to allow drainage and discourage infiltration. Stockpiles, windrows, or other obstructions that would pond water will generally be avoided.
12. Some residue areas may, due to extensive traffic or locally weak conditions, exhibit pumping, deflection, and/or liquefaction. Such areas will likely be treated by being avoided some days to recover and then bridged possibly using special measures such as lighter equipment, geogrids, geotextiles, surge stone, or other stabilization methods.
13. Once the entire RDA, or significant part, has been bridged to the middle, the geotextile and gravel will be placed from the center working outward. The bridge surface will be given a final polishing treatment with rollers and graders, geotextile placed, and gravel spread so as to avoid rutting or disturbing the bridge surface.
14. The finished surface will be generally off limits to heavy construction traffic. Future redevelopment would use trucks or equipment that does not damage the surface.

The soil cover layer will not be designed specifically for the purpose of providing infiltration control and will be composed of common fill material placed across the RDAs. Preliminary geotechnical assessments suggest that a cover layer thickness of two feet should be adequate to provide trafficable conditions in the center of the RDAs. If a solar project is constructed, geofabric and an approximate six inch layer of gravel may be placed at a later date over the cover layer to provide a final working surface for the solar facility. However, the geofabric and gravel is not required as a part of the remedy to mitigate risks.

Storm water will be managed in storm water ponds located where storm water currently accumulates with lateral extent (i.e., banks) created by the soil cover and fill layers sufficient to retain the 100-year design storm event.

6.3.2 Soil Cover (IB-2)

A two foot thick soil cover layer compliant with 35 IAC 807.305(c) ARAR will be constructed over the gypsum in IB-2. The soil cover and other fill material will meet the Tier 1 requirements found at 35 IAC 742.

The existing dikes (IB-2) will be regraded to an approximate 3(H):1(V) slope to prevent erosion and create a more stable slope, and an ARAR-compliant two foot clean soil cover will be placed over the entire surface and the side slopes. In general, storm water flow in IB-2 will be unchanged. Because the entire area will be covered with two feet of clean soil, precipitation will not contact gypsum or residue, and clean storm water on the surface of the RDA will drain inward toward the RDA storm water pond, which is designed to retain the 100 year flood event. Clean storm water draining off the side slopes will drain toward the adjacent low lying areas surrounding the RDAs.

6.3.3 Soil Cover (IB-3b)

A two foot thick soil cover layer compliant with 35 IAC 807.305(c) ARAR will be constructed over the IB-3b area that historically received runoff from RDA-1 (IB-1a) and containing surficial soil with radium concentrations exceeding the 40 CFR 192 ARAR. This area also is clearly identifiable by the red-colored soil visible on aerial photographs. The extent of the soil cover is shown on Figure 6-1. The soil cover and other fill material will meet the Tier 1 requirements found at 35 IAC 742. Alternatively, the soil exceeding the 40 CFR 192 ARAR could be removed. Soil conditions in IB-3b are more stable than in IB-1.

IB-3b will receive flows exceeding the 100-year storm recurrence interval by gravity drainage from storm water management ponds located on top of the RDAs (Figure 6-1). A low berm will be constructed on the eastern boundary of OU-1 to further limit surface water runoff to the railroad and other properties.

6.3.4 Surface Water Control/Conveyance (IB-4a)

The area immediately south of Lake Drive will continue to serve as a conveyance for clean storm water adjacent to the roadway. Future storm water will continue accumulating in the pond in the northeastern corner of the site, south of Lake Drive and west of the railroad. Based on field reconnaissance, there appears to be no engineered outflow structure from this pond. The storm water conveyance structure located directly south of Lake Drive will be lined with clean materials covering gypsum or bauxite residue waste materials that may exist. Bauxite residue placed into the former Pittsburg Lake in this area is assumed to be present at depth. Storm water along Lake Drive would not be conveyed to an interior on-Site storm water management area.

The large diked area south of the Lake Drive storm water conveyance is within the footprint of the bauxite residue and/or gypsum; therefore this area will be covered with two feet of soil, except for the area that will serve as the storm water detention area, which will be treated like the pond area in IB-1b.

6.3.5 No Action Planned (IB-3c and IB-4b)

The former SPL stockpile area (IB-3c) was the subject of an expedited cleanup process. SPL material was removed, and a cover was placed over the area following removal activities. As discussed in the Completion Report SPL Removal (Alcoa, Inc. and the City of East St. Louis, 2006a), approximately 1,500 tons of SPL were removed from an approximate 2.3 acre area within IB-3c. Following removal activities, approximately 2,500 cubic yards of clean soil was placed a minimum of six inches thick over disturbed areas and vegetated. An investigation of the former SPL area was conducted following removal activities (Alcoa, Inc. and the City of East St. Louis, 2009b). Data collected during this investigation was incorporated in the Draft Revised Baseline Human Health Risk Assessment (Alcoa, Inc. and the City of East St. Louis, 2010a). No risk drivers for remediation were identified for this area.

Area IB-4b ("Triangle Wet Area") consists of approximately 15 acres in the northeast portion of the Site of which 95% is vegetated. There is no indication of bauxite residue or gypsum present at grade; therefore soil borings were not collected from this area during RI activities. Much of the area is wet with some standing water and contains sediment and vegetation. Sediment and surface water samples were collected in area IB-4b during the RI. Sample results are

presented in the Draft Revised RI. Sample results were used to calculate risk in the human health and ecological risk assessments. Based on the results of these assessments, risk in area IB-4b does not exceed the EPA risk range; therefore no action is planned for this area.

Radiological risk was evaluated in areas IB-3c and IB-4b (linear feature between vegetated wet area and railroad tracks). A summary of the radiological survey and data evaluation is summarized in the Radiological Survey Report (Appendix C). Areas exceeding risk based criteria will be remediated in accordance with the revised ARARs analysis.

6.3.6 Backfill/Grading (IB-4d)

This task includes using gypsum from IB-2, bauxite residue or imported soil as fill to cover this barren area, eliminate the surface water ponding in IB-4d, and create the desired final elevation suitable for future site redevelopment. Once fill material has been placed and surface water eliminated, the area would be revegetated. Exposed gypsum and/or bauxite residue at the surface following backfill/grading activities will be covered with two feet of soil.

7.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents the detailed evaluation of the three RAAs developed and described in Section 6.0. Alternatives developed in the FS process are evaluated against nine CERCLA criteria (USEPA, 1988) consisting of two threshold criteria, five balancing criteria, and two modifying criteria. Each of these criteria and their application to this FS are discussed below.

Threshold Criteria (Must be met, or obtain a waiver for compliance with ARARs)

- Overall Protection of Human Health and the Environment. The assessment against this criterion describes how the alternative, as a whole, achieves and maintains protection of human health and the environment.
- Compliance with ARARs. The assessment against the criterion describes how the alternative complies with ARARs, or if a waiver is required and how it is justified. The assessment also addresses other information from advisories, criteria, and guidance that the lead and support agencies have agreed is TBC. Appendix B summarizes the ARARs analysis completed for the project.

Primary Balancing Criteria (Key factors to consider one alternative over another)

- Long-term Effectiveness and Permanence. The assessment of alternatives against this criterion evaluates the long-term effectiveness of alternatives in maintaining protection of human health and the environment after response objectives have been met.
- Reduction of Toxicity, Mobility, and Volume through Treatment. The containment technologies identified and utilized in development of alternatives are not treatment technologies and therefore do not reduce the volume, toxicity, or mobility of contaminants within the soil matrix itself. Treatment of high-volume, low-toxicity soils is not feasible. Therefore, reduction of volume, toxicity, or mobility of contaminants in soil is not applicable to the technologies and is not discussed for each alternative.
- Short-term Effectiveness. The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation of a remedy until response objectives have been met.
- Implementability. This assessment evaluates the technical and administrative feasibility of alternatives and the availability of required goods and services.
- Cost. This assessment evaluates the capital, operation and maintenance, and periodic costs of each alternative. Costs in this FS were evaluated on a net present worth basis. Capital cost estimates include both direct and indirect (overhead, etc.) costs, costs associated with engineering and administration, and a contingency factor to account for uncertainty associated with bid and scope issues not currently identified. Net present values are estimated using a discount rate of 7 percent and an operating period of 5 to 30 years. The accuracy of the cost estimates are

intended to be within +50 percent to –30 percent. Appendix G presents the detailed cost estimates for each alternative.

Modifying Criteria (Assessment of state and community concerns)

- State Acceptance. This assessment reflects IEPA's preferences for or concerns about alternatives. The IEPA has been included in the FS process from the beginning stages. The formal evaluation of the state's acceptance is completed during the comment period.
- Community Acceptance. This assessment reflects the community's apparent preferences for or concerns about alternatives. The formal evaluation of the community's acceptance is completed during the comment period.

Assessment of the modifying criteria is the responsibility of USEPA. The remainder of this section evaluates each RAA against the remaining six criteria.

7.1 RAA-0 No Action

Description. This alternative assumes that there will be no further remedial or monitoring activities performed at the site.

Overall Protection of Human Health and the Environment. No additional protection of human health or the environment will be provided under this alternative. This alternative is not protective of human health and the environment for potential future exposure scenarios.

Compliance with ARARs. This alternative does not comply with ARARs identified for this Site.

Long-term Effectiveness and Permanence. RAA-0 is not effective in controlling exposure under potential future scenarios.

Short-term Effectiveness. Since no remediation will occur under this alternative, the baseline condition will exist at the Site. The USEPA baseline cumulative risk calculations exceed the USEPA risk range of 10^{-4} to 10^{-6} for potential future residential receptors in the RDAs and gypsum area and potential future industrial workers in the RDAs; therefore RAA-0 is not effective in the short term.

Implementability. RAA-0 is implementable since no remedial action is required.

Cost. RAA-0 does not include any activities; therefore estimated cost for this alternative is $0.

7.2 RAA-1 Restricted Access

Description. This alternative consists of physical and institutional controls to restrict access. A fence will be constructed around OU-1 including IB-1, -2, -3c, portions of -3b, -4a, -4b, and -4d (see Figure X for OU-1 boundary) and deed restrictions to control potential future exposure would be implemented and enforced.

Overall Protection of Human Health and the Environment. Although access restrictions (i.e., fencing) is included as a general response action technology (limited action) in USEPA guidance (OSWER 9355.3-01), USEPA has made a site-specific determination (stated in January 17, 2012 conference call) that access restriction is not a sufficient option to address unacceptable risk at the North Alcoa Site absent active remediation.

Compliance with ARARs. This alternative does not meet IEPA's ARAR for placement of a two foot soil cover layer over the bauxite residue and gypsum.

Long-term Effectiveness and Permanence. RAA-1 is not effective or permanent. Operation and maintenance (O&M) consisting of visual inspections and routine repairs would be required to maintain a fence. Adequately maintaining the fence around IB-1 and -2 would be difficult over an extended period due to rapid growth of vegetation. Considerable effort will be needed to maintain a fence with proper clearance around OU-1.

Short-term Effectiveness. Fencing would be installed outside of the areas that contain waste materials; therefore RAA-1 will not result in adverse impacts to on-site workers or the community during implementation.

Implementability. RAA-1 is readily implementable from a physical perspective. Installation of fencing is a typical construction activity. Development of and implementation of applicable and enforceable deed restrictions will require compliance with IUECA, and IEPA has indicated they would not support this covenant absent placement of a two foot cover over the bauxite residue and gypsum.

Cost. The estimated capital, periodic, and O&M costs for RAA-1 are summarized in Appendix G, Table G-1. The estimated 30-year present value of this alternative is approximately $650,000. This cost assumes annual O&M and construction repairs.

7.3 RAA-2 Containment with Placement of ARAR-Compliant Soil Cover and On-Site Storm Water Management

Description. Alternative RAA-2 incorporates the placement of a soil cover layer with a thickness of two feet. This soil cover layer can be constructed to support future site redevelopment. Storm water improvements including installation of a storm water conveyance

structure just south of Lake Drive, and maintaining the storm water retention pond at the east end of the area will be implemented. Gypsum from IB-2 would be used for subsurface fill and berm construction as needed. Results from both the field work performed during the test strip and geotechnical investigation programs and subsequent laboratory testing indicate that there will be no significant issues in grading and replacing existing gypsum materials onsite. In general, gypsum materials will be excavated from the IB-1a, -1b, -1c, -3b and -4a areas and will be used to buttress and shape the existing dikes around the IB-1a, -1b, and -1c perimeter as wells as to flatten the slopes of the internal dike dividing the IB-1a, -1b, and -1c areas. Area IB-4d would be graded and covered as well. Residual surficial gypsum would be graded and covered with an ARAR-compliant two foot thick soil layer. A two foot thick soil cover layer compliant with 35 IAC 807.305(c) ARAR will be constructed over the IB-3b area that historically received runoff from RDA-1 (IB-1a) and contains surficial soil with radium concentrations exceeding the 40 CFR 192 ARAR.

Overall Protection of Human Health and the Environment. RAA-2 provides effective protection of human health and the environment. Potential exposure to contaminants in soils in IB-1, -2, -3b and -4a is addressed by the two foot ARAR-compliant soil cover layer and an institutional controls such as a restrictive covenant preventing future excavation, residential land use, and groundwater use for domestic purposes. The soil cover layer will also separate the residue and gypsum from storm water and will result in clean storm water runoff.

Compliance with ARARs. This alternative complies with all applicable ARARs as described in Section 3.0. Placement of cover soil in area IB-2 satisfies chemical-specific requirements by eliminated the exposure pathway. The soil cover will prevent direct contact by future industrial/commercial workers with potentially impacted subsurface gypsum with lead concentrations greater than 800 mg/kg and results in cumulative future risk within or below the 10^{-4} to 10^{-6} range. The two foot soil cover layer satisfies the cover requirements of 35 IAC 807.305(c) within the RDAs (including area IB-4a) and the gypsum areas. A preliminary engineering evaluation was conducted during the test strip and Phase 2 geotechnical programs, and the results indicate a two foot ARAR-compliant soil cover constructed in accordance with 35 IAC 807.305(c) will remain stable, effective (both during placement and over the long-term), and protective of human health and the environment. Removal of soil or placement of a two foot soil cover layer in areas that historically received runoff from RDA-1 (IB-1a) and containing surficial soil with radium concentrations exceeding 5 pCi/g above background will comply with the 40 CFR 192 ARAR. Based on the placement of a clean cover material over waste materials at the site, surface water quality and effluent standards are not applicable for the closure condition. Future users of the site will be required to obtain storm water permits pursuant to their SIC code.

Historically, ponds on the Alcoa site fit within the definition of “treatment works”, which was not considered “waters of the State”, and thus not subject to the State’s water quality standard. Title 35 of IAC 301.440 defines “waters of the State” as “all accumulations of water…surface and underground…which are wholly or partially within…the State of Illinois…except that sewers and treatment works are not included…” Title 35 IAC 301.415 defines “treatment works” as “individually or collectively those constructions or devises…used for collecting, pumping, treating, or disposing of wastewater or for the recovery of byproducts from such wastewater.” In addition, the Alcoa ponds are not considered “waters of the United States” and are not subject to Federal water quality standards because under the definition of “waters of the United States”,

40 CFR Section 122.2 states that "waste treatment systems, including treatment ponds or lagoons are not waters of the United States".

Long-term Effectiveness and Permanence. The test strip program and engineering results indicate that a two foot ARAR-compliant soil cover constructed in accordance with 35 IAC 807.305(c) will be both effective and stable over the long-term; therefore RAA-2 is both effective and permanent.

Data from the test load placed during the Test Strip program suggests that the residue has considerable ability to resist changes due to imposed load. The residue has apparently been in place for many decades and has developed a relatively strong structure. Continuing measurements of the test load settlement prior to commencement of construction as well as laboratory testing of residue samples will provide more information as to the long term response of the residue under static load of the bridge. Additional sources of settlement, such as decay of limited vegetation debris, roots, and stumps and consolidation of the bridge over time, are likely to be relatively minor given the small volumes and loads involved. These other sources are likely to be of lesser magnitude than long term, secondary consolidation of the deep residue deposits.

The cover system will either be covered with vegetation or a combination of geotextile and gravel depending upon its location on site, and site redevelopment plans. In either case, this surface covering will aid in preserving the integrity of the cover by assuring the surfaces can withstand erosion from runoff during wet periods and wind erosion during dry periods. In addition to the surface covering, routine O&M procedures comparable to that employed on similar capped/covered waste sites will assure continued long-term effectiveness. These procedures will include periodic surveillance of the areas to assure that there is no erosion or degradation of the vegetation or gravel surfacing or damage to the cover itself. In the event that damage is found, the procedures will provide for repairs to cover, resurface (both gravel and vegetation) or restore damaged areas to the designed condition as quickly as possible.

The alternative can be designed and constructed to create proper grading and ensure adequate slopes to minimize erosion of the soil cover layer. The adequacy and reliability of this alternative is ensured by enforcement of the institutional controls, and inspection and maintenance of the Site.

Short-term Effectiveness. RAA-2 does not result in adverse impacts to on-site workers or the community during implementation that cannot be managed by proper planning. A site-specific Health and Safety Plan would be developed for remediation activities. All work would be completed in compliance with applicable OSHA guidelines. Minimal environmental impacts are expected from the construction. All local requirements for construction activity will be met (traffic plans, etc.). The RAOs are readily achieved upon completion of construction, which is estimated to not require more than one to two construction seasons. OU-1 would be ready for reuse at that time.

Site grading activities, including the regarding of onsite gypsum materials, importing and placement of bridging, cover and topsoil materials, are currently scheduled to be completed within an approximate eight month period. During this time, the primary issues affecting the local community are those related to dust (generated from gypsum operations and the onsite traffic of the fill delivery trucks) and traffic generated by the fill delivery trucks entering and leaving the site.

The Site Specific HASP will address dust monitoring and will describe the means and methods by which dust will be controlled. This plan will be in place before any work is started and will remain so throughout the construction process. Periodic surveillance of the requirements of the plan will be performed during the construction period to assure its proper and complete implementation.

A Traffic Plan will be prepared and implemented before deliveries begin. The requirements of the Traffic Plan and the schedule of activities will be discussed with local and state authorities prior to the commencement of fill material deliveries. Periodic surveillance of the requirements of the plan will be performed during the construction period to assure its proper and complete implementation.

Implementability. RAA-2 is readily implementable, and although no agreement to date has been reached, it is anticipated the environmental easement/restrictive covenant to Alcoa (with USEPA and the State of Illinois as third party beneficiaries) to implement land use restrictions over these areas will be implemented. Most tasks in RAA-2 are common, reliable construction activities that do not entail any significant technical difficulties, but some aspects of the alternative will require specific expertise to implement.

During the Test Strip program, the bridge was placed over the residue with little difficulty using relatively large equipment that should be capable of efficient placement of large amounts of material. Trucks or other equipment dumping the bridge material will operate in as dispersed a manner as practicable, so as to limit traffic over any one location and to provide compactive benefit of tire or tracks over a wide area. Bridge material will be spread and tracked in using small to medium, low pressure dozers as D-4 to D-6 size. Once the entire RDA, or a significant part, has been bridged to the middle, the geotextile and gravel will be placed from the center working outward. Geotextile will be placed, and gravel spread so as to avoid rutting or disturbing the bridge surface. The finished surface will then be off limits to further heavy equipment traffic.

Cost. The estimated capital and O&M costs for RAA-2 are summarized in Appendix G, Table G-2. The estimated present value of this alternative is approximately $24,990,000. This cost assumes annual O&M for a period of 30 years.

8.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

Remedial action alternatives are evaluated in relation to one another for each of the evaluation criteria. The purpose of the evaluation is to identify the relative advantages and disadvantages of each alternative. A summary of the comparative analysis is provided in Table 8-1.

8.1 Overall Protection of the Human Health and the Environment

With the exception to RAA-0 (no action), all of the RAAs are protective of human health and the environment. RAA-1 is less protective than RAA-2 as it provides a less permanent solution and does not comply with ARARs specifically 35 IAC 807.305(c) capping requirements. RAA-1 is dependent on the security of the site fencing and the ability to prevent exposure over the long term to site wastes that pose unacceptable risk, and the protectiveness of RAA-2 is dependent on O&M to maintain the integrity of cover materials.

8.2 Compliance with ARARs

RAA-0 and RAA-1 would not comply with ARARs identified for this Site (Section 3.0) specifically 35 IAC 807.305(c) cover requirements and 40 CFR 192. RAA-2 would be designed and implemented to comply with all Site ARARs including placement of an ARAR-compliant two foot soil cover over gypsum and bauxite residue waste materials, and in areas that historically received runoff from RDA-1 (IB-1a) and containing surficial soil with radium concentrations exceeding the 40 CFR 192 ARAR.

8.3 Long-Term Effectiveness and Permanence

RAA-0 and RAA-1 are not effective or permanent over the long-term. RAA-2 is effective over the long-term as described in Section 7.3 (Long-term Effectiveness and Permanence). Geotechnical testing and evaluations indicate that the cover material will be stable over both the short-term and long-term. O&M activities required to maintain the stable conditions are described in Section 7.3.

8.4 Short-Term Effectiveness

RAA-1 could be completed in the shortest period of time without adverse impacts and therefore has the highest short-term effectiveness. RAA-2 would be completed in approximately eight months and would have a longer period of time without adverse impacts and a lower short-term effectiveness. Additional information regarding short-term effectiveness of RAA-2 is presented in Section 7.3 Short-term Effectiveness. HASPs will be used to protect on-Site workers during implementation. Dust monitoring and dust control activities will be performed. A Traffic Plan will be prepared to minimize the potential impact of construction activities on the local off-Site area.

8.5 Implementability

RAA-0 does not include any remedial actions, and RAA-1 is easily implemented. RAA-2 is more difficult to implement. Implementation of RAA-2 will require some specialized equipment (low ground pressure) in certain areas with soft bauxite residue. Specialized geotechnical applications including placement of a soil cover layer will be required to stabilize residue and/or minimize the use of specialized equipment.

8.6 Cost

Estimated costs associated with each alternative are summarized on Table 8-1. Details of the cost estimates for each alternative are presented in Appendix G. RAA-2 is the lowest cost alternative that meets the two threshold criteria of protection of human health and the environment and compliance with ARARs in the shortest timeframe. The RAA-2 alternative has the highest composite rating of the balancing criteria.

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TABLES

TABLE 2-1

SUMMARY OF THE CHEMICAL COMPOSITION OF BAUXITE RESIDUE AND GYPSUM NORTH ALCOA SITE, EAST ST. LOUIS, ILLINOIS

Detected Chemical	Surface Soil Samples						Subsurface Soil Samples					
Metals	Bauxite Residue (IB-1) (mg/kg)			Gypsum (IB-2) (mg/kg)			Bauxite Residue (IB-1) (mg/kg)			Gypsum (IB-2) (mg/kg)		
	No.	Avg	Max	No.	Avg	Max	No.	Avg	Max	No.	Avg	Max
Aluminum	56	62,370	127,000	18	7,513	61,100	61	64,868	96,200	11	9,665	32,200
Antimony	38	3.74	9.46	4	3.06	4.62	35	4.2	31.4	1	4.07	4.07
Arsenic	56	23.7	76.2	9	11.9	43.7	60	32.8	170	9	13	66.7
Barium	56	101	794	18	129	292	61	116	274	11	125	273
Cadmium	39	4.0	23.7	17	0.982	7.25	40	1.63	9.52	7	0.484	1.61
Chromium	56	479	1,100	18	34.4	306	61	361	947	11	14.6	42.6
Cobalt	52	2.0	12.8	6	1.14	2.69	57	2.52	48.2	8	3.56	14.5
Copper	56	14	41.7	18	12.7	138	61	19	243	11	11.4	33.4
Lead	56	143	1,290	18	690	1,230	61	103	1,280	11	603	2,250
Manganese	56	328	1,480	18	37.5	259	61	435	2,380	11	263	1,660
Mercury	56	0.293	0.91	18	0.209	0.657	60	0.315	0.757	11	0.129	0.61
Nickel	56	7.37	23.2	15	3.21	25	61	7.66	52.1	10	8.37	35.6
Selenium	20	5.44	16	3	3.12	3.58	38	7.8	181	3	5.22	13.3
Silver	37	1.85	3.23	12	0.323	0.597	41	2.44	7.52	4	0.482	0.819
Thallium	28	5.82	19.8	1	10.4	10.4	34	10.2	195	4	3.08	7.09
Vanadium	56	637	1,220	17	91.3	950	61	531	1,190	11	50.3	326
Zinc	53	49	227	18	73	370	60	21.0	88.7	11	35.3	92.5
Wet Chemistry												
pH (s.u.)	56	7.3	12.0	18	4.6	7.6	61	7.6	12.2	11	4.8	8.3
Fluoride	56	55.7	419	18	49	156	61	78.3	624	11	46.5	148
Cyanide	23	4.65	29.4	4.0	9.1	21.4	22	32.1	143	5	1.47	3.8

Notes:
1. Volatile and semi-volatile organic compounds were only sporadically detected in these materials.
2. Data from RI Report Section 4.0.

TABLE 2-2

RME AND CT SUMMED THEORETICAL EXCESS LIFETIME CANCER RISKS
SITE-WIDE SCENARIOS
NORTH ALCOA SITE, EAST ST. LOUIS, ILLINOIS

Investigative Block/ Media	Receptor	RME Summed Theoretical Excess Lifetime Cancer Risk	Appendix C Table #	CT Summed Theoretical Excess Lifetime Cancer Risk	Appendix C Table #
IB-1 - combined (surface soil, surface water, sediment)	Current/Future Trespasser	3×10^{-7}	1	2×10^{-7}	15
IB-2 surface soil	Current/Future Trespasser	1×10^{-7}	2	3×10^{-8}	16
IB-3 (surface soil, surface water, sediment)	Current/Future Trespasser	8×10^{-7}	3	3×10^{-7}	17
IB-3 (surface soil)	Future Industrial Worker	2×10^{-5}	4	1×10^{-6}	18
IB-3a current industrial area (surface soil)	Current/Future Industrial Worker	7×10^{-6}	5	--	--
IB-3 (surface/ subsurface soil)	Future Construction Worker	2×10^{-6}	6	3×10^{-7}	19
IB-4a (IB-4a surface soil; IB-4a,b,d surface water and sediment)	Current/Future Trespasser	5×10^{-7}	7	3×10^{-7}	20
IB-4a (surface soil)	Future Industrial Worker	1×10^{-5}	8	2×10^{-6}	21
IB-4a (surface/ subsurface soil)	Future Construction Worker	2×10^{-6}	9	4×10^{-7}	22
IB-4a (surface soil)	Future Sports Player	1×10^{-6}	10	2×10^{-7}	23
IB-4c (surface soil)	Future Youth Ball Player	8×10^{-7}	11	2×10^{-7}	24
IB-4c (surface soil)	Future Maintenance Worker	1×10^{-6}	12	2×10^{-7}	25
IB-4e (subsurface soil)	Future Industrial Worker	7×10^{-6}	13	1×10^{-6}	26
IB-4e (subsurface soil)	Future Construction Worker	1×10^{-6}	14	2×10^{-7}	27
IB-4e (Upchurch Industrial Well-groundwater)	Current/Future Industrial Worker	NA[1]	--	NA[1]	--

[1] NA = Not Applicable. COPCs are not considered to be carcinogenic.

TABLE 2-3

RME AND CT SUMMED NONCANCER HAZARD SUMMARY
SITE-WIDE SCENARIOS
NORTH ALCOA SITE, EAST ST. LOUIS, ILLINOIS

Investigative Block	Receptor	RME Summed Hazard Index	Appendix C Table #	CT Summed Hazard Index	Appendix C Table #
IB-1 - combined (surface soil, surface water, sediment)	Current/Future Trespasser	0.03	28	0.02	43
IB-2 surface soil	Current/Future Trespasser	0.004	29	0.0006	44
IB-3 (surface soil, surface water, sediment)	Current/Future Trespasser	0.02	30	0.009	45
IB-3 (surface soil)	Future Industrial Worker	0.07	31	0.03	46
IB-3a current industrial area (surface soil)	Current/Future Industrial Worker	0.04	32	--	--
IB-3 (surface/ subsurface soil)	Future Construction Worker	0.06	33	0.01	47
IB-4a (IB-4a surface soil; IB-4a,b,d surface water and sediment)	Current/Future Trespasser	0.01	34	0.008	48
IB-4a (surface soil)	Future Industrial Worker	0.1	35	0.07	49
IB-4a (surface/ subsurface soil)	Future Construction Worker	0.2	36	0.09	50
IB-4a (surface soil)	Future Sports Player	0.05	37	0.02	51
IB-4c (surface soil)	Current/Future Youth Ball Player	0.04	38	0.01	52
IB-4c (surface soil)	Current/Future Maintenance Worker	0.03	39	0.009	53
IB-4e (subsurface soil)	Future Industrial Worker	0.04	40	0.02	54
IB-4e (subsurface soil)	Future Construction Worker	0.01	41	0.002	55
IB-4e (Upchurch Industrial Well-groundwater)	Current/Future Industrial Worker	0.08	42	--	--

TABLE 2-4
EXPOSURE POINT CONCENTRATION SUMMARY - OPERABLE UNIT 1 - SURFACE SOIL
RME AND AVERAGE
FORMER ALCOA EAST ST. LOUIS OPERATIONS; EAST ST. LOUIS, IL

OU1 Exposure Point	Medium	Depth (ft)	COPC	# Detects/ Total #	Maximum Detection (mg/kg)	Mean (mg/kg)	ProUCL results		
							ProUCL distribution	EPA Recommended stat method	Exposure Point Concentration[a] (mg/kg)
IB-1	Soil	0-2	Arsenic	55/55	76.2	2.38E+01	gamma	approx. gamma UCL	26
		0-2	Manganese	55/55	1480	3.31E+02	gamma	approx. gamma UCL	375
		0-2	Vanadium	55/55	1220	6.30E+02	Nonparametric	95% Chebyshev	846
IB-2	Soil	0-2	Arsenic	9/18	43.7	6.45 (1)	Nonparametric	95% KM (t) UCL	11.38
		0-2	Vanadium	17/18	950	86.3 (1)	Lognormal	99% KM (Chebyshev) UCL	622
IB-4a	Soil	0-2	Arsenic	12/12	48.5	2.47E+01	gamma	approx. gamma UCL	30.0
		0-2	Manganese	13/13	2110	8.33E+02	Nonparametric	95% Chebyshev	1658
		0-2	Vanadium	12/12	419	1.79E+02	normal	Student's t-statistic	229
IB3 samples from RI (includes samples outside of OU1)	Soil	0-2	Arsenic	40/40	31.8	1.41E+01	normal	Student's t-statistic	16.2
		0-2	Vanadium	40/40	813	1.74E+02	Nonparametric	99% Chebyshev	519
		0-2	Benzo(a)anthracene	39/39	7.1	7.00E-01	Nonparametric	99% Chebyshev	3.39
		0-2	Benzo(a)pyrene	39/39	8.9	7.63E-01	Nonparametric	99% Chebyshev	3.70
		0-2	Benzo(b)fluoranthene	39/39	6.6	6.60E-01	Nonparametric	99% Chebyshev	3.09
		0-2	Dibenz(a,h)anthracene	29/39	1.2	0.0816 (1)	Nonparametric	99% KM (Chebyshev) UCL	0.43
		0-2	IndenoPyrene	39/39	8.9	6.72E-01	Nonparametric	99% Chebyshev	3.39
IB-3 samples within OU1 boundary	*Soil*	*0-2*	*Arsenic*	*22/22*	*29.4*	*1.38E+01*	*normal*	*Student's t-statistic*	*16.9*
		0-2	*Vanadium*	*22/22*	*813*	*1.13E+01*	*Lognormal*	*97.5% Chebyshev*	*352*
		0-2	*Benzo(a)anthracene*	*22/22*	*7.1*	*6.60E-01*	*Lognormal*	*97.5% Chebyshev*	*3.00*
		0-2	*Benzo(a)pyrene*	*22/22*	*5.8*	*6.10E-01*	*Lognormal*	*97.5% Chebyshev*	*2.63*
		0-2	*Benzo(b)fluoranthene*	*22/22*	*5.9*	*5.90E-01*	*Lognormal*	*97.5% Chebyshev*	*2.50*
		0-2	*Dibenz(a,h)anthracene*	*21/21*	*0.51*	*6.80E-02*	*Lognormal*	*95% Chebyshev UCL*	*0.20*
		0-2	*IndenoPyrene*	*22/22*	*4.8*	*5.20E-01*	*Lognormal*	*95% Chebyshev UCL*	*1.70*

[a] Exposure Point Concentration (EPC) is EPA Recommended Upper Confidence Limit (UCL) from ProUCL ouput, unless otherwise noted.

(1) Mean calculated by the Kaplan Meier (KM) Method with NDs included at the detection limits.

TABLE 2-5

RME SUMMED RISK RESULTS
OPERABLE UNIT 1 - TRESPASSER SCENARIO
NORTH ALCOA SITE, EAST ST. LOUIS, ILLINOIS

Investigative Block/ Media	Receptor	COPC	Exposure Point Concentration (mg/kg)	RME Summed Theoretical Excess Lifetime Cancer Risk	RME Summed Hazard Index
Draft Baseline Risk Assessment Results					
IB-1 Surface Soil	Current/Future Trespasser	arsenic	26.5	2.30E-07	0.004
		vanadium	846	--	0.003
IB-2 surface soil	Current/Future Trespasser	arsenic	11.4	1.00E-07	0.002
		vanadium	622	--	0.002
IB-4a Surface Soil	Current/Future Trespasser	arsenic	30	2.60E-07	0.004
IB-3 Surface Soil - RI Boundary	Current/Future Trespasser	arsenic	16.2	1.41E-07	0.002
		vanadium	519	--	0.002
		benzo(a)pyrene	3.7	2.36E-07	--
		other carcinogenic PAH COPCs	0.43-3.4	9.06E-08	--
FFS Analysis: Estimate IB3 OU1 Cancer Risk and HI by ratio of IB3 EPCs[1]					
IB-3 Surface Soil - Samples within OU1 Boundary	*Current/Future Trespasser*	*arsenic*	*16.9*	*1.47E-07*	*0.002*
		vanadium	*352*	*--*	*0.001*
		BaP	*2.63*	*1.68E-07*	*--*
		other carcinogenic PAH COPCs[2]	*0.2 - 3.0*	*7.99E-08*	*--*
		Summed Risk Results		***4.E-07***	***0.004***

(1) IB3 OU1 Risk and HI estimated by multiplying IB3 RI Summed Theoretical Excess Lifetime Cancer Risk and HI values by ratio of (IB3 OU1 EPC)/(IB 3 RI EPC)

(2) EPC ratio for other PAHs is the maximum 95% UCL for each group (for BaA in both cases), then multiplied RI summed risk for these PAHs by the EPC ratio (3.0/3.4).

TABLE 2-6
SUMMARY OF BASELIN ECOLOGICAL RISK CONCLUSIONS
NORTH ALCOA SITE, EAST ST. LOUIS, IL

IB	Receptor	Pathways	Risk Conclusions
Sitewide	Whitetail Deer	Soil/Surface Water/Food	Potential risks to local wildlife populations are low.
	Coyote	Soil/Surface Water/Food	Potential risks to local wildlife populations are low.
	Red-tailed Hawk	Soil/Surface Water/Food	Potential risks to local wildlife populations are low.
	Mallard		
	- Omnivore	Sediment/Surface Water/Food	Potential risks to local wildlife populations are low.
	- Herbivore	Sediment/Surface Water/Food	Potential risks to local wildlife populations are low.
	Black-Crowned Night Heron	Sediment/Surface Water/Food	Potential risks to local wildlife populations are low.
IB-1a	Deer Mouse	Soil/Surface Water/Food	Potential risks to local wildlife populations are low.
	American Robin		
	- Omnivore	Soil/Surface Water/Food	Potential for risk to individuals from chromium, selenium and cyanide. Risks are likely overstated based on multiple uncertainties and limited habitat quality. Very limited effects on the population of birds are predicted.
	- Herbivore	Soil/Surface Water/Food	Potential for risk to individuals from selenium and cyanide. Risks are likely overstated based on multiple uncertainties and limited habitat quality. Very limited effects on the population of birds are predicted.
	Muskrat	Sediment/Surface Water/Food	Low potential for risk predicted from vanadium. No suitable habitat is present for the muskrat due to the unvegetated nature of the standing water in IB-1a.
	Black-Crowned Night Heron	Sediment/Surface Water/Food	None. A very low risk is predicted from chromium, but the habitat quality is poor and the risk estimate assumes 100% area use. No risk is predicted at 75% area use.
IB-1b	Deer Mouse	Soil/Surface Water/Food	Potential risk to individuals from vanadium. LOAEL HQ equaled 2.2.
	American Robin		
	- Omnivore	Soil/Surface Water/Food	Potential for risk to individuals from chromium, selenium and cyanide. Risks are likely overstated based on multiple uncertainties and limited habitat quality. Very limited effects on the population of birds are predicted.
	- Herbivore	Soil/Surface Water/Food	Potential for risk to individuals from chromium, lead, selenium and cyanide. Risks are likely overstated based on multiple uncertainties and limited habitat quality. Very limited effects on the population of birds are predicted.
	Muskrat	Sediment/Surface Water/Food	Low potential for risk predicted from vanadium. Suitable habitat is present for the muskrat in IB-1b, but is limited in size. Any risk predicted would be applicable to only a few individuals that may inhabit the IB. Potential risks to local wildlife populations are low.
	Black-Crowned Night Heron	Sediment/Surface Water/Food	None. A very low risk is predicted from chromium and lead, but the risk estimate assumes 100% area use. No risk is predicted at a still conservative 40% area use.
IB-1c	Deer Mouse	Soil/Surface Water/Food	Potential risk to individuals from vanadium. LOAEL HQ equaled 2.6.
	American Robin		
	- Omnivore	Soil/Surface Water/Food	Potential for risk to individuals from chromium, selenium and cyanide. Risks are likely overstated based on multiple uncertainties and very limited habitat quality. Very limited effects on the population of birds are predicted.
	- Herbivore	Soil/Surface Water/Food	Potential for risk to individuals from chromium, selenium and cyanide. Risks are likely overstated based on multiple uncertainties and very limited habitat quality. Very limited effects on the population of birds are predicted.
	Muskrat	Sediment/Surface Water/Food	Low potential for risk predicted from vanadium. No suitable habitat is present for the muskrat due to the ephemeral nature of the standing water in IB-1c.
	Black-Crowned Night Heron	Sediment/Surface Water/Food	None. A very low risk is predicted from chromium, but the risk estimate assumes 100% area use. No risk is predicted at a still conservative 40% area use.
IB-2	Whitetail Deer	Soil	Potential risks to local wildlife populations are low.
	Coyote	Soil	Potential risks to local wildlife populations are low.
	Red-tailed Hawk	Soil	Potential risks to local wildlife populations are low.
IB-3b	Deer Mouse	Soil/Surface Water/Food	Potential risks to local wildlife populations are low.
	American Robin		

TABLE 2-6
SUMMARY OF BASELIN ECOLOGICAL RISK CONCLUSIONS
NORTH ALCOA SITE, EAST ST. LOUIS, IL

IB	Receptor	Pathways	Risk Conclusions
	- Omnivore	Soil/Surface Water/Food	Potential for risk to individuals from chromium, cyanide and selenium. Risks are likely overstated based on multiple uncertainties. Very limited effects on the population of birds are predicted.
	- Herbivore	Soil/Surface Water/Food	Potential for risk to individuals from chromium, cyanide and selenium. Risks are likely overstated based on multiple uncertainties. Very limited effects on the population of birds are predicted.
	Muskrat	Sediment/Surface Water/Food	Low potential for risk predicted from vanadium. Phase I data also predicted potential risks from fluoride. Suitable habitat is present for the muskrat in IB-3b. Any risk predicted would be applicable to only a few individuals that may inhabit the IB. Potential risks to local wildlife populations are low.
	Black-Crowned Night Heron	Sediment/Surface Water/Food	A potential for risk is predicted from exposure to cyanide. The risk calculation for cyanide has multiple uncertainty issues. Risks are likely overstated and no risks to the local population of heron receptors are predicted. Risks were driven by a sediment sample in one small pond (<1/2 acre) within the IB. No risks are predicted at a still conservative 10% area use.
IB-4a	Deer Mouse	Soil/Surface Water/Food	A low potential for risk was predicted in Phase I for cadmium and selenium. Food items collected in Phase II in other areas of the Site show concentrations lower than predicted in Phase I. Potential risks to local wildlife populations are low.
	American Robin		
	- Omnivore	Soil/Surface Water/Food	A low potential for risk was predicted in Phase I for cadmium, chromium, cyanide, lead and selenium. Food items collected in Phase II in other areas of the Site show concentrations lower than predicted in Phase I. Very limited effects on the population of birds are predicted.
	- Herbivore	Soil/Surface Water/Food	A low potential for risk was predicted in Phase I for cadmium, chromium, cyanide, fluoride, lead and selenium. Food items collected in Phase II in other areas of the Site show concentrations lower than predicted in Phase I. Very limited effects on the population of birds are predicted.
	Muskrat	Sediment/Surface Water/Food	Potential risks to local wildlife populations are low.
	Black-Crowned Night Heron	Sediment/Surface Water/Food	Very limited effects on the population of birds are predicted.
IB-4b	Muskrat	Sediment/Surface Water/Food	Low potential for risk predicted from vanadium. No risks are predicted with area use less than 90%. Potential risks to local wildlife populations are low.
	Black-Crowned Night Heron	Sediment/Surface Water/Food	Low potential for risk predicted from chromium, lead and cyanide. No risks are predicted with area use less than 75%. Very limited effects on the population of birds are predicted.
IB-4c	Muskrat	Sediment/Surface Water/Food	Low potential for risk predicted from lead and selenium. Very little suitable habitat is present for the muskrat due to the mostly unvegetated nature of the standing water in IB-4d. No risks are predicted with area use less than 90%.
	Black-Crowned Night Heron	Sediment/Surface Water/Food	Low potential for risk predicted from lead and cyanide. Very little suitable habitat is present due to the small area mostly unvegetated nature of the standing water in IB-4d. No risks are predicted with area use less than 90%.

TABLE 5-1

IDENTIFICATION OF POTENTIALLY APPLICABLE TECHNOLOGIES AND PROCESS OPTIONS
NORTH ALCOA SITE, EAST ST. LOUIS, ILLINOIS

Soil General Response Action	Remedial Technology	Process Options	Description	Screening Comments
No Action	None	Not Applicable	No Action	Required for consideration by NCP
Institutional Controls	Access Restrictions	Deed Restriction	Deed restriction would be designed and would prohibit excavation and limit future uses of the Site where required.	Potentially Applicable
		Fencing	A fence would physically contol access to the Site	Potentially Applicable
Containment	Horizontal Barriers	Low-Permeability Cover System, Synthetic Liner	Synthetic membranes and/or clay cover over contaminated areas - typically used to control vertical infiltration	Not Applicable - vertical migration has not been identified as a pathway of concern.
		Permeable Cover System	Installation of permeable cover designed to prevent contact with contaminated soil.	Potentially Applicable
		Soil Stabilization	Mixing with cement to immobilize contamination - typically utilized to control migration of impacted material.	Not Applicable - vertical migration has not been identified as a pathway of concern.
		Grout Injection	Inject grout into the subsurface to create an artificial horizontal aquaclude - usually used in conjunction with a slurry wall to contain/control groundwater	Not Applicable - groundwater is not a media of concern at the Site.
	Vertical Barriers	Slurry Wall/Sheet Piling/Grout Injection	Installation of trench with slurry, sheet piles, or grout in drilled holes around contaminated areas.	Horizontal mobilization of lead-contaminated soil has not been identified as a transport mechanism.
	Surface Controls	Regrading, revegetation, storm water diversion/collection, silt fencing	All process options are variations of controls intended to control storm water and minimize erosion.	Potentially Applicable

Technology that is screened out.

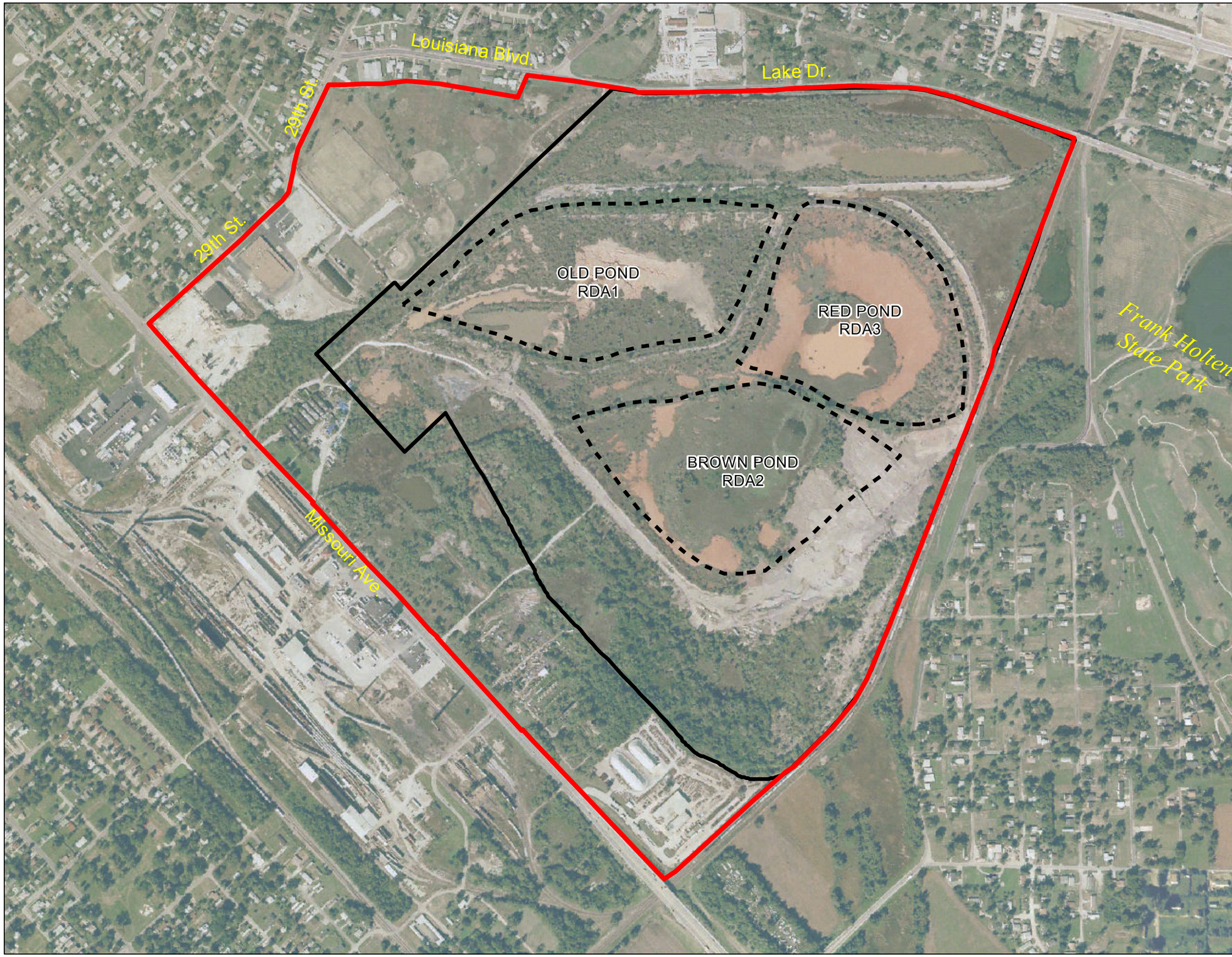
TABLE 8-1

SUMMARY OF CERCLA EVALUATION CRITERIA
NORTH ALCOA SITE, EAST ST. LOUIS, ILLINOIS

Remediation Action Alternative	Alternative Description	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Short-Term Effectiveness	Implementability	Cost[1] (Present Value)
RAA-0	No Action	No	No	None	None	N/A	$0
RAA-1	Restricted Access	Yes	No	None	High	High	$650,000
RAA-2	Containment with Placement of ARAR-Compliant Soil Cover and On-Site Storm Water Management	Yes	Yes	High	Medium	High	$24,990,000

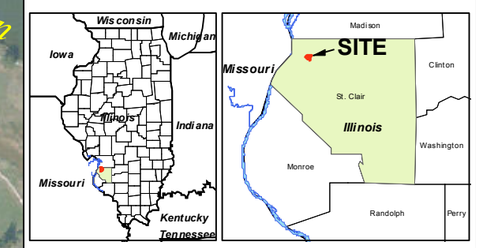
Note:
[1]Cost reported as present value.

FIGURES



EXPLANATION

- Site Boundary
- Proposed Operable Unit No. 1 Boundary
- Mud Lakes



N

0 600 1,200

Feet

AERIAL PHOTOGRAPHY: SEPTEMBER 1, 2000

NORTH ALCOA SITE

EAST ST. LOUIS, ILLINOIS

FIGURE 1-1

SITE LOCATION MAP

PROJECT: 114-021309	DATE: NOVEMBER 18, 2011	
REV: 1	BY: SMM	CHECKED: JCM

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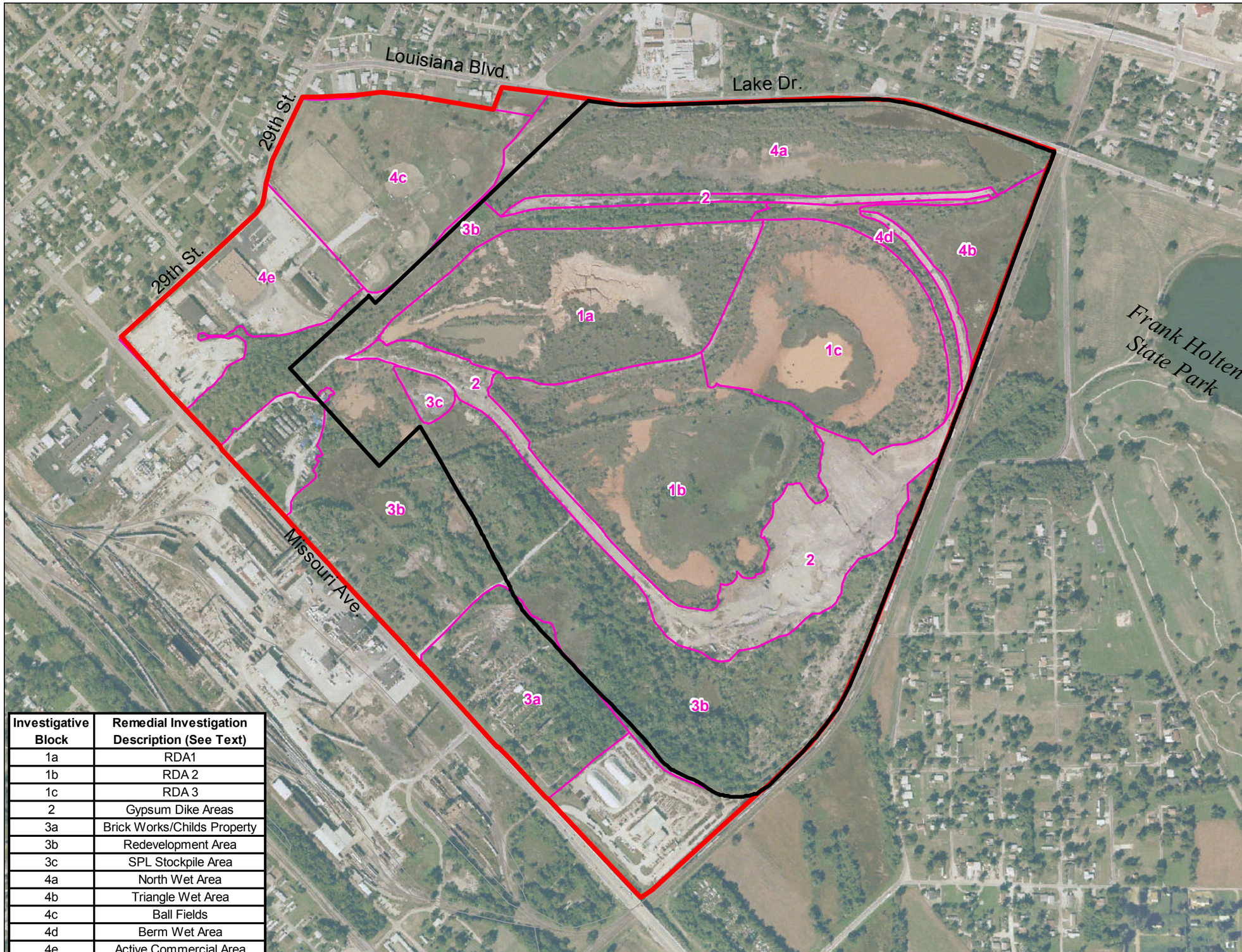

Investigative Block	Remedial Investigation Description (See Text)
1a	RDA1
1b	RDA 2
1c	RDA 3
2	Gypsum Dike Areas
3a	Brick Works/Childs Property
3b	Redevelopment Area
3c	SPL Stockpile Area
4a	North Wet Area
4b	Triangle Wet Area
4c	Ball Fields
4d	Berm Wet Area
4e	Active Commercial Area

EXPLANATION

Proposed Operable Unit No. 1 Boundary

Site Boundary

Note:

1. Boundaries of Investigative Blocks were originally set forth in the Remedial Investigation Work Plan (2003). Several properties outside the proposed limits of Operable Unit No. 1 have changed ownership since that time.

N

0 600 1,200

Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 1-2

PROPOSED OPERABLE UNIT NO. 1 BOUNDARY

PROJECT: 114-021309	DATE: NOVEMBER 18, 2011	
REV: 1	BY: SMM	CHECKED: JCM

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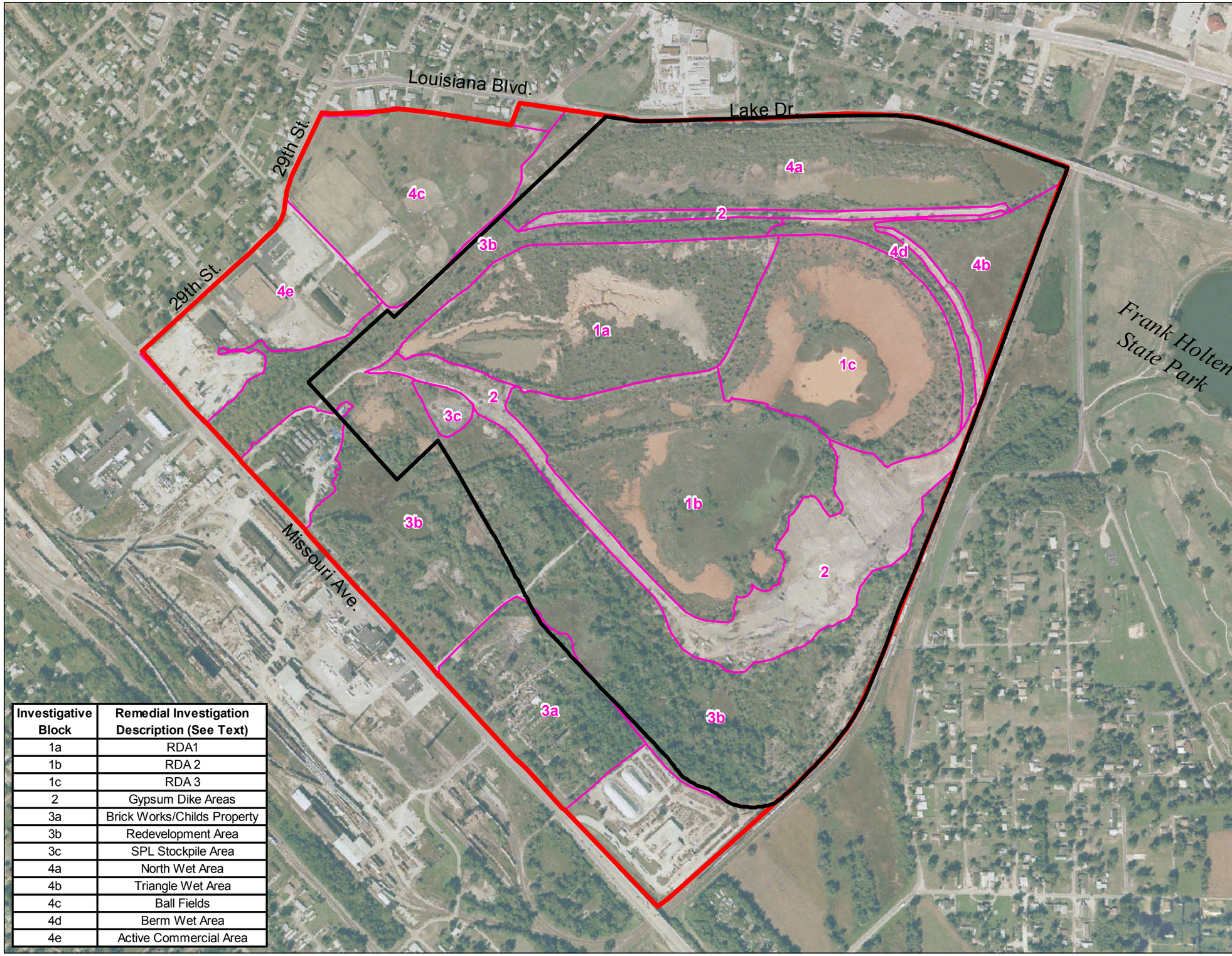

Investigative Block	Remedial Investigation Description (See Text)
1a	RDA1
1b	RDA 2
1c	RDA 3
2	Gypsum Dike Areas
3a	Brick Works/Childs Property
3b	Redevelopment Area
3c	SPL Stockpile Area
4a	North Wet Area
4b	Triangle Wet Area
4c	Ball Fields
4d	Berm Wet Area
4e	Active Commercial Area

EXPLANATION

- Proposed Operable Unit No. 1 Boundary
- Site Boundary
- Investigative Blocks

Note:

1. Boundary of Investigative Blocks were originally set forth in the Remedial Investigation Work Plan (2003). Several properties outside the proposed limits of Operable Unit No. 1 have changed ownership since that time.

N

0 600 1,200

Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-1

INVESTIGATIVE BLOCKS

PROJECT: 114-021309	DATE: NOVEMBER 18, 2011	
REV: 1	BY: SMM	CHECKED: JCM

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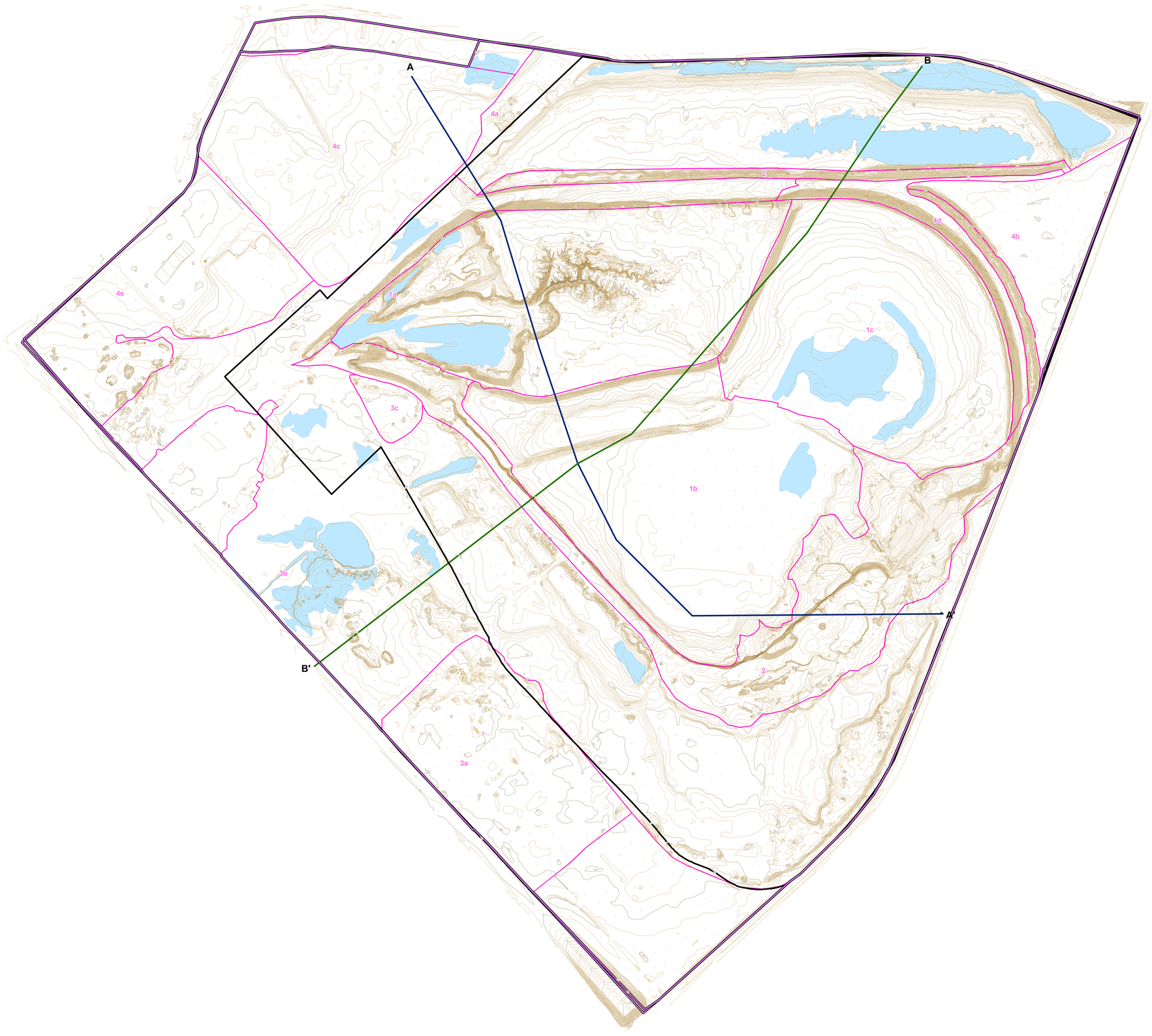

EXPLANATION

- Site Boundary
- Proposed Operable Unit No. 1 Boundary
- Cross Section A - A'
- Cross Section B - B'
- Site Boundary
- Investigative Blocks
- Open Water (at time of photo)

Note:

Topographic conditions outside Operable Unit Boundary No. 1 have been modified since the date of this topographic map.

N

0 200 400

Feet

NORTH ALCOA SITE

EAST ST. LOUIS, ILLINOIS

FIGURE 2-2

SITE TOPOGRAPHIC MAP FROM FEBRUARY 2005

PROJECT: 114-021309	DATE: NOVEMBER 18, 2011	
REV: 1	BY: SMM	CHECKED: JCM

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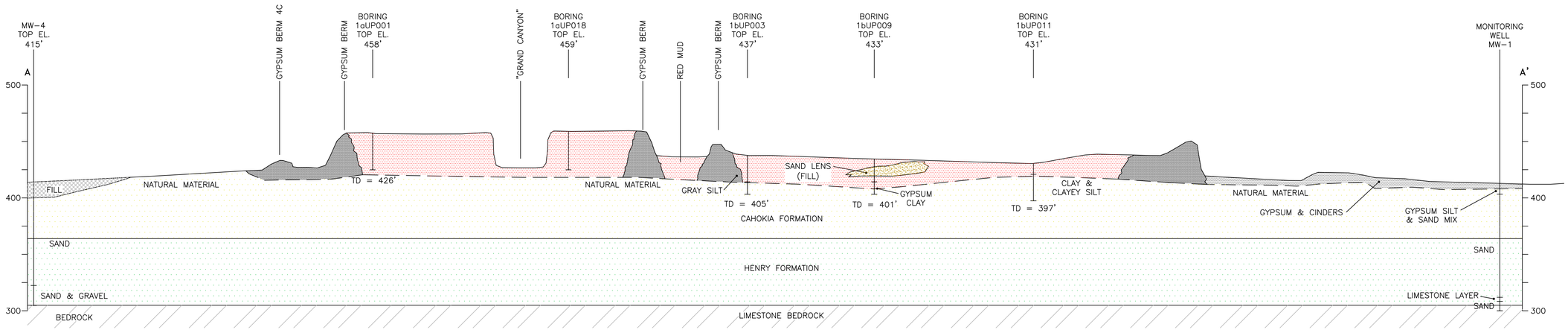

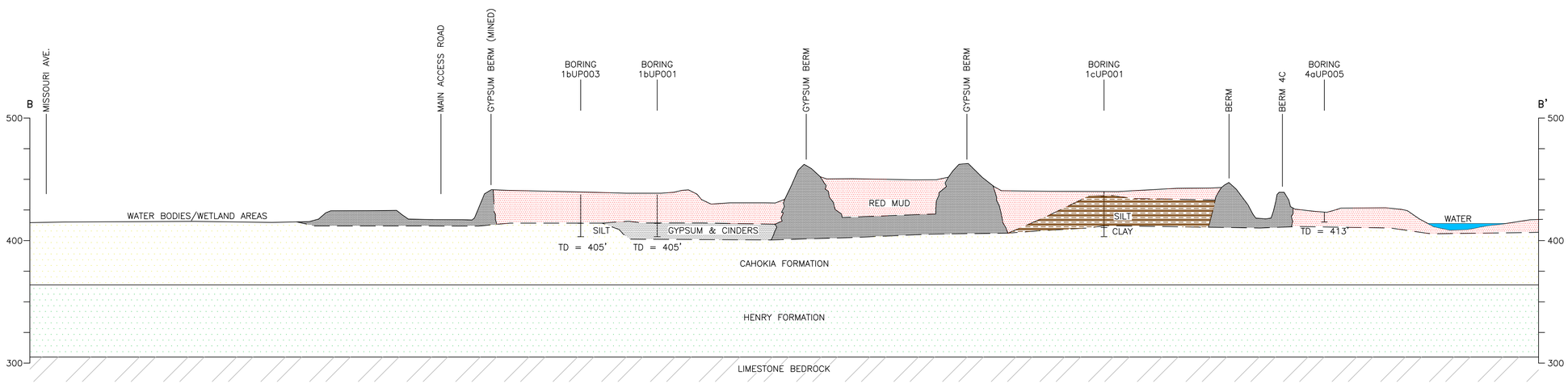

LEGEND:

TOP EL. – TOP GROUND SURFACE ELEVATION

INTERVAL IS IN RED MUD

TD – TOTAL DEPTH IN FT-MSL

NOTES:

1. PRE FILLING GROUND SURFACE ELEVATION OF 410–416 FT-MSL BASED ON GOVERNMENT TOPOGRAPHICAL MAPPING (CIRCA 1900).

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-3

GEOLOGIC CROSS SECTIONS
A–A' & B–B'

PROJECT: 021309	DATE: NOV 18, 2011	
REV: 0	BY: SMM	CHECKED: JCM

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Plot time: 02:19 pm
Plot date: 10-20-2004
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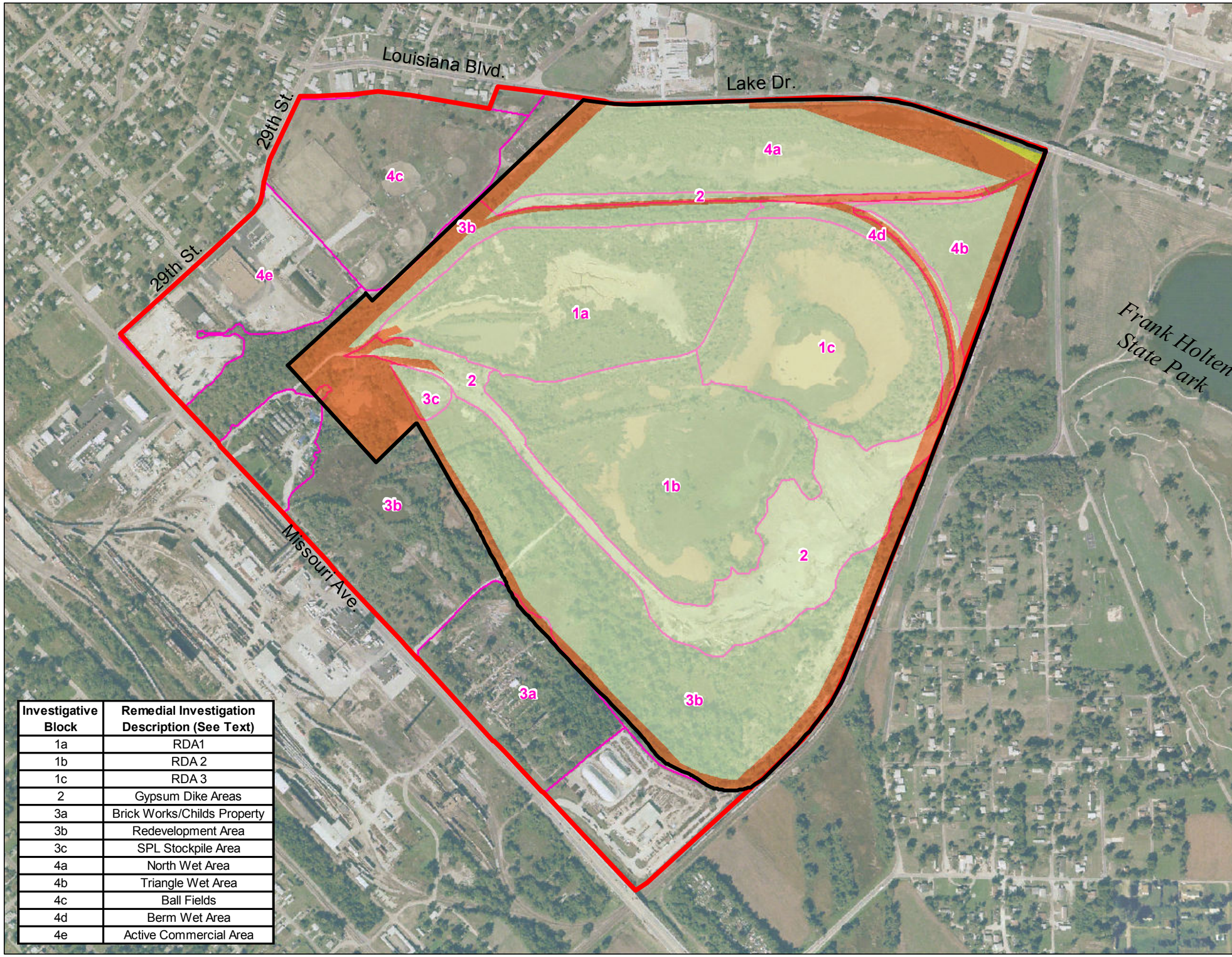

Investigative Block	Remedial Investigation Description (See Text)
1a	RDA1
1b	RDA 2
1c	RDA 3
2	Gypsum Dike Areas
3a	Brick Works/Childs Property
3b	Redevelopment Area
3c	SPL Stockpile Area
4a	North Wet Area
4b	Triangle Wet Area
4c	Ball Fields
4d	Berm Wet Area
4e	Active Commercial Area

EXPLANATION

Proposed Operable Unit No. 1 Boundary

Site Boundary

Property Ownership (2003)

?

Alton & Southern RR

City of East St. Louis

Note:

1. Boundaries of Investigative Blocks were originally set forth in the Remedial Investigation Work Plan (2003). Several properties outside the proposed limits of Operable Unit No. 1 have changed ownership since that time.

N

0 600 1,200

Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-4

PROPERTY OWNERSHIP WITHIN OPERABLE UNIT NO. 1

PROJECT: 114-021309	DATE: NOVEMBER 18, 2011	
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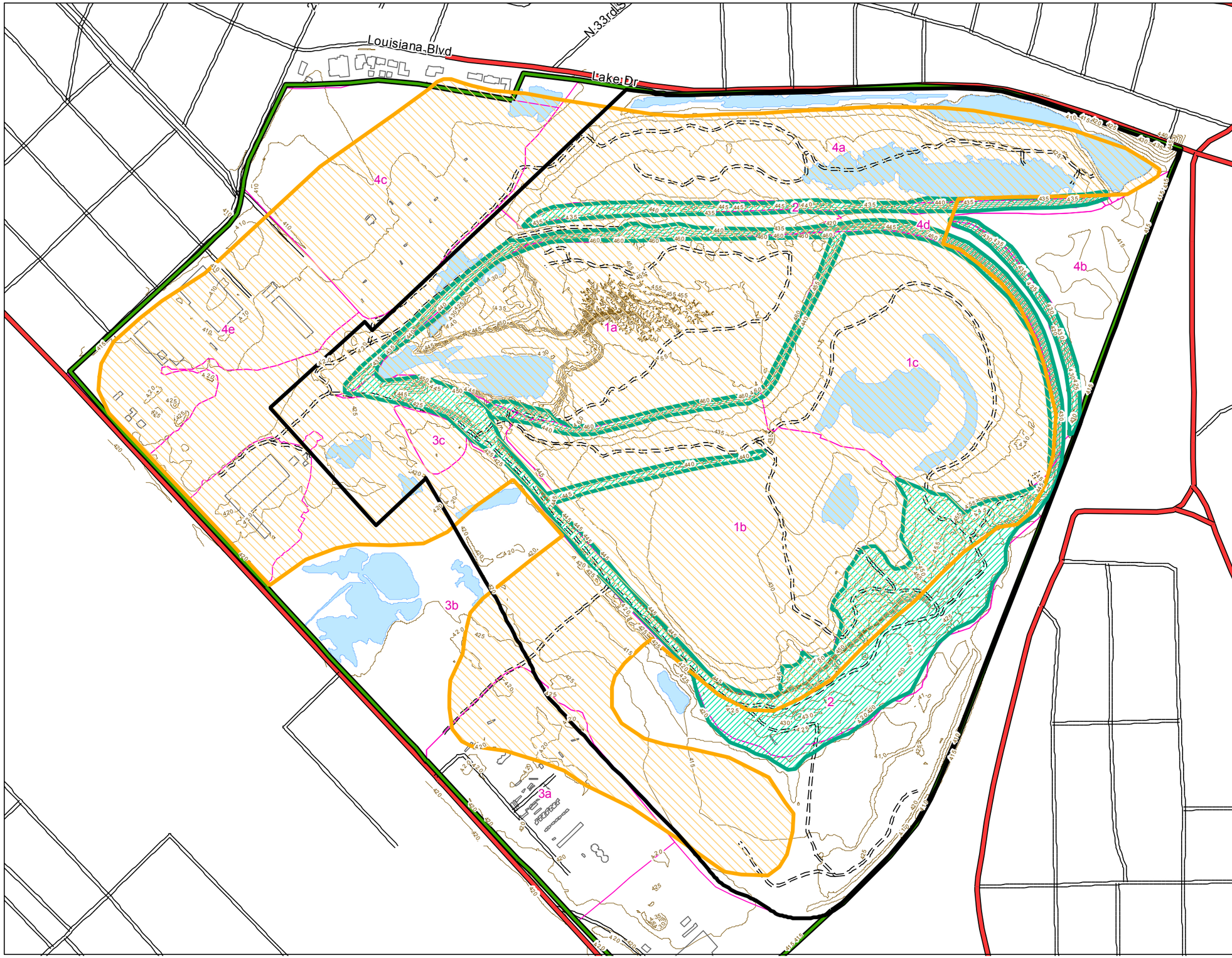

EXPLANATION

- Proposed Operable Unit No. 1 Boundary
- Approximate Limit of Bauxite Residue
- Approximate Limit of Gypsum
- Site Boundary
- Investigative Block
- Primary Street
- Secondary Street
- Roads on Site (from GPS)
- Open Water (at time of photo)
- Building Outline
- Topographic Contour (5 ft)

Note:

1. Boundary of Investigative Blocks were originally set forth in the Remedial Investigation Work Plan (2003). Several properties outside the proposed limits of Operable Unit No. 1 have changed ownership since that time.

N

0 500 1,000

Feet

NORTH ALCOA SITE

EAST ST. LOUIS, IL

FIGURE 2-5

KNOWN EXTENT OF BAUXITE RESIDUE & GYPSUM

PROJECT: 114-021309	DATE: NOVEMBER 18, 2011	
REV: 1	BY: SMM	CHECKED: JCM

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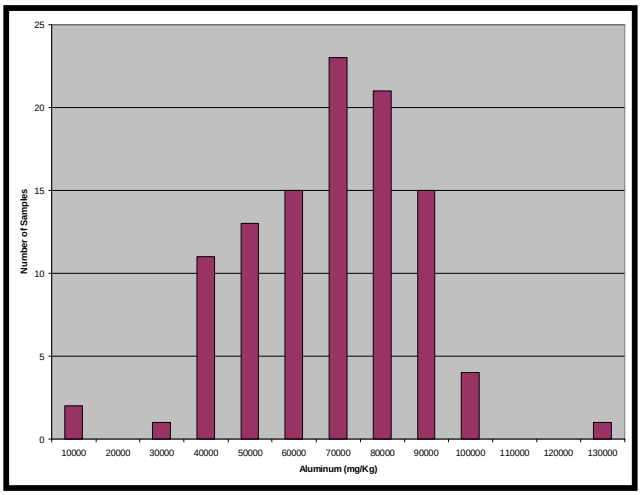
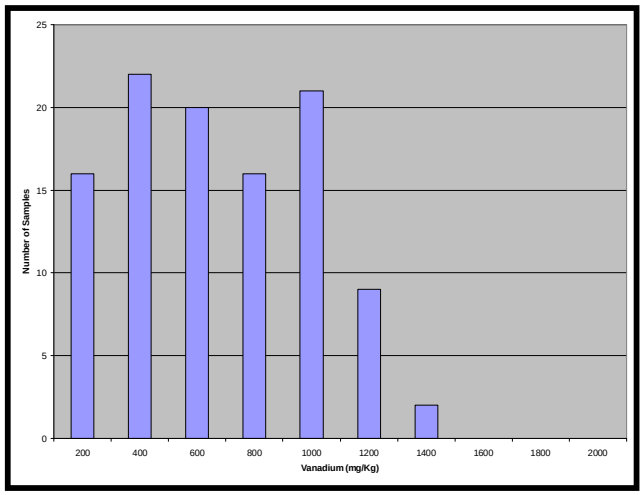
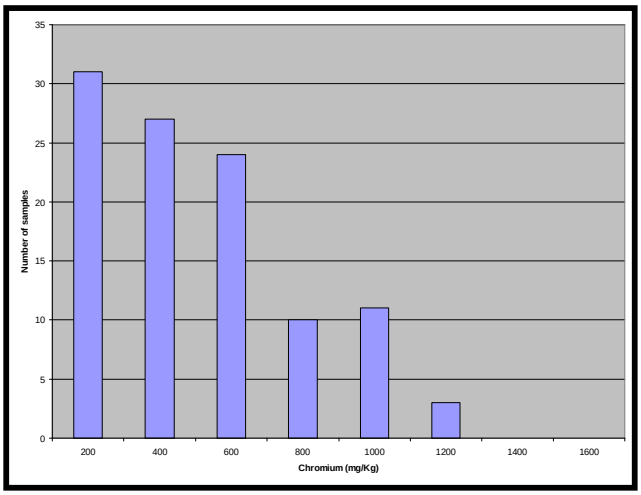
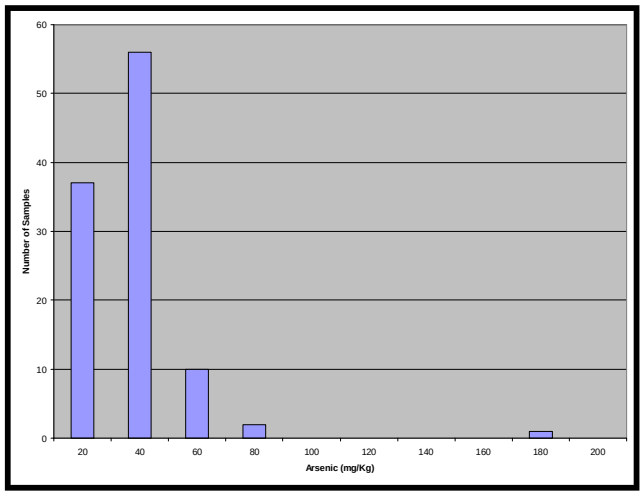
Path: E:\ESL\021309\FS Figures Draft\Figure 2-5 Known Extent of Bauxite.mxd









NOTE:

1. Basic data presented in Section 4.0 of the RI Report.

NORTH ALCOA SITE

EAST ST. LOUIS, ILLINOIS

Figure 2-6

HISTOGRAMS OF SELECTED COPCs IN BAUXITE RESIDUE

PROJECT: 021309	BY: SMM	REVISIONS
DATE: NOV 2011	CHECKED: JCM	1

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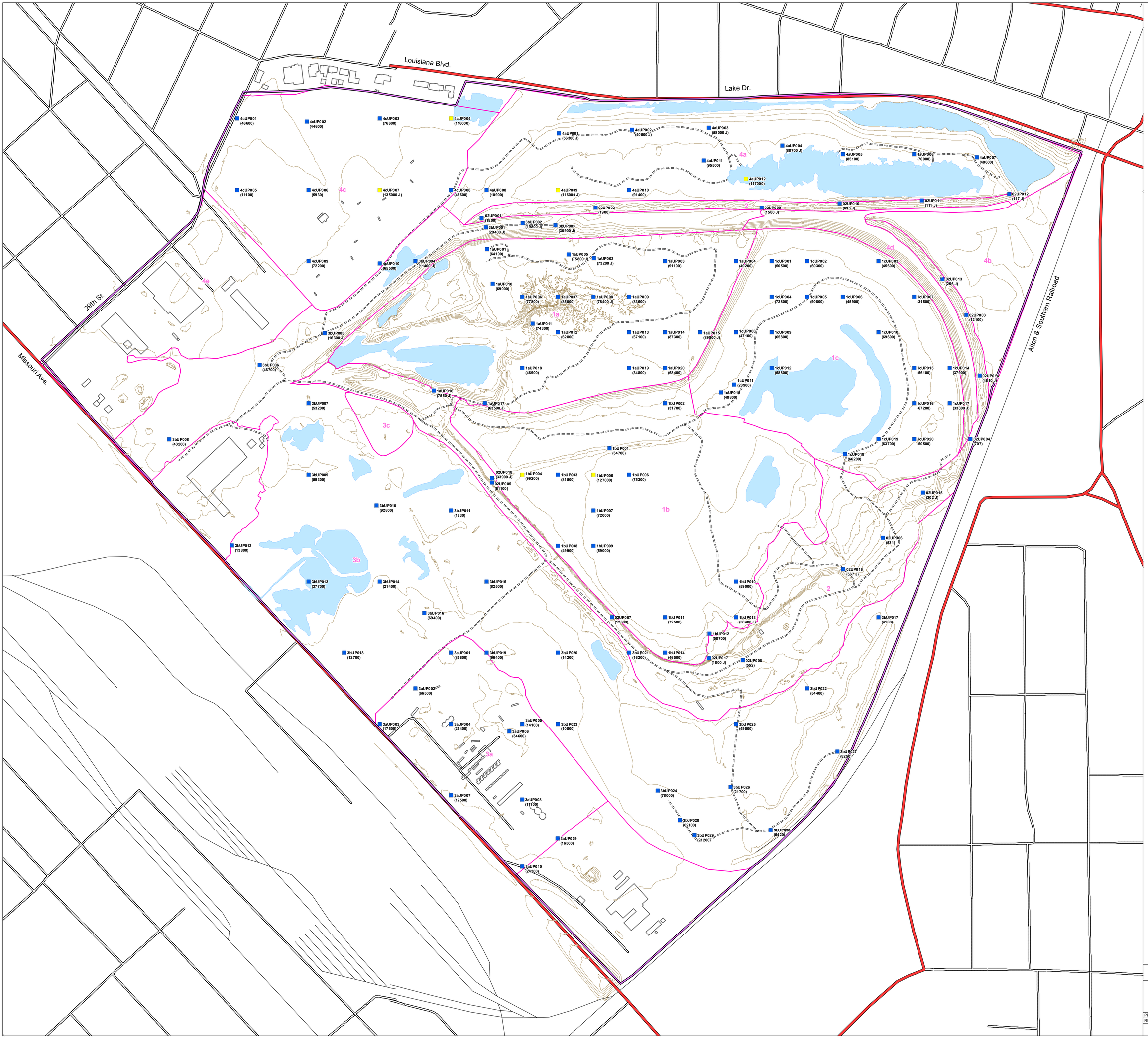

Legend

- Sample Locations Below RSL
- Sample Locations Exceeding RSL
- Site Boundary
- Investigative Block
- Open Water
- Building outline

Transportation

- Primary Street
- Secondary Street
- Roads on Site (from MFG GPS)
- Railroad

Surface Topography

- Index Contour (5 ft)

NOTE:
- RSL = Regional Screening Limit
- (1800) - Soil sample result in mg/kg
- RSL limit for aluminum = 99,000 mg/kg
- J - Indicates estimated value
- U - Indicates non-detect

N

0 200 400
Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-7

ALUMINUM
RESULTS OF SITEWIDE
SURFACE SOIL SAMPLES

PROJECT: 021309	DATE: NOVEMBER 18, 2011	
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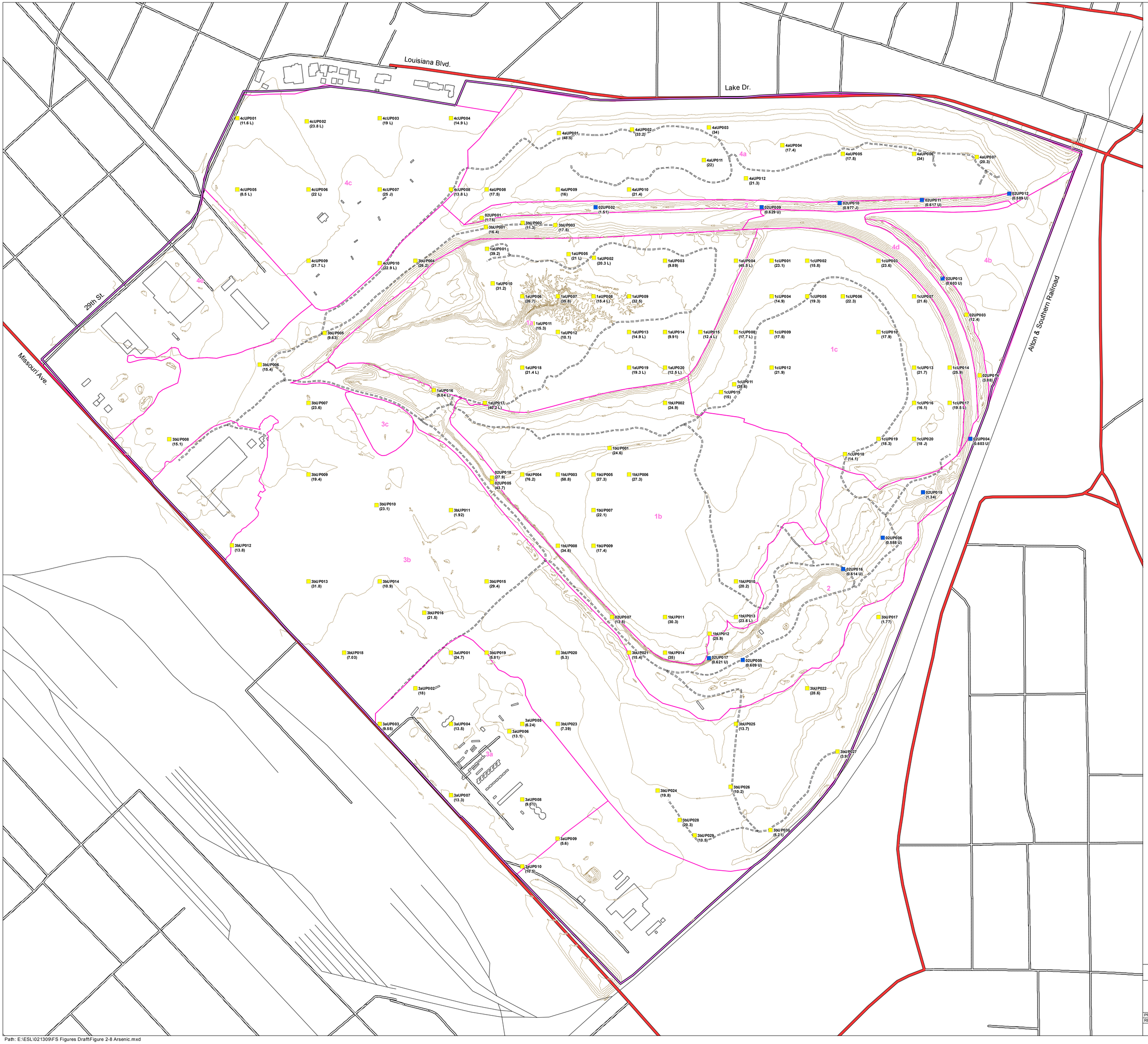
Path: E:\ESL\021309\FS Figures Draft\Figure 2-7-Aluminum.mxd



NORTH ALCOA SITE

EAST ST. LOUIS, ILLINOIS

FIGURE 2-8

ARSENIC
RESULTS OF SITEWIDE
SURFACE SOIL SAMPLES

PROJECT: 021309	DATE: NOVEMBER 18, 2011
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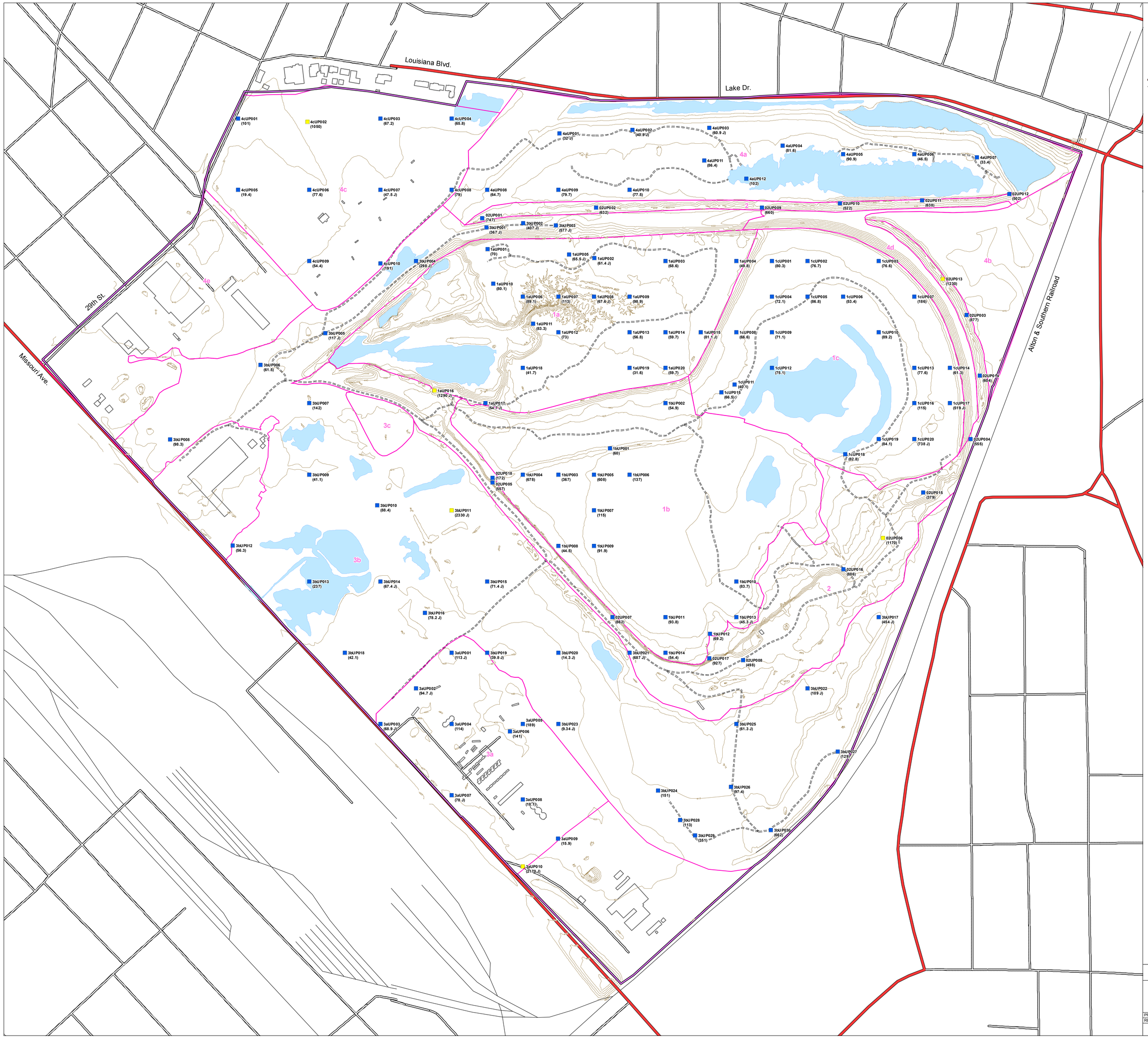
Path: E:\ESL\021309\FS Figures Draft\Figure 2-8 Arsenic.mxd



NORTH ALCOA SITE

EAST ST. LOUIS, ILLINOIS

FIGURE 2-9

LEAD
RESULTS OF SITEWIDE SURFACE SOIL SAMPLES

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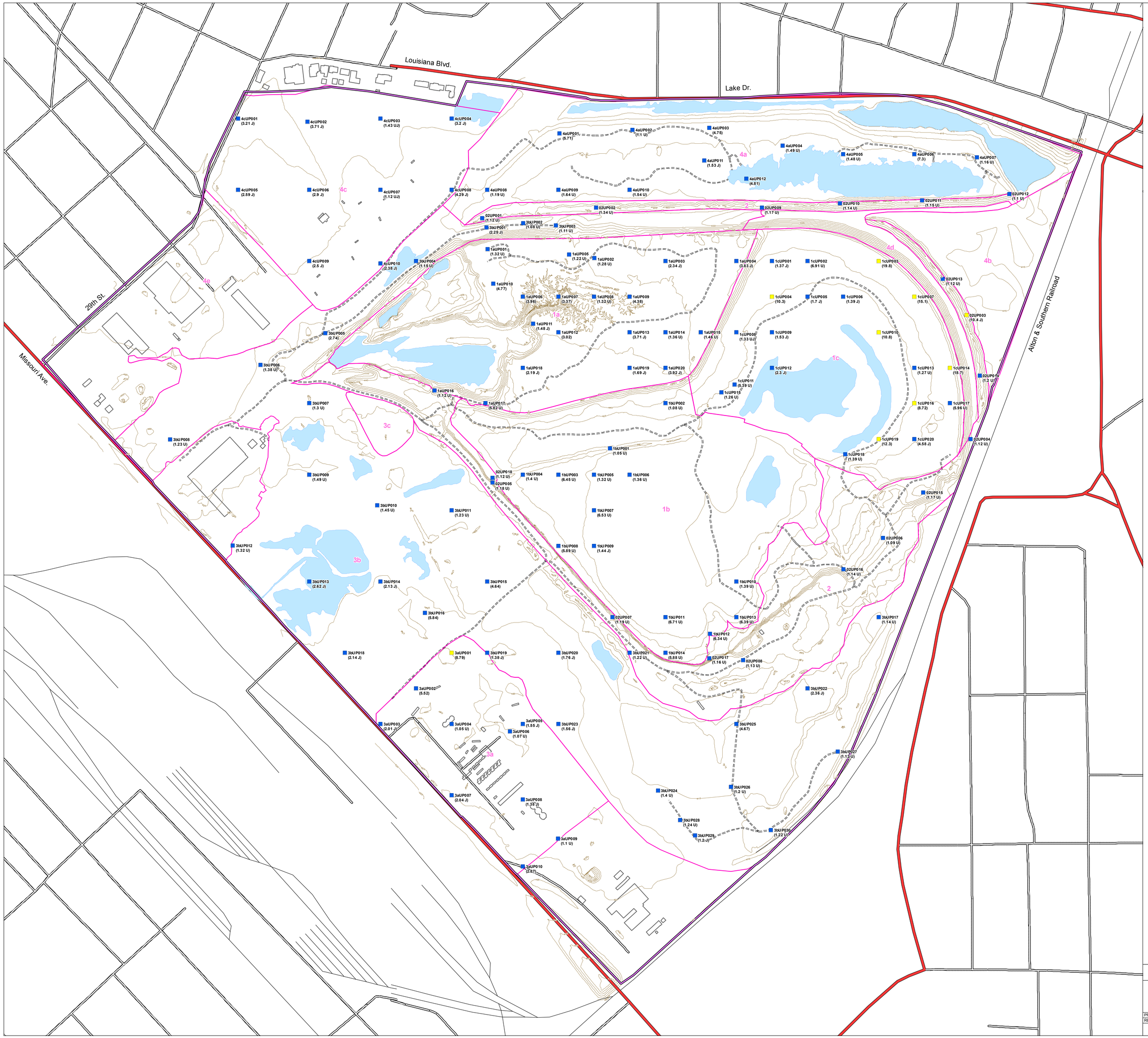
Path: E:\ESL\021309\FS Figures Draft\Figure 2-9 Lead.mxd



Legend

- Sample Locations Below RSL
- Sample Locations Exceeding RSL
- Site Boundary
- Investigative Block
- Open Water
- Building outline

Transportation

- Primary Street
- Secondary Street
- Roads on Site (from MFG GPS)
- Railroad

Surface Topography

- Index Contour (5 ft)

NOTE:
- RSL = Regional Screening Limit
- (8.4) - Soil sample result in mg/kg
- RSL limit for thallium = 8.2 mg/kg
- J - Indicates estimated value
- U - Indicates non-detect

N

0 200 400
Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-10

THALLIUM RESULTS OF SITEWIDE SURFACE SOIL SAMPLES

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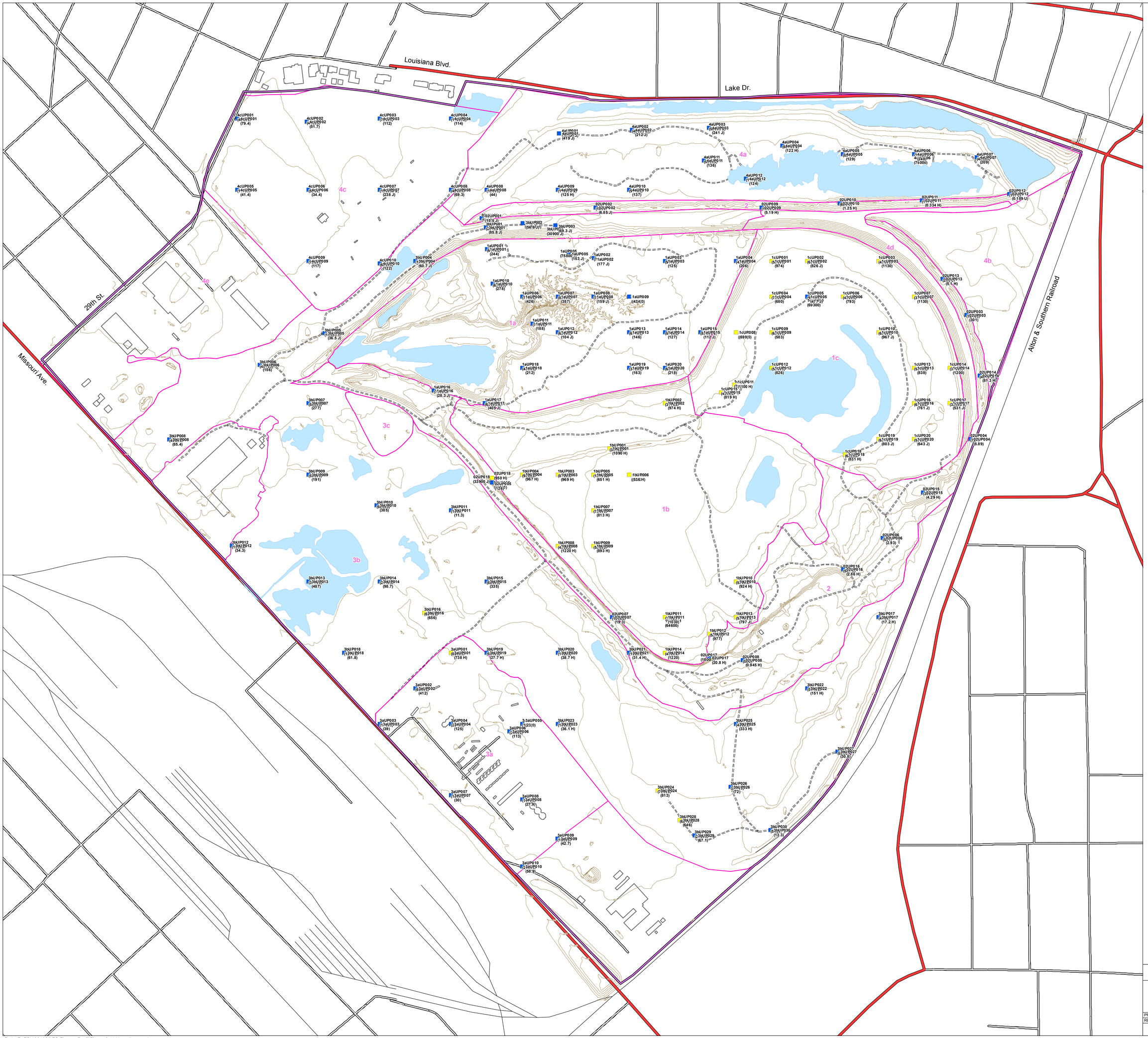
Path: E:\ESL\021309\FS Figures Draft\Figure 2-10 Thallium.mxd



Legend

- Sample Locations Below RSL
- Sample Locations Exceeding RSL
- Site Boundary
- Investigative Block
- Open Water
- Building outline

Transportation

- Primary Street
- Secondary Street
- Roads on Site (from MFG GPS)
- Railroad

Surface Topography

- Index Contour (5 ft)

NOTE:
- RSL = Regional Screening Limit
- (106) - Soil sample result in mg/kg
- RSL limit for vanadium = 520 mg/kg
- J - Indicates estimated value
- U - Indicates non-detect

N

0 200 400
Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-11

VANADIUM RESULTS OF SITEWIDE SURFACE SOIL SAMPLES

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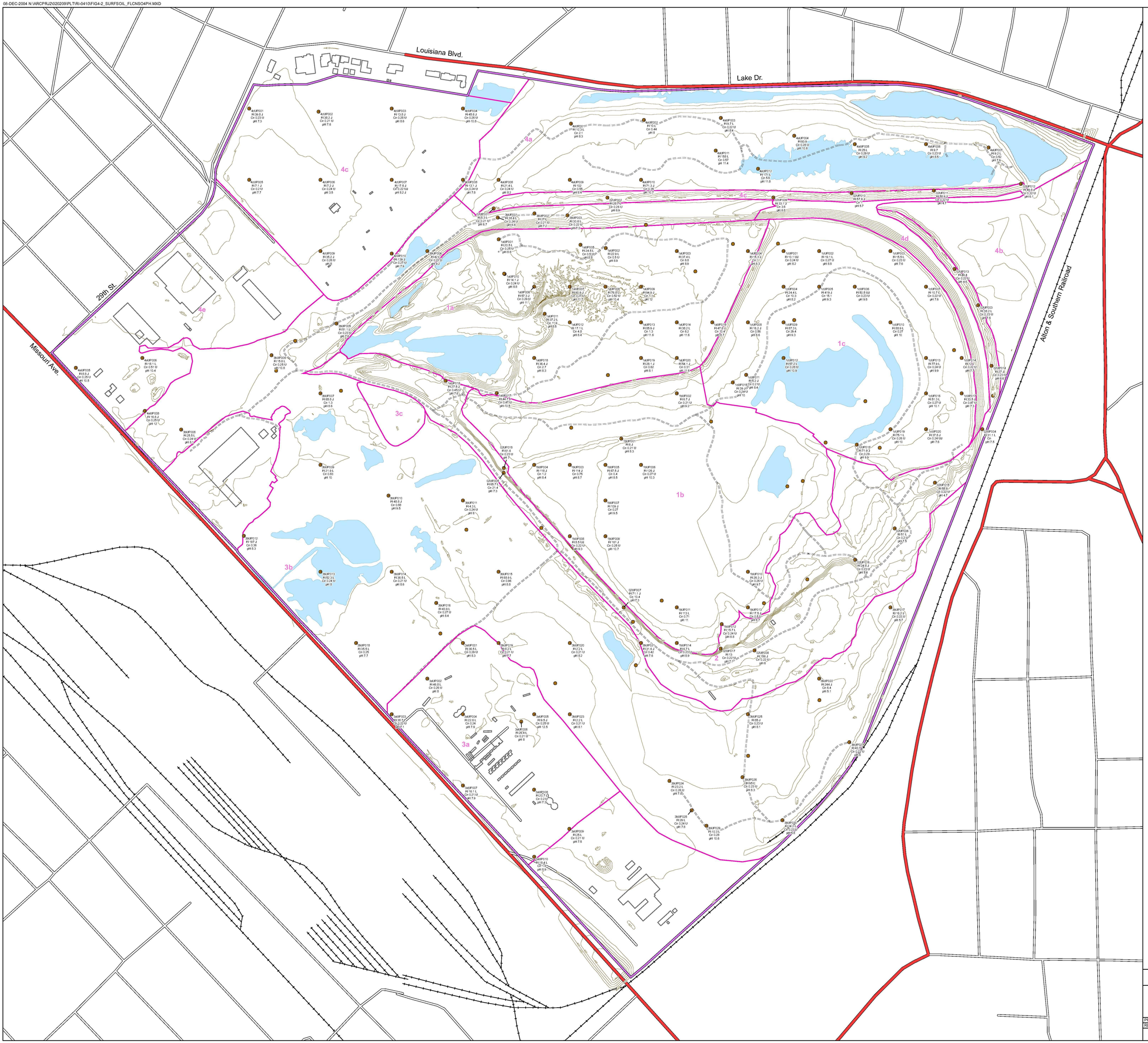
Path: E:\ESL\021309\FS Figures Draft\Figure 2-11 Vanadium.mxd

08-DEC-2004 N:\ARCPRJ\2020209\PLT\RI-0410\FIG4-2_SURFSOIL_FLCNSO4PH.MXD



Legend

Transportation

- Primary Street
- Secondary Street
- Roads on Site (from MFG GPS)
- Railroad
- Open Water
- Initial Site Boundary
- Investigative Blocks
- Building outline

Surface Topography

- Index Contour (5 ft)
- Surface Soil Sample Results in mg/kg

N

0 200 400
Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-12
FLUORIDE, CYANIDE AND pH RESULTS OF SITEWIDE SURFACE SOIL SAMPLES

PROJECT: 021309	DATE: NOV 18, 2011	
REV: 01	BY: SMM	CHECKED: JCM

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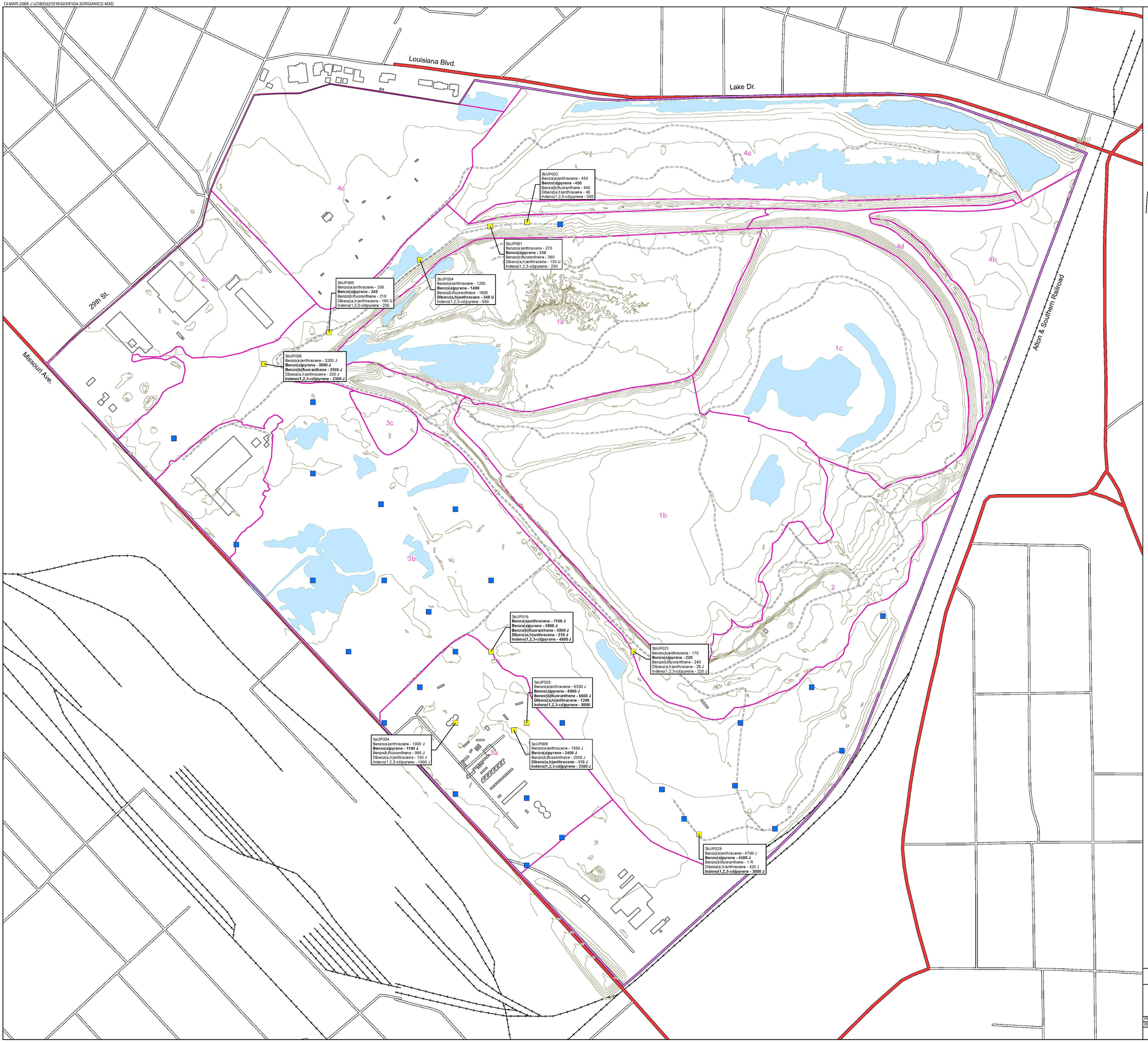
13-MAR-2009 J:\JOBS\021018\GIS\FIG4-3ORGANICS.MXD



Legend

- Sample Locations Below RSL
- Sample Location Exceeding RSL
- Site Boundary
- Investigative Block
- Open Water
- Building outline

Transportation

- Primary Street
- Secondary Street
- Roads on Site (from TT GPS)
- Railroad

Surface Topography

- Index Contour (5 ft)

NOTE:
- All results are in ug/kg.
- RSL = Regional Screening Limit

Sample ID

3aUP004
Benzo(a)anthracene - 1000 J
Benzo(a)pyrene - 1100 J
Benzo(b)fluoranthene - 990 J
Dibenz(a,h)anthracene - 130 J
Indeno(1,2,3-cd)pyrene - 1000 J

Result Exceeding RSL (Bold)

Result Below RSL

Regional Screening Limits Table

Analyte	RSL (ug/kg)
Benzo(a)anthracene	7100
Benzo(a)pyrene	210
Benzo(b)fluoranthene	2100
Dibenz(a,h)anthracene	210
Indeno(1,2,3-cd)pyrene	2100

N

0 200 400
Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-13
ORGANICS
RESULTS OF SITEWIDE SURFACE SOIL SAMPLES

PROJECT: 021309	DATE: NOV 18, 2011	
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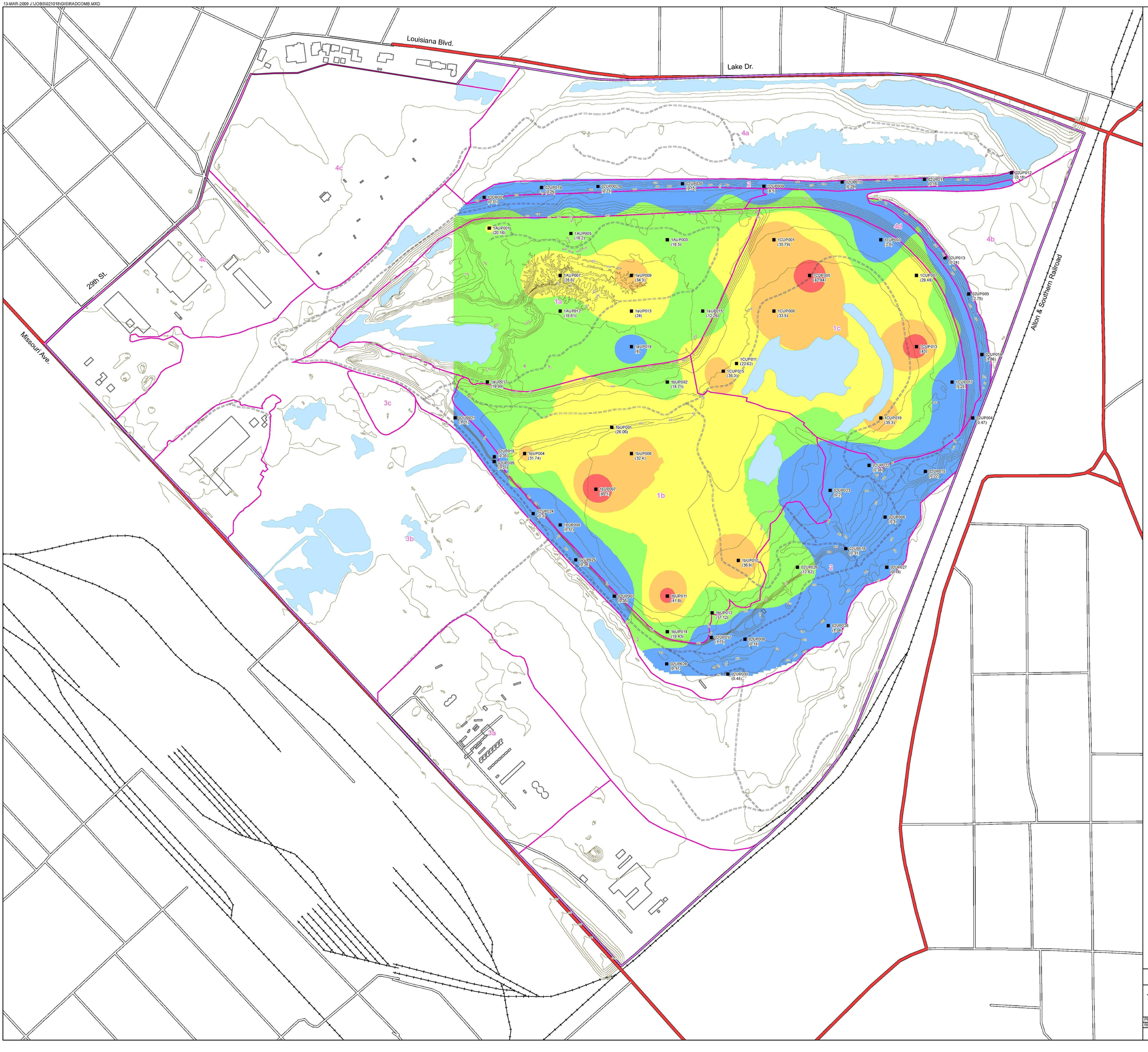

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-14
TOTAL RADIUM (RA-226 & RA-228) RESULTS IN SURFACE SOIL SAMPLES

PROJECT: 021309	DATE:NOV 18, 2011	
REV: 01	BY:SMM	CHECKED:JCM

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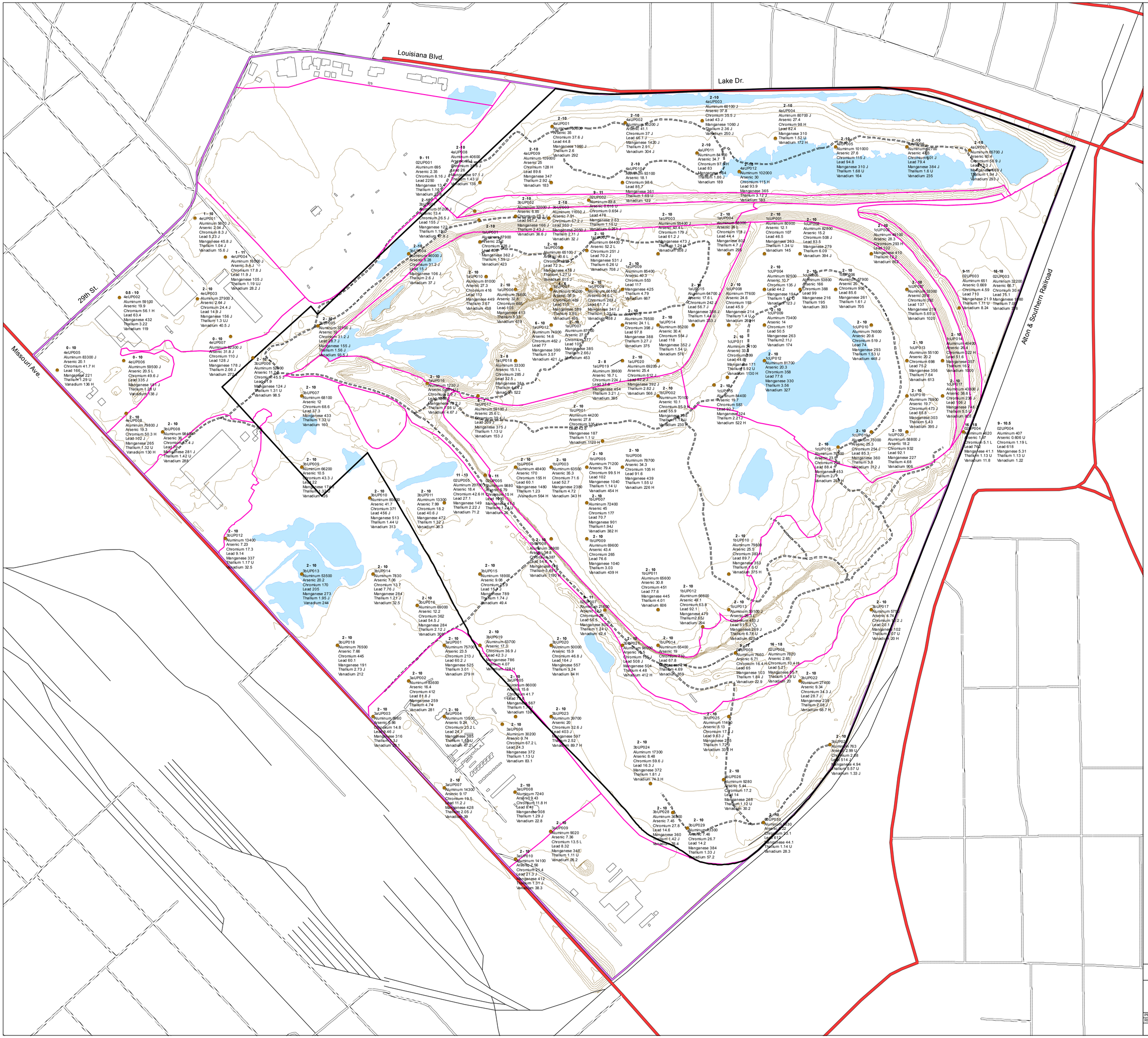
Path: Y:\ESL\021363\mxd\FIG 2-15 SUBSURF METALS.mxd



NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-15

LOCATION AND METALS RESULTS OF SITEWIDE SUBSURFACE SOIL SAMPLES

PROJECT: 021363	DATE: FEB 10, 2012	
REV: 0	BY: SMM	CHECKED: JCM

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Path: Y:\ESL\021363\mxd\FIG 2-16 SUBSURF FlCnSO4pH.mxd

Legend

Transportation

- Primary Street
- Secondary Street
- Roads on Site (from MFG GPS)
- Railroad
- Open Water
- Site Boundary
- Investigative Block
- Building outline

Surface Topography

- Index Contour (5 ft)
- Sub-Surface Sample Results in mg/kg or pH

N

0 200 400
Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-16

FLUORIDE, CYANIDE AND pH RESULTS OF SITEWIDE SUBSURFACE SOIL SAMPLES

PROJECT: 021363	DATE: FEBRUARY 10, 2012	
REV: 0	BY: SMM	CHECKED: JCM

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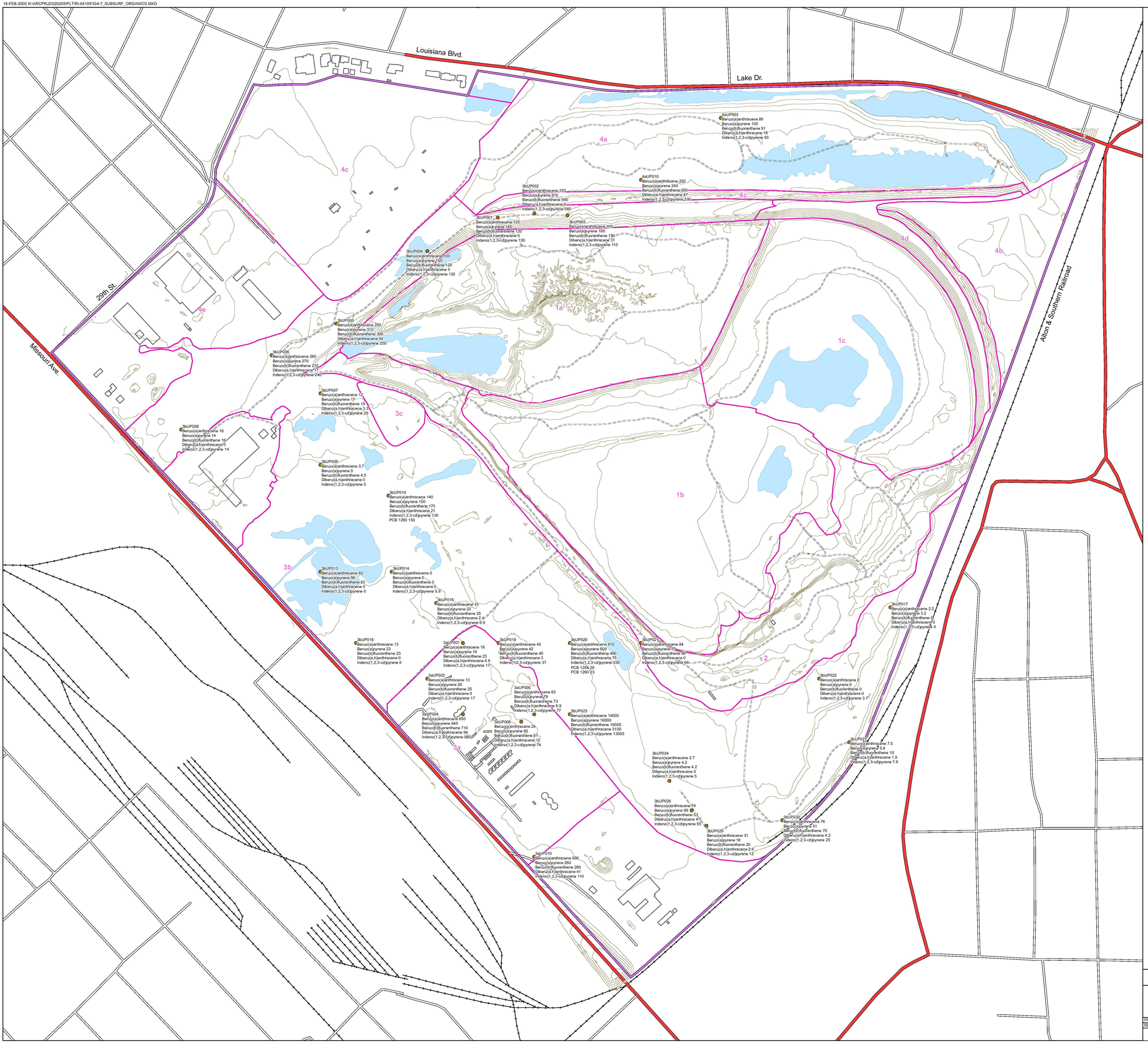
18-FEB-2005 N:\ARCPRJ2\020209\PLT\RI-0410\FIG4-7_SUBSURF_ORGANICS.MXD



NORTH ALCOA SITE

EAST ST. LOUIS, ILLINOIS

FIGURE 2-17

ORGANICS RESULTS OF SITEWIDE SUB SURFACE SOIL SAMPLES

PROJECT: 021309	DATE: NOV 18, 2011	
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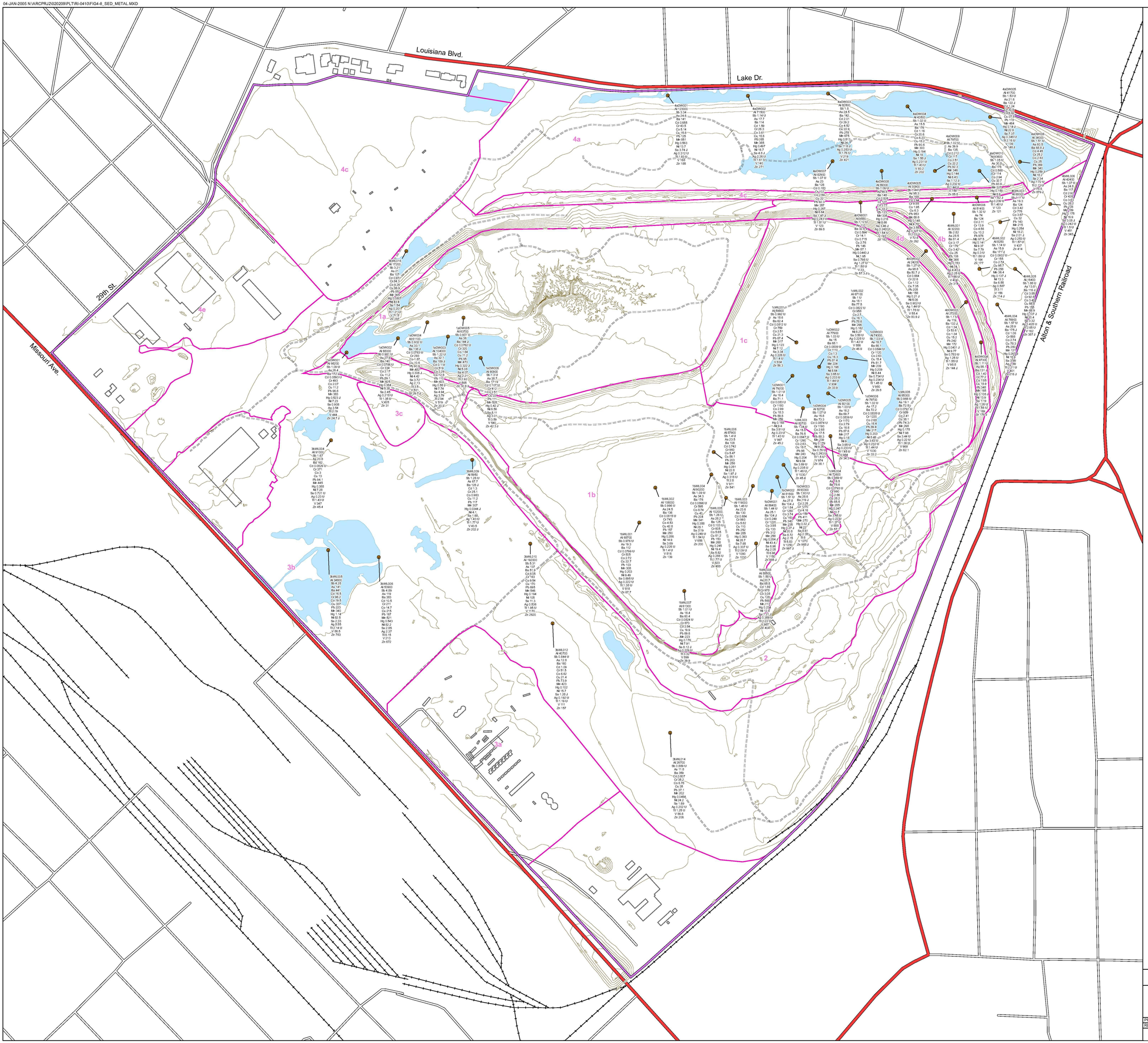
04-JAN-2005 N:\ARCPRJ\020209\PLTIRI-0410\FIG4-8_SED_METAL.MXD



Legend

Transportation

- Primary Street
- Secondary Street
- Roads on Site (from MFG GPS)
- Railroad
- Open Water
- Initial Site Boundary
- Investigative Block
- Building outline

Surface Topography

- Index Contour (5 ft)
- Sediment Sample
  Results in mg/kg

N

0 200 400
Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-18
METALS
RESULTS OF SITEWIDE
SEDIMENT SAMPLES

PROJECT: 021309	DATE: NOV 18, 2011
REV: 01	BY: SMM CHECKED: JCM

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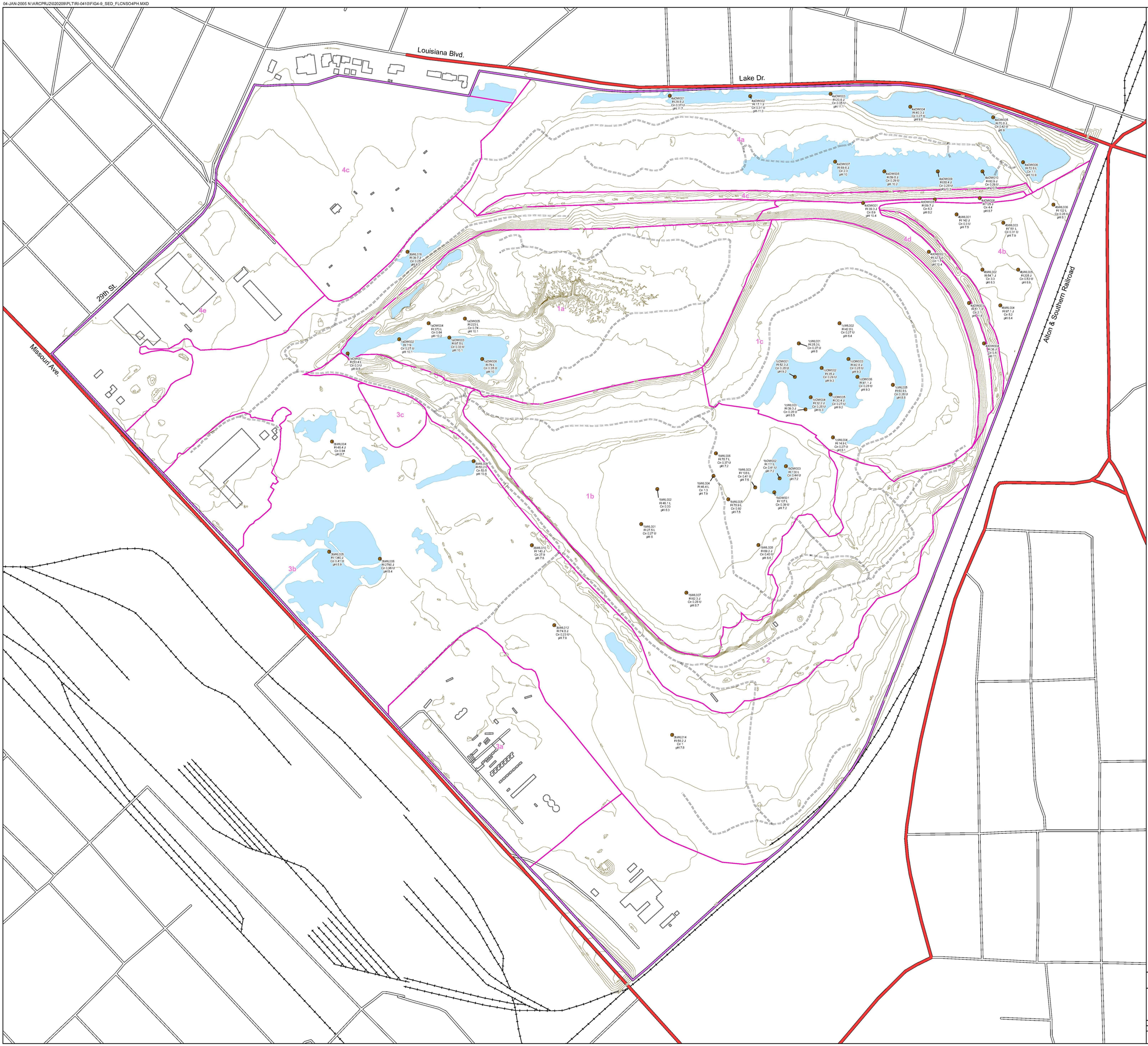
04-JAN-2005 N:\ARCPRJ\020209\PLTIRI-0410\FIG4-9_SED_FLCNSO4PH.MXD



Legend

Transportation

- Primary Street
- Secondary Street
- Roads on Site (from MFG GPS)
- Railroad
- Open Water
- Initial Site Boundary
- Investigative Block
- Building outline

Surface Topography

- Index Contour (5 ft)
- Sediment Sample Location Results in mg/kg or pH

N

0 200 400
Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-19
FLUORIDE, CYANIDE AND pH RESULTS OF SITEWIDE SEDIMENT SAMPLES

PROJECT: 021309	DATE: NOV 18, 2011	
REV: 01	BY: SMM	CHECKED: JCM

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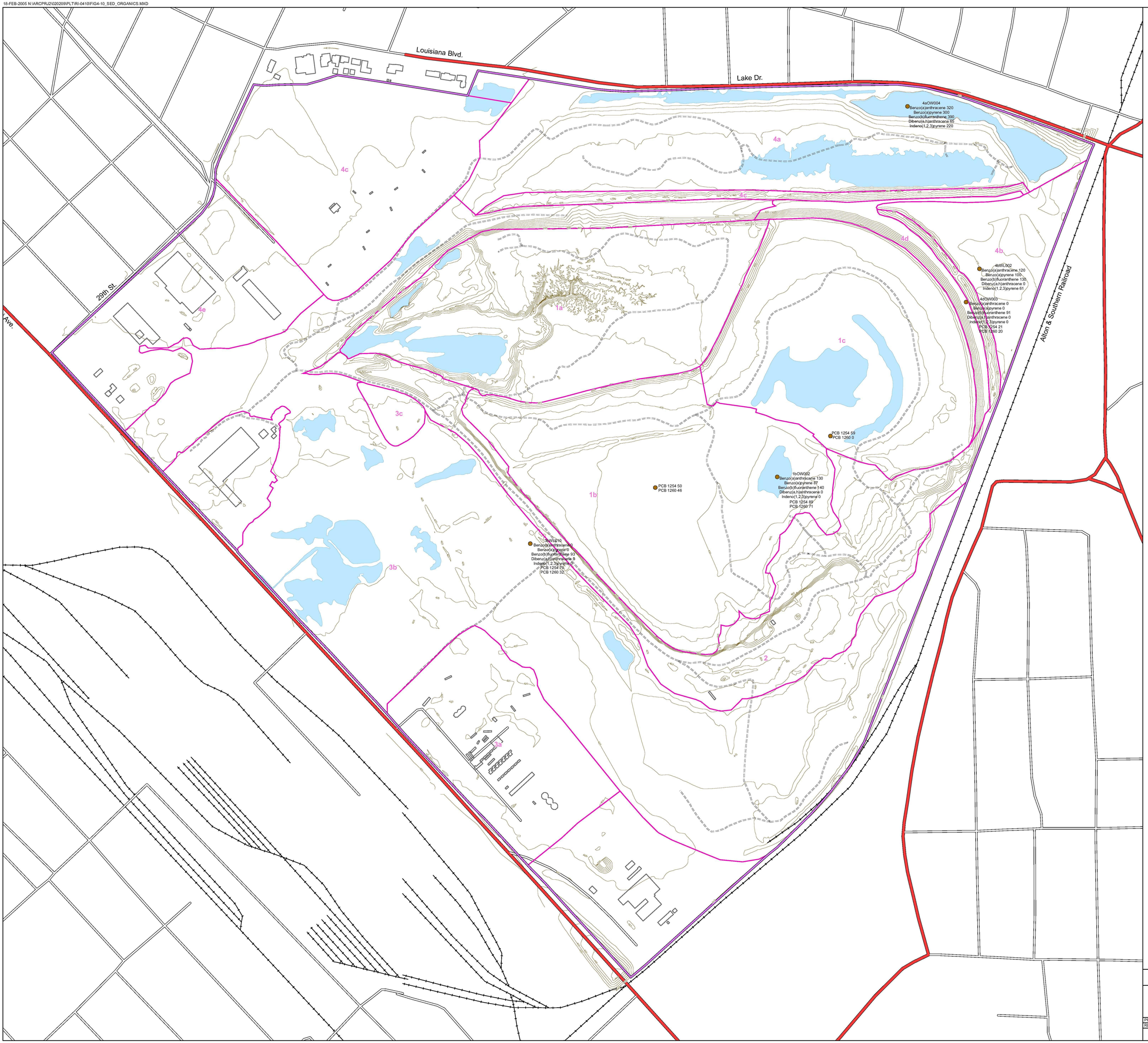
18-FEB-2005 N:\ARCPRJ2\020209\PLT\RI-0410\FIG4-10_SED_ORGANICS.MXD



Legend

Transportation

- Primary Street
- Secondary Street
- Roads on Site (from MFG GPS)
- Railroad
- Open Water
- Initial Site Boundary
- Investigative Block
- Building outline

Surface Topography

- Index Contour (5 ft)
- Sediment Sample Results in mg/kg

N

0 200 400
Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-20
ORGANICS RESULTS OF SITEWIDE SEDIMENT SAMPLES

PROJECT: 021309	DATE: NOV 18, 2011	
REV: 01	BY: SMM	CHECKED: JCM

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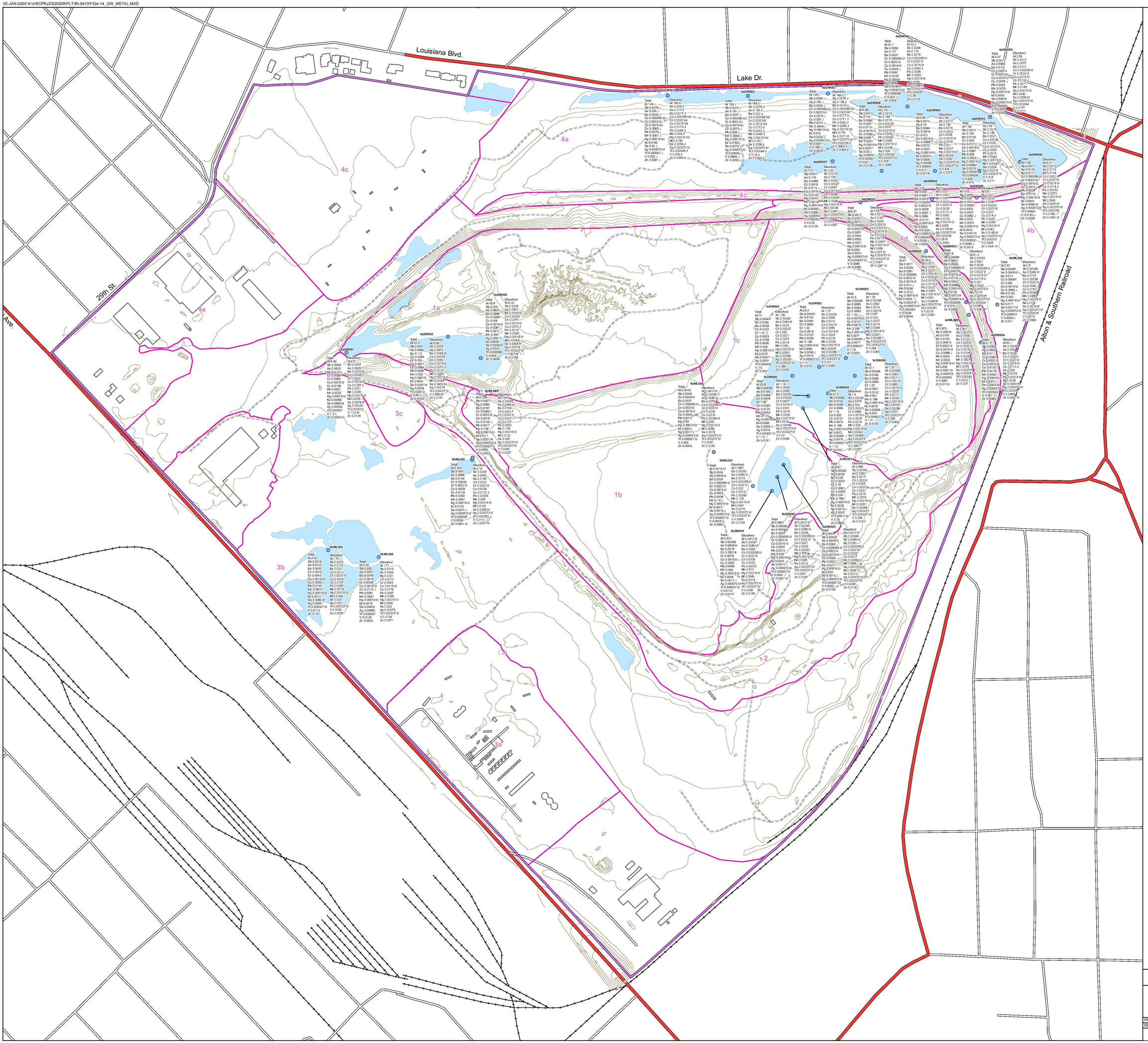
05-JAN-2005 N:\ARCPRJ2\020209\PLTR\I-0410\FIG4-14_GW_METAL.MXD



NORTH ALCOA SITE

EAST ST. LOUIS, ILLINOIS

FIGURE 2-21

TOTAL AND DISSOLVED METAL RESULTS OF SITEWIDE SURFACE WATER SAMPLES

PROJECT: 021309	DATE: NOV 18, 2011	
REV: 01	BY: SMM	CHECKED: JCM

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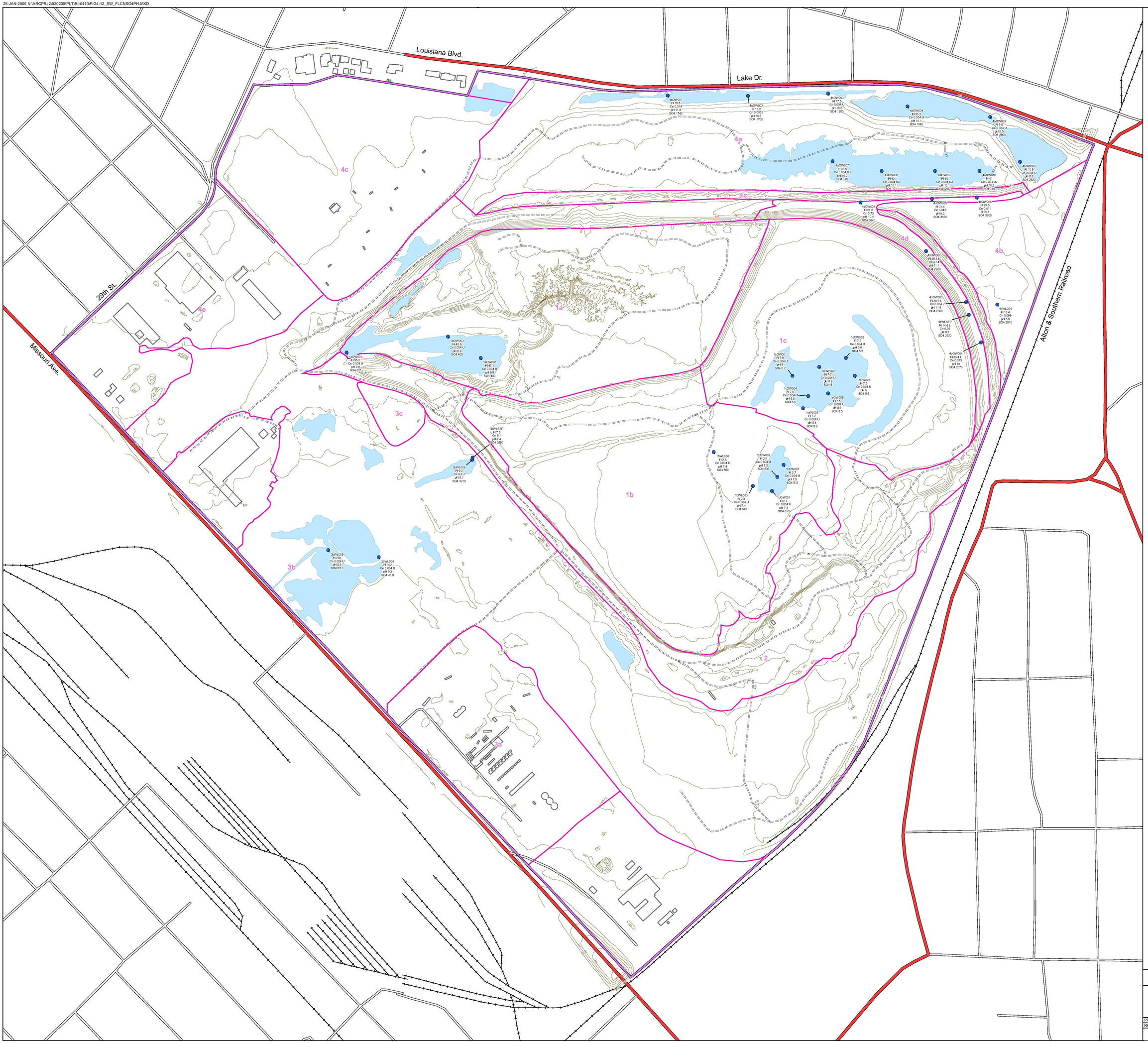
25-JAN-2005 N:\ARCPRJ\020209\PLTIRI-0410\FIG4-12_SW_FLCNSO4PH.MXD



Legend

Transportation

- Primary Street
- Secondary Street
- Surface Water Sample
- Roads on Site (from MFG GPS)
- Railroad
- Open Water
- Initial Site Boundary
- Investigative Block
- Building outline

Surface Topography

- Index Contour (5 ft)

N

0 200 400
Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-22
FLUORIDE, CYANIDE, pH and SULFATE RESULTS OF SITEWIDE SURFACE WATER SAMPLES

PROJECT: 021309	DATE: NOV 18, 2011	
REV: 01	BY: SMM	CHECKED: JCM

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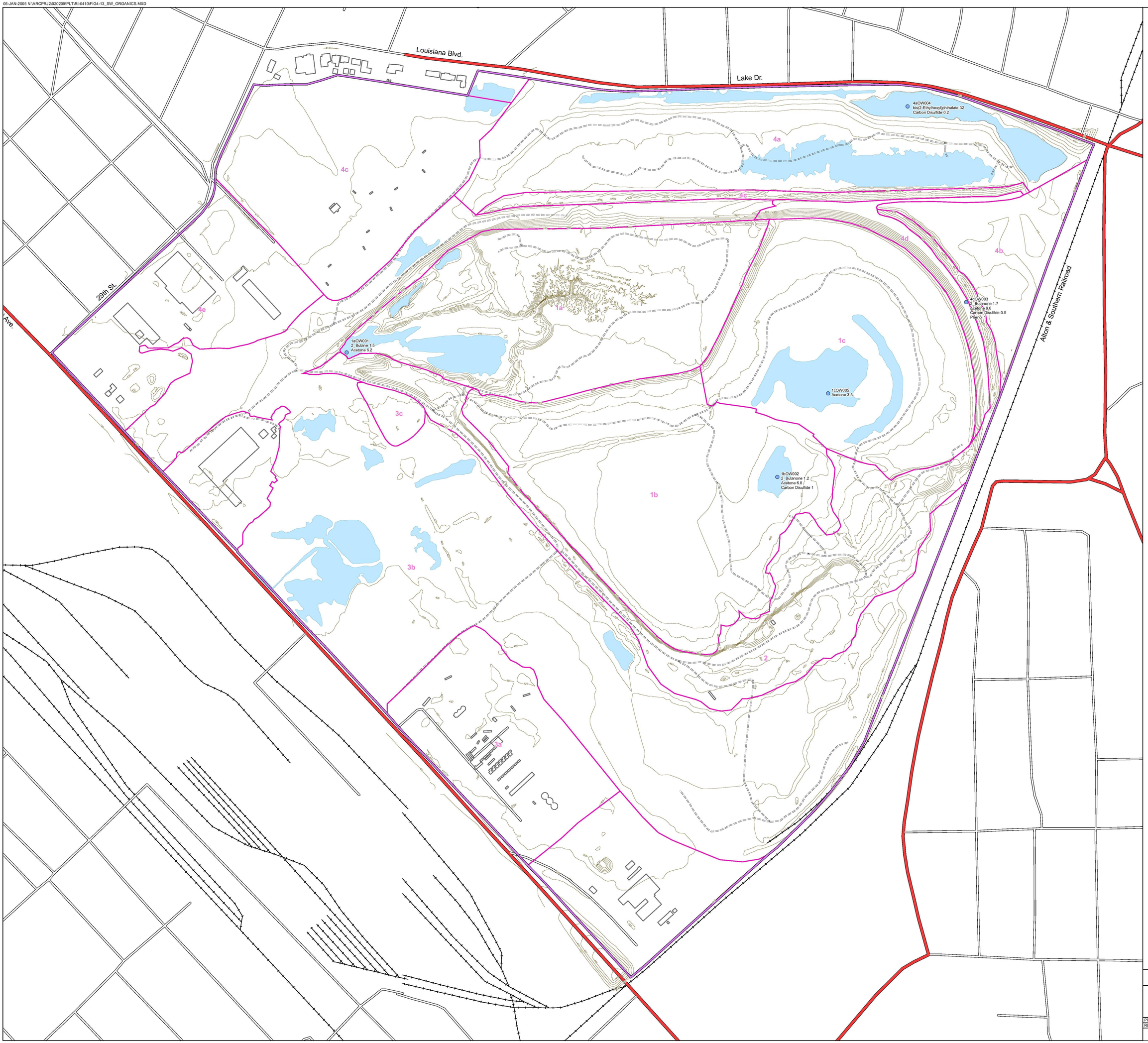
05-JAN-2005 N:\ARCPRJ2\020209\PLT\RI-0410\FIG4-13_SW_ORGANICS.MXD



Legend

Transportation

- Primary Street
- Secondary Street
- Roads on Site (from MFG GPS)
- Railroad
- Open Water
- Initial Site Boundary
- Investigative Block
- Building outline

Surface Topography

- Index Contour (5 ft)
- Surface Water Sample (Organics Only) Results in mg/kg

N

0 200 400
Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-23
ORGANICS RESULTS OF SITEWIDE SURFACE WATER SAMPLES

PROJECT: 021309	DATE: NOV 18, 2011	
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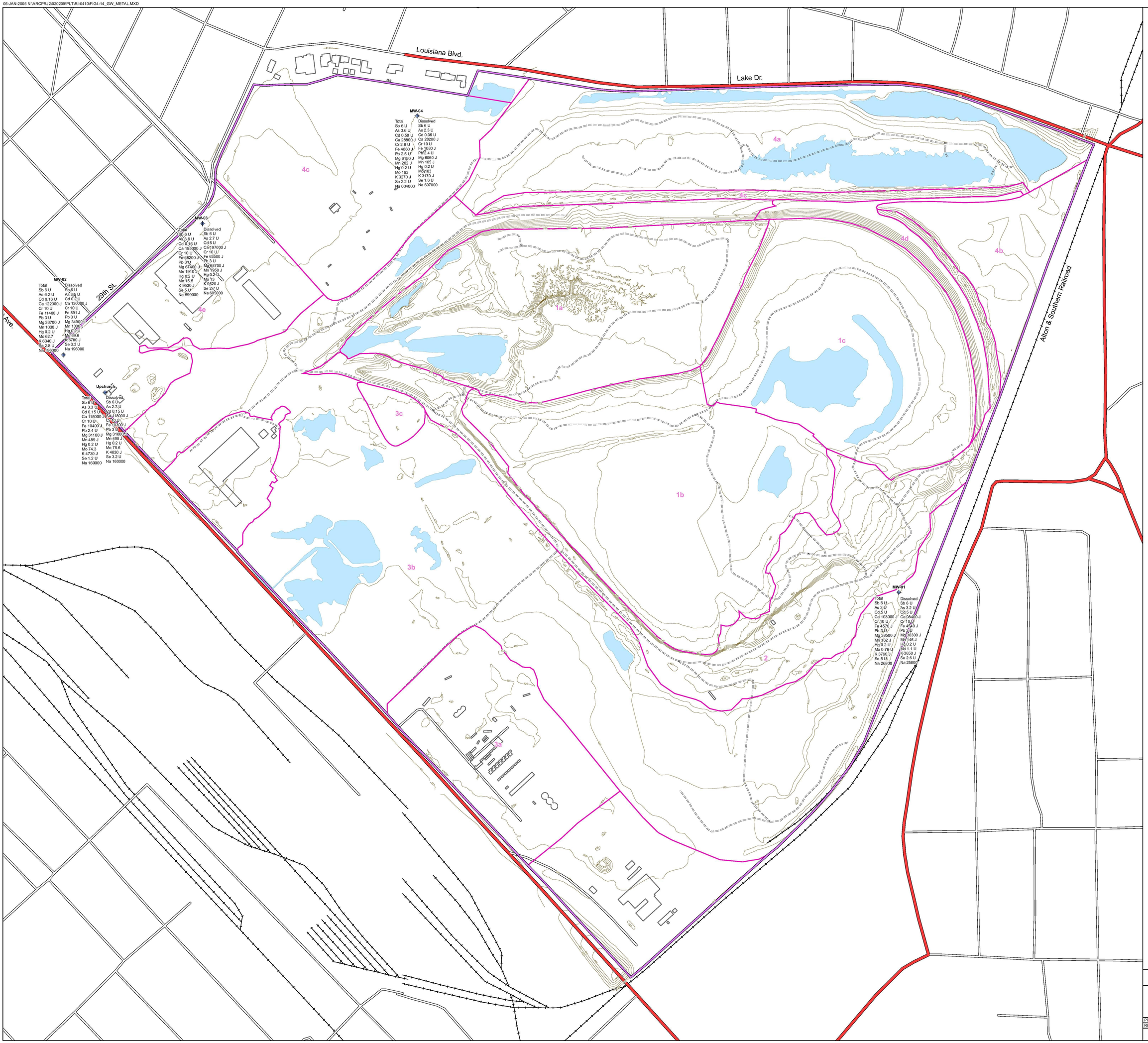
05-JAN-2005 N:\ARCPRJ2\020209\PLT\RI-0410\FIG4-14_GW_METAL.MXD



Legend

Transportation

- Primary Street
- Secondary Street
- Roads on Site (from MFG GPS)
- Railroad
- Open Water
- Initial Site Boundary
- Investigative Block
- Building outline
- Index Contour (5 ft)
- Monitoring Well Results in mg/kg

N

0 200 400
Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2-24
ANALYTICAL RESULTS OF SITEWIDE GROUNDWATER SAMPLES

PROJECT: 021309	DATE: NOV 18, 2011
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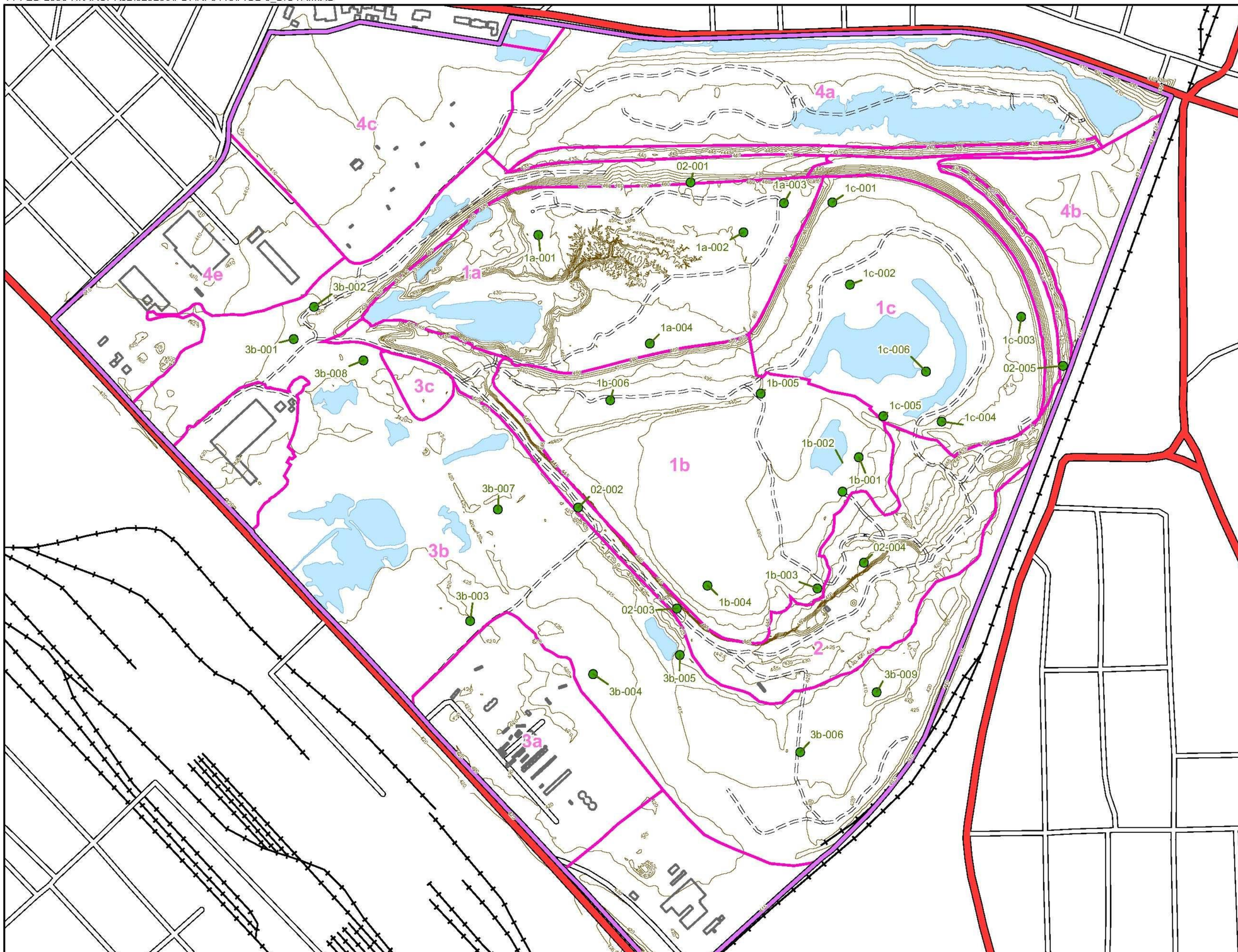
14-FEB-2005 N:\ARCPRJ2\020209\PLT\RI-0410\FIG2-8_BIOTA.MXD



Legend

- Initial Site Boundary
- Investigative Block
- Building outline

Transportation

- Primary Street
- Secondary Street
- Roads on Site (from MFG GPS)
- Railroad
- Open Water
- Index Contour (5 ft)
- Biota Sample Location

N

0 500 1,000

Feet

NORTH ALCOA SITE

EAST ST. LOUIS, ILLINOIS

FIGURE 2-25

LOCATIONS OF PHASE 2 ECOLOGICAL SAMPLES

PROJECT: 021309	DATE: NOV 18, 2011	
REV: 01	BY: SMM	CHECKED: JCM

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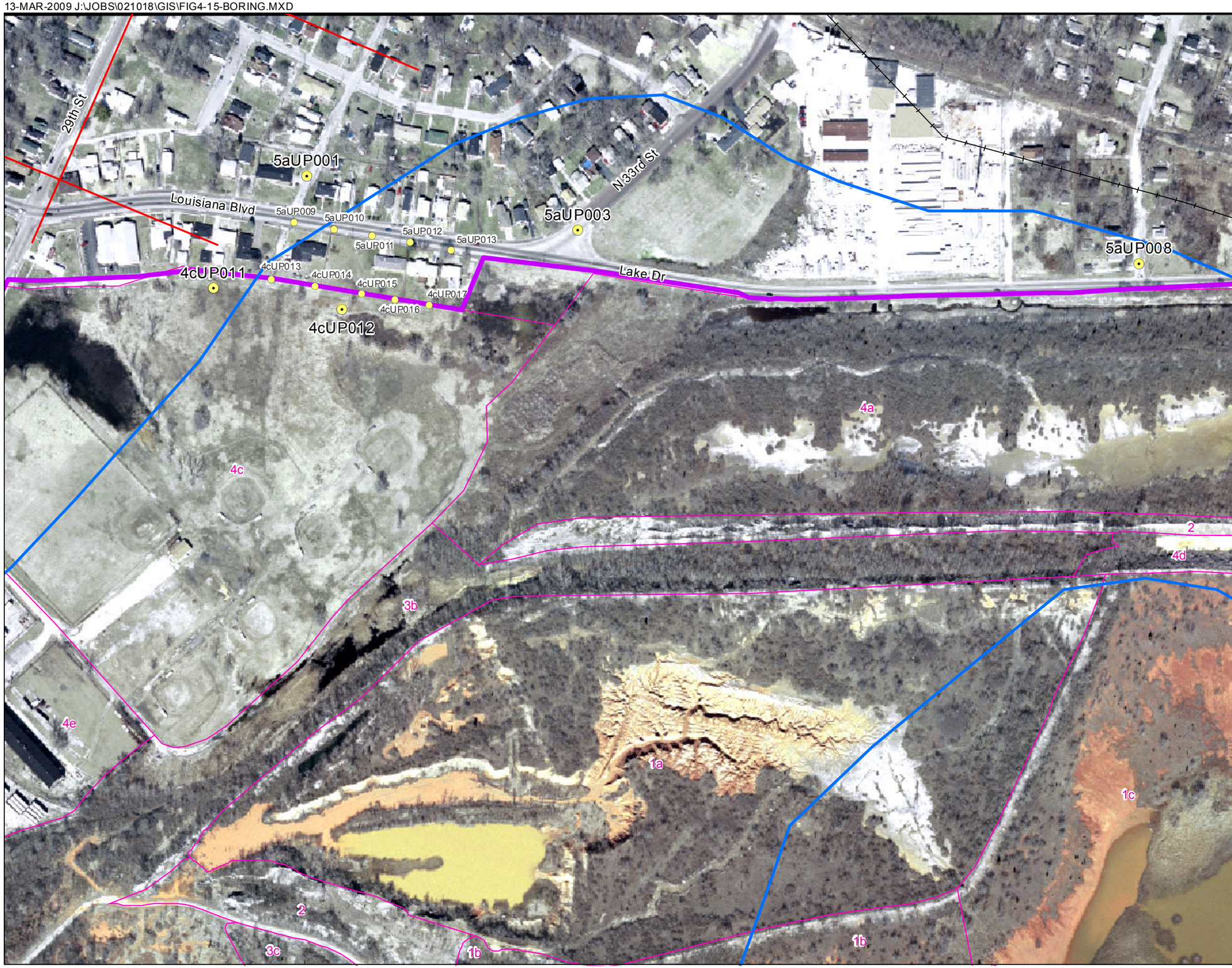
13-MAR-2009 J:\JOBS\021018\GIS\FIG4-15-BORING.MXD



Legend

- Railroad from 1900 topo
- Roads from 1900 topo
- Pittsburg Lake from 1900 topo
- Investigative Block
- Site Boundary
- Boring Location (12-14-2004)
- Previous Boring Location

N

0 250 500

Feet

NORTH ALCOA SITE

EAST ST. LOUIS, IL

FIGURE 2-26

OFFSITE INVESTIGATORY BORINGS
REMEDIAL INVESTIGATION

PROJECT: 021309	DATE: NOVEMBER 18, 2011	
REV: 01	BY: SMM	CHECKED: JCM

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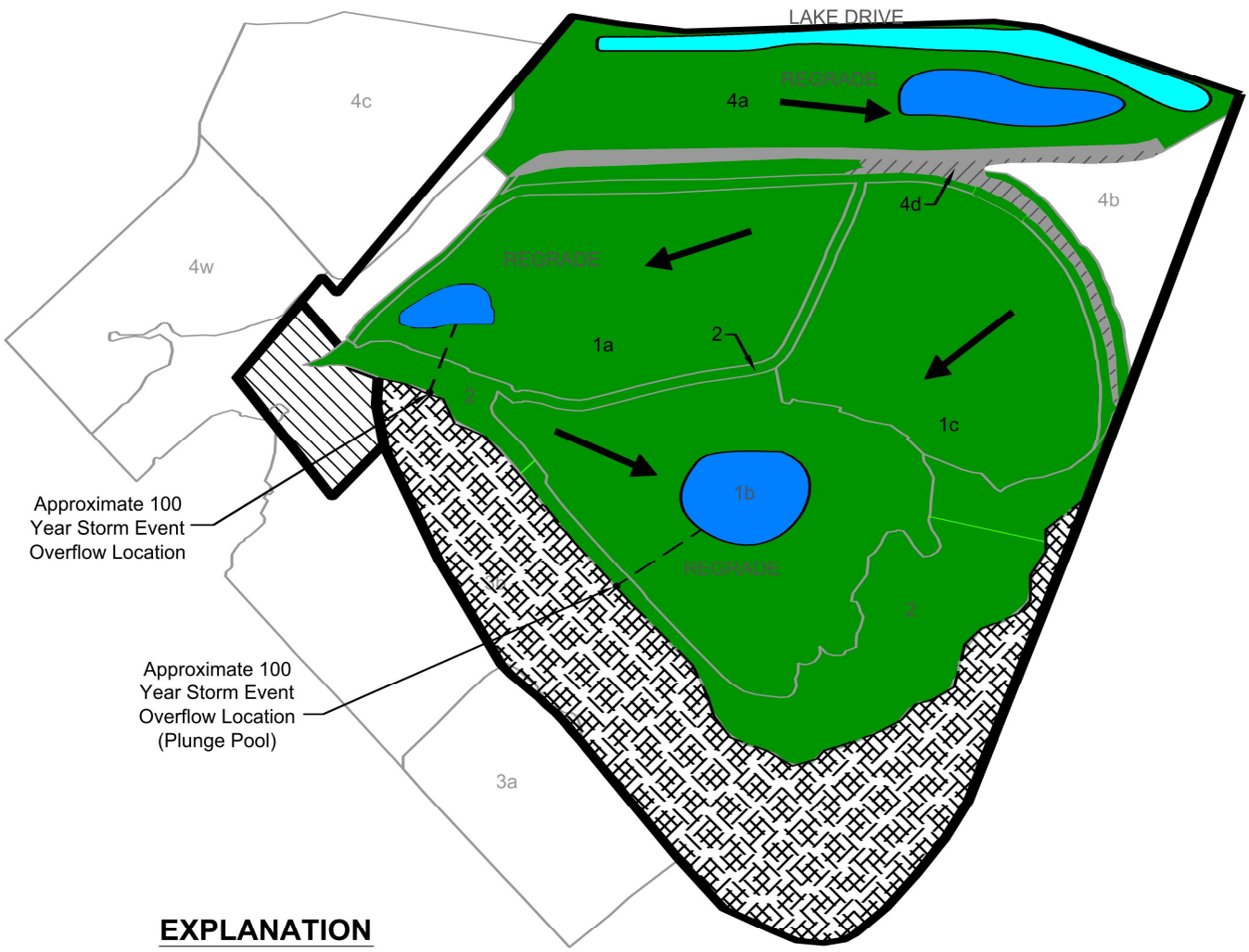

EXPLANATION

- Surface Water Flow Direction
- Surface Water/Conveyance Along Lake Drive
- Proposed Storm Water Management Pond (Conceptual Location)
- Placement of Two Foot Soil Cover Layer Over Exposed Bauxite Residue and Gypsum
- Placement of Two Foot Soil Cover Layer to Address 40 CFR 192 ARAR
- Eliminate Ponded Water
- General Area of Storm Water Overflow
- Proposed Operable Unit Boundary No.1

Note: Final storm water overflow area and depth is currently being evaluated and will be presented in the final storm water design.

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

Figure 6-1

RAA–2
CONCEPTUAL DESIGN
PLAN VIEW

PROJECT: 021363	BY: SMM	REVISIONS 01
DATE: APRIL 2012	CHECKED: JCM	

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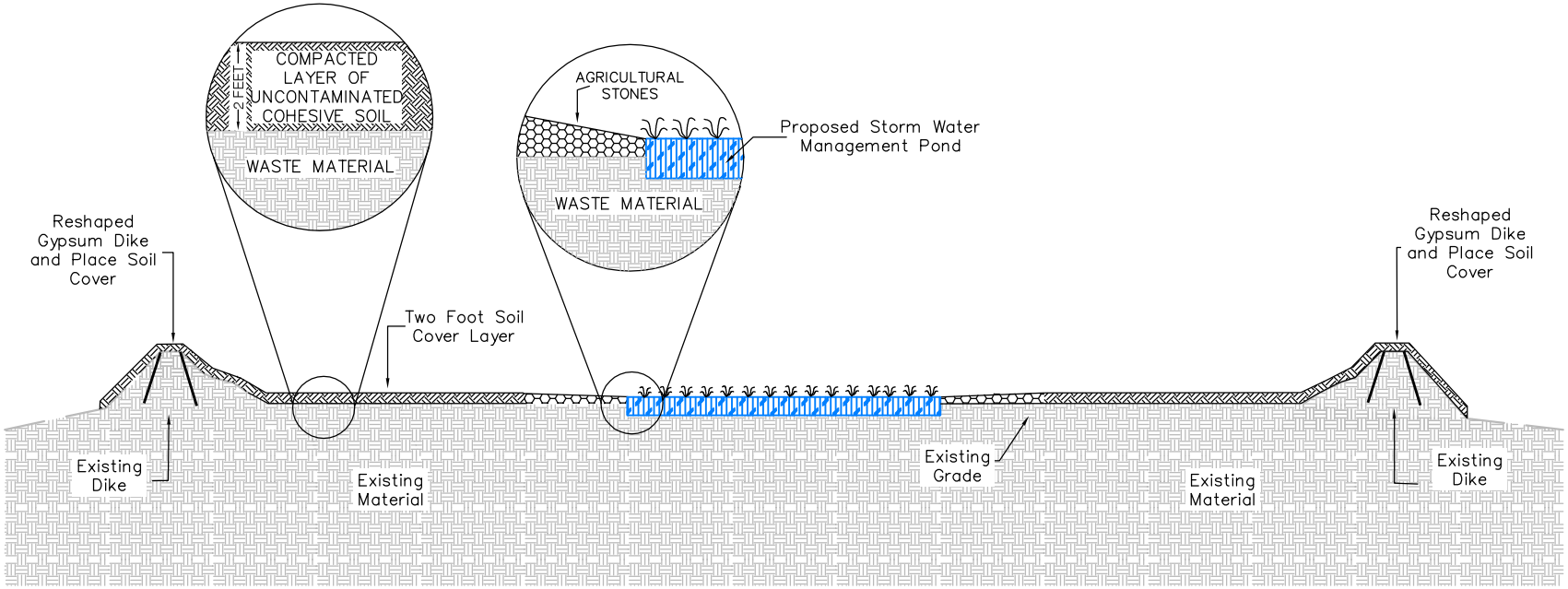

NOT TO SCALE

LEGEND

EXISTING GRADE/MATERIAL

2-FOOT SOIL COVER LAYER

PROPOSED STORM WATER MANAGEMENT POND

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

Figure 6-2

RAA–2
CONCEPTUAL DESIGN
CROSS SECTION

PROJECT: 021363	BY: SMM	REVISIONS 02
DATE: MARCH 2012	CHECKED: BLM	

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COMPLEX WORLD, CLEAR SOLUTIONS

APPENDIX A
USEPA BASELINE RESIDENTIAL, INDUSTRIAL/COMMERCIAL WORKER, AND TRESPASSER RISK CALCULATIONS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
9311 GROH ROAD
GROSSE ILE, MI 48138

MEMORANDUM

SUBJECT: Assumptions used for the Alcoa default residential future use scenario

FROM: Keith Fusinski, PhD Environmental Health Scientist US EPA
Superfund Division, Remedial Response Branch #1, Remedial Response Section #1

TO: Dion Novak, Remedial Project Manager US EPA
Superfund Division, Remedial Response Branch #1, Remedial Response Section #2

DATE: 4/11/2012

Below are the assumptions used to derive a residential scenario as discussed. A default residential exposure is for 263 days per year for a total of 30 years. Six years as a child and 24 years as an adult. Due to the climate of the region, it is assumed that the ground will be frozen for 3 months out of the year. This would result in an exposure to soil for 263 days per year for 30 years. Chemical specific inputs can be found on the June 2011 US EPA Regional Screening tables (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/ Generic_Tables/pdf/ressoil_sl_table_bwrun_JUN2011.pdf)

Chemical Contaminants

Determination of chemical ingestion risks

Daily Ingestion Rate = Conc x IngR x EF x ED x CF x AbsF / BW x AT

$LECR_{ing}$ = Daily Ingestion Rate x Sfo

HQ_{ing} = Daily Ingestion Rate / RfD

Determination of chemical inhalation risks

Inhaled Daily Intake Rate = Conc x EF x ED x (1/PEF) / AT

$LECR_{inh}$ = Inhaled Daily Intake Rate x IUR

HQ_{inh} = Inhaled Daily Intake Rate/RfC

Determination of chemical dermal risks

DA_{event} = Conc x AF x DAF x CF

Daily intake rate = DA_{event} x EF x ED x SA / BW x AT

$LECR_{der}$ = Daily Intake Rate x Sfo

HQ_{der} = Daily Intake Rate / RfD

Where;

AbsF= Absorption Factor = 1 (Rags A)

AF = Adherence Factor for adult= 0.011 for adult; 0.04 for children (Rags E)

AT = Averaging Time for non-cancer effects children (365 days/year x 6 years) = 2190 days

AT = Averaging Time for non-cancer effects adult (365 days/year x 24 years) = 8760 days

AT = Averaging Time for cancer effects (365/year x 70 years) = 25550 days)

BW = Body Weight = 70 kg for adult; 15 kg for child

Conc = concentration of contaminant

CF = Conversion Factor ($1x10^{-6}$ kg per mg)

DA_{event} = Absorbed dose per event

DAF = Dermal Absorption Factor = 0.03 (Rags E)

HQ = Hazard Quotient (US EPA recommends <1)

IngR = Ingestion rate = 100 mg/day for adult; 200 mg/day for child

IUR = Inhalation Unit Risk (Chemical specific)

EF = Exposure Frequency = 263 days/year

ED = Exposure Duration = 24 years for adult; 6 years for children

LECR = Lifetime Excess Cancer Risk (US EPA recommends $1x10^{-6}$ or 1 in a million)

PEF = Particulate Emission Factor (chemical specific)

RfC = Inhalation Reference Concentration (Chemical specific)

RfD = Reference Dose (Chemical specific)

SA = Surface Area exposed to contaminate

Child - warm months wearing shorts, short sleeve shirt socks and shoes = 2640 cm^2
Child - cool months wearing pants, short sleeve shirt socks and shoes = 1320 cm^2
Adult – warm months wearing shorts, short sleeve shirt socks and shoes = 7200 cm^2
Adult cool months wearing pants, short sleeve shirt socks and shoes = 3600 cm^2

Sfo = Oral Slope Factor (Chemical Specific)

Radiological Contaminants

Incidental ingestion of soil

CDI soil (pCi) = conc (pCi) x IngR x EF x ED x $1x10^{-3}$ g/mg

Inhalation of particles emitted from soil

CDI inhalation (pCi) = conc (pCi) x IR x EF x ED x (1/PEF) x (T_{in} + T_{out} x DF) $1x10^{3}$ g/mg

External exposure to ionizing radiation

CDI external (pCi-year/g) = conc (pCi) x ACF x (T_{out} + (T_{in} x GSF)) x (EF/365) x (ET/24 hours)

LECR = CDI x Exposure specific slope factor for each contaminant

Where;

ACF = Area Correction Factor (0.9)

Conc = concentration of contaminant

DF = Dilution Factor (0.4)

GSF = Gamma Shielding Factor (0.4)

IngR = Ingestion rate = 100 mg/day for adult; 200 mg/day for child

IR = Inhalation Rate = $20m^3$/day for adult; $10m^3$/day for child

ED = Exposure Duration (24 years for adult and 6 years for child)

EF = Exposure Frequency (263)

ET = Exposure Time =24 hours

LECR = Lifetime Excess Cancer Risk (US EPA recommends $1x10^{-6}$ or 1 in a million)

PEF = Particulate Emission Factor (1.36×10^9)

T_{in} = Time spent indoors = 0.8

T_{out} = Time spent outdoors = 0.2

Table 1
FINAL HYPOTHETICAL RESIDENTIAL RECEPTOR (0-2 ft EPCs)
100% of daily soil ingestion rate

IB-1

Radiation exposure for resident IB-1

COPC	Cancer risks		
	Ing	Inh	Ext
Ra226+D	1.68E-06	3.78E-09	5.15E-04
Ra228+D	1.52E-05	6.82E-09	2.99E-03
Th-232	1.92E-06	5.64E-08	8.30E-08
U-238+D	1.06E-06	1.02E-08	2.31E-05
Total=	1.99E-05	7.72E-08	3.52E-03

IB-1 Chemicals of concern

COPC	Total Health Risk		
	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Aluminum	6.40E-01	6.88E-02	-
Arsenic	8.58E-01	9.25E-02	4.74E-05
Chromium (total)	-	-	-
Chromium(III) calculated	4.07E-03	4.36E-04	-
Chromium(VI) calculated	3.39E-01	3.64E-02	6.24E-05
Vandium	1.63E+00	1.74E-01	-
Total	3	0.4	1.E-04

Lifetime excess cancer risks from hypothetical residential exposure scenario to IB-1	
Lifetime excess cancer risks =	4.E-03
Child Non-cancer risks =	3
Adult Non-cancer risks =	0.4

IB-2

Radiation exposure for resident IB-2

COPC	Cancer risks		
	Ing	Inh	Ext
Ra226+D	2.09E-07	4.72E-10	6.44E-05
Ra228+D	1.08E-06	4.83E-10	2.12E-04
Th-232	1.36E-07	4.00E-09	5.88E-09
U-238+D	1.97E-07	1.88E-09	4.27E-06
Total=	1.62E-06	6.83E-09	2.80E-04

IB-2 Chemicals of concern

COPC	Total Health Risk		
	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Arsenic	3.69E-01	3.98E-02	2.04E-05
Vandium	1.20E+00	1.28E-01	-
Totals	1.56E+00	1.68E-01	2.04E-05

Lifetime excess cancer risks from hypothetical residential exposure scenario to IB-2	
Lifetime excess cancer risks =	3.E-04
Child Non-cancer risks =	1.56
Adult Non-cancer risks =	0.2

IB-4

IB-4a 0-2ft bgs

COPC	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Aluminum	8.63E-01	9.28E-02	-
Arsenic	9.70E-01	1.06E-01	5.37E-05
Benzo(a)pyrene	-	-	2.21E-06
Totals	1.83E+00	1.99E-01	5.59E-05

IB-4c 0-2ft bgs

COPC	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Arsenic	7.00E-01	7.65E-02	3.88E-05

IB-4e 2-10ft bgs

COPC	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Arsenic	7.33E-01	8.02E-02	4.07E-05

Lifetime excess cancer risks from hypothetical residential exposure scenario to IB-4a	
Lifetime excess cancer risks =	6.E-05
Child Non-cancer risks =	1.83
Adult Non-cancer risks =	0.2

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Superfund Division, Remedial Response Branch #1, Remedial Response Section #1

TO: Dion Novak, Remedial Project Manager US EPA
Superfund Division, Remedial Response Branch #1, Remedial Response Section #2

DATE: 4/11/2012

Below are the assumptions used to derive a commercial scenario as discussed. Chemical specific inputs can be found on the June 2011 US EPA Regional Screening tables (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/ressoil_sl_table_bwrun_JUN2011.pdf)

Chemical Contaminants

Determination of chemical ingestion risks

Daily Ingestion Rate = Conc x IngR x EF x ED x CF x AbsF / BW x AT

$LECR_{ing}$ = Daily Ingestion Rate x Sfo

HQ_{ing} = Daily Ingestion Rate / RfD

Determination of chemical inhalation risks

Inhaled Daily Intake Rate = Conc x EF x ED x (1/PEF) / AT

$LECR_{inh}$ = Inhaled Daily Intake Rate x IUR

HQ_{inh} = Inhaled Daily Intake Rate/RfC

Determination of chemical dermal risks

DA_{event} = Conc x AF x DAF x CF

Daily intake rate = DA_{event} x EF x ED x SA / BW x AT

$LECR_{der}$ = Daily Intake Rate x Sfo

HQ_{der} = Daily Intake Rate / RfD

Where;

AbsF= Absorption Factor = 1 (Rags A)

AF = Adherence Factor = 0.011 (Rags E)

AT = Averaging Time for non-cancer effects (365 days/year x 25 years) = 9125 days

AT = Averaging Time for cancer effects (365/year x 70 years) = 25550 days)

BW = Body Weight (70 kg for adult)

Conc = concentration of contaminant

CF = Conversion Factor ($1x10^{-6}$ kg per mg)

DA_{event} = Absorbed dose per event

DAF = Dermal Absorption Factor = 0.03 (Rags E)

HQ = Hazard Quotient (US EPA recommends <1)

IngR = Ingestion rate of commercial worker =50 mg/day

IUR = Inhalation Unit Risk (Chemical specific)

EF = Exposure Frequency (250 days/year)

ED = Exposure Duration (25 years)

LECR = Lifetime Excess Cancer Risk (US EPA recommends $1x10^{-6}$ or 1 in a million)

PEF = Particulate Emission Factor (chemical specific)

RfC = Inhalation Reference Concentration (Chemical specific)

RfD = Reference Dose (Chemical specific)

SA = Surface Area exposed to contaminate (Adult hands and face) = 1306 cm^2

Sfo = Oral Slope Factor (Chemical Specific)

Radiological Contaminants

Incidental ingestion of soil

CDI soil (pCi) = conc (pCi) x IngR x EF x ED x $1x10^{-3}$ g/mg

Inhalation of particles emitted from soil

CDI inhalation (pCi) = conc (pCi) x IR x EF x ED x (1/PEF) x (T_{in} + T_{out} x DF) $1x10^{3}$ g/mg

External exposure to ionizing radiation

CDI external (pCi-year/g) = conc (pCi) x ACF x (T_{out} + (T_{in} x GSF)) x (EF/365) x (ET/24 hours)

LECR = CDI x Exposure specific slope factor for each contaminant

Where;

ACF = Area Correction Factor (0.9)

Conc = concentration of contaminant

DF = Dilution Factor (0.4)

GSF = Gamma Shielding Factor (0.4)

InR = Ingestion rate of commercial worker (50 mg/day)

IR = Inhalation Rate ($20m^3$/8-hr work day)

ED = Exposure Duration (25 years)

EF = Exposure Frequency (250)

ET = Exposure Time (8 hours)

LECR = Lifetime Excess Cancer Risk (US EPA recommends $1x10^{-6}$ or 1 in a million)

PEF = Particulate Emission Factor (1.36×10^{9})

T_{in} = Time spent indoors (0.8)

T_{out} = Time spent outdoors (0.2)

Table 2
FINAL HYPOTHETICAL FULL-TIME INDUSTRIAL/COMMERCIAL RECEPTOR (0-2 ft EPCs)
100% of daily soil ingestion rate

IB-1

Radiation exposure for worker IB-1

COPC	Cancer risks		
	Ing	Inh	Ext
Ra226+D	5.53E-07	3.33E-09	1.36E-04
Ra228+D	5.03E-06	6.00E-09	7.89E-04
Th-232	6.35E-07	4.97E-08	2.19E-08
U-238+D	3.51E-07	8.94E-09	6.09E-06
Total=	6.56E-06	6.79E-08	9.31E-04

IB-1 Chemicals of concern

COPC	Total Health Risk		
	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Aluminum	0.00E+00	3.29E-02	-
Arsenic	0.00E+00	4.36E-02	7.00E-06
Chromium (total)	-	-	-
Chromium(III) calculated	0.00E+00	2.07E-04	-
Chromium(VI) calculated	0.00E+00	1.73E-02	9.32E-06
Vandium	0.00E+00	8.28E-02	-
Total	0.00E+00	0.2	1.6E-05

Lifetime excess cancer risks from worker exposure scenario to IB-1	
Lifetime excess cancer risks =	1.E-03
Adult Non-cancer risks =	0.2

IB-2

Radiation exposure for worker IB-2

COPC	Cancer risks		
	Ing	Inh	Ext
Ra226+D	6.91E-08	4.16E-10	1.70E-05
Ra228+D	3.56E-07	4.25E-10	5.59E-05
Th-232	4.50E-08	3.52E-09	1.55E-09
U-238+D	6.50E-08	1.65E-09	1.13E-06
Total=	5.35E-07	6.01E-09	7.40E-05

IB-2 Chemicals of concern

COPC	Total Health Risk		
	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Arsenic	0.00E+00	1.87E-02	3.01E-06
Vandium	0.00E+00	6.09E-02	-
Totals	0.00E+00	0.08	3.01E-06

Lifetime excess cancer risks from worker exposure scenario to IB-2	
Lifetime excess cancer risks =	8.E-05
Adult Non-cancer risks =	0.08

IB-4

IB-4a 0-2ft bgs

COPC	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Aluminum	0.00E+00	4.43E-02	-
Arsenic	0.00E+00	4.93E-02	7.92E-06
Totals	0.00E+00	9.36E-02	7.92E-06

IB-4c 0-2ft bgs

COPC	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Arsenic	0.00E+00	3.56E-02	5.72E-06

IB-4e 2-10ft bgs

COPC	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Arsenic	0.00E+00	3.73E-02	5.99E-06

Lifetime excess cancer risks from worker exposure scenario to IB-4a	
Lifetime excess cancer risks =	8.E-06
Adult Non-cancer risks =	0.09

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MEMORANDUM

SUBJECT: Assumptions used for the Alcoa trespasser scenario

FROM: Keith Fusinski, PhD Environmental Health Scientist US EPA
Superfund Division, Remedial Response Branch #1, Remedial Response Section #1

TO: Dion Novak, Remedial Project Manager US EPA
Superfund Division, Remedial Response Branch #1, Remedial Response Section #2

DATE: 4/11/2012

Below are the assumptions used to derive a trespasser scenario as discussed. Trespasser exposure is for 20 days per year for a total of 30 years. 10 years as an adolescent and 20 years as an adult. Chemical specific inputs can be found on the June 2011 US EPA Regional Screening tables (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/ressoil_sl_table_bwrun_JUN2011.pdf)

Chemical Contaminants

Determination of chemical ingestion risks

Daily Ingestion Rate = Conc x IngR x EF x ED x CF x AbsF / BW x AT

$LECR_{ing}$ = Daily Ingestion Rate x Sfo

HQ_{ing} = Daily Ingestion Rate / RfD

Determination of chemical inhalation risks

Inhaled Daily Intake Rate = Conc x EF x ED x (1/PEF) / AT

$LECR_{inh}$ = Inhaled Daily Intake Rate x IUR

HQ_{inh} = Inhaled Daily Intake Rate/RfC

Determination of chemical dermal risks

DA_{event} = Conc x AF x DAF x CF

Daily intake rate = DA_{event} x EF x ED x SA / BW x AT

$LECR_{der}$ = Daily Intake Rate x Sfo

HQ_{der} = Daily Intake Rate / RfD

Where;

AbsF= Absorption Factor = 1 (Rags A)

AF = Adherence Factor for adult= 0.011 for adult; 0.04 for adolescent (Rags E)

AT = Averaging Time for non-cancer effects adolescent (365 days/year x 10 years) = 3650 days

AT = Averaging Time for non-cancer effects adult (365 days/year x 20 years) = 7300 days

AT = Averaging Time for cancer effects (365/year x 70 years) = 25550 days)

BW = Body Weight = 70 kg for adult; 40 kg for adolescent

Conc = concentration of contaminant

CF = Conversion Factor ($1x10^{-6}$ kg per mg)

DA_{event} = Absorbed dose per event

DAF = Dermal Absorption Factor = 0.03 (Rags E)

HQ = Hazard Quotient (US EPA recommends <1)

IngR = Ingestion rate = 100 mg/day for adult and adolescent

IUR = Inhalation Unit Risk (Chemical specific)

EF = Exposure Frequency = 20 days/year

ED = Exposure Duration = 20 years for adult; 10 years for adolescent

LECR = Lifetime Excess Cancer Risk (US EPA recommends $1x10^{-6}$ or 1 in a million)

PEF = Particulate Emission Factor (chemical specific)

RfC = Inhalation Reference Concentration (Chemical specific)

RfD = Reference Dose (Chemical specific)

SA = Surface Area exposed to contaminate

Adolescent - warm months wearing shorts, short sleeve shirt socks and shoes = 2640 cm^2
Adolescent - cool months wearing pants, short sleeve shirt socks and shoes = 1320 cm^2
Adult – warm months wearing shorts, short sleeve shirt socks and shoes = 7200 cm^2
Adult cool months wearing pants, short sleeve shirt socks and shoes = 3600 cm^2

Sfo = Oral Slope Factor (Chemical Specific)

Radiological Contaminants

Incidental ingestion of soil

CDI soil (pCi) = conc (pCi) x IngR x EF x ED x $1x10^{-3}$ g/mg

Inhalation of particles emitted from soil

CDI inhalation (pCi) = conc (pCi) x IR x EF x ED x (1/PEF) x (T_{in} + T_{out} x DF) $1x10^{3}$ g/mg

External exposure to ionizing radiation

CDI external (pCi-year/g) = conc (pCi) x ACF x (T_{out} + (T_{in} x GSF)) x (EF/365) x (ET/24 hours)

LECR = CDI x Exposure specific slope factor for each contaminant

Where;

ACF = Area Correction Factor (0.9)

Conc = concentration of contaminant

DF = Dilution Factor (0.4)

GSF = Gamma Shielding Factor (0.4)

IngR = Ingestion rate = 100 mg/day for adult and adolescent

IR = Inhalation Rate = 1.6m^3/hour for adult; 1.2m^3/hour for adolescent

ED = Exposure Duration (20 years for adult and 10 years for adolescent)

EF = Exposure Frequency 20 days/year

ET = Exposure Time = 2 hours/day

LECR = Lifetime Excess Cancer Risk (US EPA recommends $1x10^{-6}$ or 1 in a million)

PEF = Particulate Emission Factor (1.36 x 10^{9})

T_{in} = Time spent indoors = 0.0

T_{out} = Time spent outdoors = 1.0

Table 3
FINAL TRESPASSER 20 DAY/YEAR SUMMARY SHEET (0-2 ft EPCs)
100% of daily soil ingestion rate

IB-1

Radiation exposure for trespasser IB-1

COPC	Cancer risks		
	Ing	Inh	Ext
Ra226+D	1.06E-07	1.08E-09	6.28E-06
Ra228+D	9.65E-07	1.95E-09	3.64E-05
Th-232	1.22E-07	1.61E-08	1.01E-09
U-238+D	6.74E-08	2.90E-09	2.81E-07
Total=	1.26E-06	2.21E-08	4.30E-05

IB-1 Chemicals of concern

COPC	Total Health Risk		
	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Aluminum	9.14E-03	5.23E-03	-
Arsenic	1.25E-02	7.05E-03	1.71E-06
Chromium (total)	-	-	-
Chromium(III) calculated	5.81E-05	3.32E-05	-
Chromium(VI) calculated	4.84E-03	2.77E-03	2.23E-06
Vandium	2.32E-02	1.32E-02	-
Total	0.05	0.03	3.94E-06

Lifetime excess cancer risks from trespasser exposure scenario to IB-1	
Lifetime excess cancer risks =	5.E-05
Adolescent Non-cancer risks =	0.05
Adult Non-cancer risks =	0.03

IB-2

Radiation exposure for trespasser IB-2

COPC	Cancer risks		
	Ing	Inh	Ext
Ra226+D	1.33E-08	1.35E-10	7.85E-07
Ra228+D	6.83E-08	1.38E-10	2.58E-06
Th-232	8.64E-09	1.14E-09	7.17E-11
U-238+D	1.25E-08	5.37E-10	5.20E-08
Total=	1.03E-07	1.95E-09	3.42E-06

IB-2 Chemicals of concern

COPC	Total Health Risk		
	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Arsenic	5.30E-03	3.03E-03	7.33E-07
Vandium	1.70E-02	9.74E-03	-
Totals	2.23E-02	1.28E-02	7.33E-07

Lifetime excess cancer risks from trespasser exposure scenario to IB-2	
Lifetime excess cancer risks =	4.E-06
Adolescent Non-cancer risks =	0.02
Adult Non-cancer risks =	0.01

IB-4

IB-4a 0-2ft bgs

COPC	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Aluminum	1.23E-02	7.06E-03	-
Arsenic	1.41E-02	7.98E-03	1.93E-06
Totals	2.64E-02	1.50E-02	1.93E-06

IB-4c 0-2ft bgs

COPC	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Arsenic	1.00E-02	5.77E-03	1.38E-06

IB-4e 2-10ft bgs

COPC	Child Non-Cancer	Adult Non-Cancer	Lifetime Cancer Risk
Arsenic	1.06E-02	6.04E-03	1.46E-06

Lifetime excess cancer risks from trespasser exposure scenario to IB-4a	
Lifetime excess cancer risks =	2.E-06
Adolescent Non-cancer risks =	0.03
Adult Non-cancer risks =	0.02

APPENDIX B
ARAR ANALYSIS

APPENDIX B

SUMMARY OF POTENTIAL ARARs
OU-1, NORTH ALCOA SITE, EAST ST. LOUIS, ILLINOIS

Standard, Requirement, Criteria or Limitation	Citation	Applicable	Relevant and Appropriate	To Be Considered (TBC)	Comment
Location Specific ARARs					
General Use Water Quality Standards	35 IAC Part 302	No	No	No	See Section 3.0 for description of on-site pond as "treatment works". All waste materials are covered with clean fill and there are no ongoing industrial activities at the site; therefore NPDES is not applicable. Future industrial redevelopment will require storm water permits per SIC code.
Federal Water Quality Criteria	Clean Water Act 33 U.S.C. ss/1251 et seq. (1977) 303(or 40CFR 131)	No	No	No	See Section 3.0 for description of on-site pond as "treatment works". All waste materials are covered with clean fill and there are no ongoing industrial activities at the site; therefore NPDES is not applicable. Future industrial redevelopment will require storm water permits per SIC code.
Air Quality Standards	35 IAC Part 243, and the Clean Air Act 42 U.S.C. s/s 7401 et seq. (1970)	Yes	No	No	Ambient air quality standards to be maintained
National Emission Standards for Hazardous Air Pollutants Compliance Monitoring (NESHAPS)	40 CFR Part 61 and 63	Yes	No	No	Ambient air quality standards to be maintained during construction activities.
Federal Water Quality Criteria for Drinking Water	The Safe Drinking Water Act (SDWA); 42 U.S.C. s/s 300f et seq. (1974)	No	No	No	No surface or groundwater wells are used for the drinking water supply. The neighboring areas are on the city water supply. See July 22, 2011 letter from USEPA.
Federal Management of Hazardous and Non-Hazardous Waste	The Resource Conservation and Recovery Act (RCRA); 42 U.S.C. s/s 321 et seq. (1976)	No	No	No	40 CFR Part 261.4,states that solid waste from the extraction, beneficiation, and processing of ore and minerals are not hazardous waste. Therefore the wastes on-Site are classified as RCRA non-hazardous under the Bevill exemption.

APPENDIX B

SUMMARY OF POTENTIAL ARARs
OU-1, NORTH ALCOA SITE, EAST ST. LOUIS, ILLINOIS

Standard, Requirement, Criteria or Limitation	Citation	Applicable	Relevant and Appropriate	To Be Considered (TBC)	Comment
Location Specific ARARs					
Federal program for the conservation of threatened and endangered plants and animals and the habitats in which they are found	The Endangered Species Act (ESA); 7 U.S.C. 136;16 U.S.C. 460 et seq. (1973)	No	No	No	As discussed in the Ecological Risk Assessment, the species observed on-Site include typical urban wildlife. More wide-ranging species such as waterfowl, small birds and mammals such as whitetail deer and coyote may occasionally visit the Site, but it is small and of too low quality to represent a significant resource for local populations.
Fish and Wildlife Conservation	Fish and Wildlife Conservation Act 16 USC 2901 et seq.	No	No	No	As discussed in the Baseline Ecological Risk Assessment, the species observed on-Site include typical urban wildlife. More wide-ranging species such as waterfowl, small birds and mammals such as whitetail deer and coyote may occasionally visit the Site, but it is small and of too low quality to represent a significant resource for local populations.
Floodplain Management	Floodplain Management Executive Order 11988	No	No	No	Peripheral areas of the site are located within the 100-year floodplain, but the specific areas that are undergoing remediation are not located within the 100-year floodplain.
Preservation of Landmarks	National Historic Preservation Act of 1966 (NHPA)	No	No	No	No buildings are located on-site that constitute historical buildings.
Wilderness Areas	Wilderness Act of 1964 (16 U.S.C. 1131-1136, 78 Stat. 890)	No	No	No	The site is an industrial area, and does not contain any wilderness areas.
Chemical Specific ARARs					
General Use Water Quality Standards	35 IAC Part 302	No	No	Yes	Please see Section 3.0 for an explanation of this criteria.
IL Solid Waste Standards	35 IAC Part 807.305	No	Yes	Yes	Please see Section 3.0 for an explanation of this criteria.

APPENDIX B

SUMMARY OF POTENTIAL ARARs
OU-1, NORTH ALCOA SITE, EAST ST. LOUIS, ILLINOIS

Standard, Requirement, Criteria or Limitation	Citation	Applicable	Relevant and Appropriate	To Be Considered (TBC)	Comment
Chemical Specific ARARs					
IL Solid Waste Standards	35 IAC 811	No	No	No	Please see Section 3.0 for an explanation of this criteria.
Federal Hazardous Waste Regulations	RCRA, Subtitle C	No	No	No	Please see Section 3.0 for an explanation of this criteria.
Federal Soil Cleanup Criteria	40 CFR Part 192	No	Yes	No	Please see Section 3.0 for an explanation of this criteria.
Cleanup Levels for CERCLA Sites with Radioactive Contamination	OSWER No. 9200.4-18	Yes	No	No	Cleanups should generally achieve risk levels in the 10^{-4} to 10^{-6} range.
Federal and State Effluent Standards	35 IAC Part 304	No	No	Yes	All waste materials are covered with clean fill and there are no ongoing industrial activities at the site; therefore NPDES is not applicable. Future industrial redevelopment will require storm water permits per SIC code.
Risk Based Cleanup Objectives (TACO)	35 IAC Part 742	No	Yes	Yes	Please see Section 3.0-institutional controls and requirements for chemical (residential Tier 1 criteria) composition of fill material used as an engineered barrier.

Notes:

1. All actual remedial actions would be designed and implemented in compliance with all applicable Federal, State, and local ARARs. The ARARs presented here represent some of the more significant requirements.

APPENDIX C
RADIOLOGICAL SURVEY REPORT

North Alcoa Site
East St. Louis, Illinois
Radiological Survey Report

ALCOA, Inc.
City of East St. Louis

January 6, 2012

Prepared by:

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TABLE OF CONTENTS

1. INTRODUCTION & SCOPE 3

2. BACKGROUND 4

3. WORK PERFORMED 6

3.1 Methodology 6

3.2 Gamma Survey completeness 9

3.3 Background Surveys 10

4. RESULTS 11

4.1 Background Gamma Radiation Levels 11

4.2 Background Soil Concentrations 11

4.3 Gamma Survey Results 12

4.5 Subsurface Soil Sampling 15

4.6 Correlation of Survey Measurements to Soil Concentrations 16

4.7 Soil Compositing Comparison 17

5. CONCLUSIONS 19

1. INTRODUCTION & SCOPE

Radiological surveys and sampling were performed on November 14 through November 18, 2011 pursuant to the Administrative Order on Consent and Statement of Work (AOC/SOW) to conduct a Remedial Investigation/Feasibility Study (RI/FS) for the North Alcoa Site (the Site), East St. Louis (U.S. EPA Docket No. V-W-'03-C-728, signed December 31, 2002) and the North Alcoa Site East St. Louis, Illinois Radiological Survey Work Plan (Work Plan) dated November 4, 2011. Alcoa Inc. (Alcoa) and the City of East St. Louis (the City) are Respondents under the Consent Order with the U.S. Environmental Protection Agency (USEPA).

The Site is defined in the AOC/SOW (page 4) as:

> "Site" or "Facility" or "North Alcoa Site" shall mean the facility as that term is defined at 42 U.S.C. Section 9601(9), which includes the following areas in East St. Louis, Illinois: 1) the property located north of Missouri Avenue, which is approximately bounded by 29th St. to the west, Alton Southern Railroad to the east and Lake Drive to the north; and 2) areas located north of Missouri Avenue where hazardous substances have or may have come to be located from former Alcoa operations.

The overall Site boundary set forth in the first part of this definition is shown in Figure 1. In the interest of facilitating Site redevelopment, the Respondents and USEPA have agreed that the Site will be subdivided into Operable Units. The geographic extent of Operable Unit No. 1 (OU-1) is shown in Figure 2, and includes the bauxite residue impoundments, gypsum areas, and other adjacent areas. Although not yet formalized, the remaining area of the Site may be addressed as Operable Unit No. 2 (OU-2).

This reports details the results of gamma survey and soil sampling activities conducted at the Site in accordance with the Work Plan. The gamma surveys evaluated the site conditions with respect to external radiation levels, measured in units of

microRoentgens/hour (µR/hr). External radiation is one of the primary risk drivers for remediation of the Site. Additionally, the agency has identified 40 CFR 192 as an ARAR for the Site, and this regulation contains closure criteria specified in radiation exposure rate units of µR/hr. The soil sampling evaluated radioactive material concentrations in the surface and subsurface soils.

2. BACKGROUND

Alcoa formerly operated a bauxite refinery in East St. Louis from the early 1900's to the 1950's. The operation removed alumina from crushed bauxite using caustic liquor. The remaining material, termed "bauxite residue," was stored in several Residue Disposal Areas (RDAs). Initially, these areas were natural depressions related to Pittsburg Lake (an oxbow lake) and surrounding swamps. Later, RDAs were extended above grade by constructing perimeter dikes and filling the interior with residue. Perimeter dikes were constructed using another by-product of the bauxite refinery, anhydrite ($CaSO_4$) and/or gypsum ($CaSO_4*2H_2O$).

Over the years, the pH and Sodium Adsorption Ratio (SAR) of some areas of the residue has decreased to a point that the bauxite residue supports growth of vegetation. Generally, vegetation has established in the peripheral and central areas of each RDA, but intermediate areas remain barren.

The Remedial Investigation (RI) collected radionuclide soil concentration data within the RDAs and associated dikes. However, during the RI no radionuclide soil concentration data were collected outside of these Investigative Blocks (IBs). No gamma survey data were collected from anywhere on Site prior to the current investigation, nor were background soil radionuclide concentration or background gamma exposure rate data available either.

Evaluation of the baseline risk at the Site revealed that the primary risk driver is external radiation, with a cancer risk that is an order of magnitude greater than the risk from

inhalation or ingestion of radionuclides or from non-radioactive chemicals via any exposure pathway. For the RDAs (IB-1) and Gypsum Area (IB-2), one of the proposed remediation alternatives is to place a 2-foot cover over these areas. Once a cover is in place, the radionuclide inhalation and ingestion risk drops to zero as there is no complete exposure pathway. Similarly, the chemical risk drops to zero as well. The 2-foot soil cover serves to shield underlying radioactive material, reducing the external exposure to an individual at that location and thus would also reduce the risk due to external radiation. The gamma survey described in this Work Plan will establish the baseline external radiation levels and allow for quantification of the amount of external radiation risk reduction provided by a 2-foot soil cover.

To date, external exposure rates and associated risk have been based upon estimating the external exposure rate from radionuclide concentrations measured in surficial soil samples and the use of reasonable maximum exposure (RME) conditions. However, external exposure levels are driven by wide-area concentrations rather than point-wise conditions. With inhalation or ingestion, the intake can be a relatively small, discrete amount of material which results in the associated risk; however, external exposures are different. External exposure is due to an integration of the radiation exposure from all the material in the vicinity of a receptor. Material up to several meters or even further can contribute to the external exposure at any point. Under these conditions, the RME concentration of radioactive material at any location is not as important as the average concentration in the vicinity of the receptor that contributes to the external exposure.

This concept is contained in the 40 CFR 192 ARAR. 40 CFR 192.12(a) states that the Ra-226 concentration in soil averaged over a 100 square meter ($m^{2)}$ area and averaged over the top 15 centimeters (cm) (6 inches) of depth shall not exceed 5 picocuries per gram (pCi/g) above background. Below the top 15 cm, the concentration shall not exceed 15 pCi/g above background in any 15 cm interval and averaged over a 100 m^2area. This 100 m^2 area is the “vicinity” of the receptor that contributes the bulk of the radiation exposure.

40 CFR 192.12(b)(2) states that the level of gamma radiation shall not exceed 20 µR/hr above background in any occupied or habitable building. There presently are not any buildings within OU-1. However, if this requirement is met outdoors, any building erected at a later date would necessarily have an exposure rate less than 20 µR/hr above background as well. 40 CFR 192.20(b)(1) states that compliance with these 192.12 (a) and (b) requirements should be demonstrated through radiation surveys designed to measure compliance averaged over defined areas (i.e., 100 m^2). This is the basis for conducting the gamma surveys and establishing a correlation between radionuclide concentrations in the soil and gamma exposure rates.

3. WORK PERFORMED

3.1 Methodology

The North Alcoa Site East St. Louis, Illinois Radiological Survey Work Plan (Work Plan) dated November 4, 2011 specified the following activities to be performed:

- Gamma surveys over accessible areas
- Collection of surface soil samples
- Collection of subsurface soil samples
- Determination of background soil concentrations and exposure rates.

Gamma surveys were performed with 3”x 3” NaI detectors connected to GPS-enabled dataloggers at a height of 1 meter above the ground surface. This height equates to the lower torso of most individuals and is considered representative of the exposure to an individual on the site. For areas accessible by an All Terrain Vehicle (ATV), i.e., Kawasaki Mule, surveys were performed on transects spaced approximately 10 meters apart traversed at a speed of no more than 2 m/s with measurements logged every 2 seconds. The NaI detector was mounted on an extension off the back of the ATV with a clear view of the ground. Areas clear of vegetation or with vegetation that could be driven over by the ATV were surveyed in this manner. A greater than expected portion of the phragmites-covered areas were able to be surveyed on the ATV with only the areas with the densest and/or tallest stands of phragmites being inaccessible by the ATV.

Areas inaccessible to the ATV were surveyed on foot where on-foot access was possible. Manual surveys were collected on wider-spaced transects than was performed with the ATV. The spacing of the manual transects was largely determined by accessibility constraints. The location and spacing of transects was field-determined with the objective of making 4-5 transects over each feature. Some areas were not accessible by either means and were not surveyed. Areas with standing water were not surveyed due to the hazard posed by the water and the shielding effect of the water which would negate the effectiveness of the gamma survey.

Locations for surface soil samples were selected based upon two objectives. The first was to obtain radiological data in areas where no such data had previously been obtained. These areas include IB-3, IB-4, and background data. The second objective was to establish a correlation between radionuclide concentrations and gamma survey measurements. To meet the second objective, the results of the gamma surveys were used to select locations representative of a range of gamma exposure rate levels.

A five-point composite sample was collected at each selected location. One point was centered at the sampling location with the other 4 points placed 2 meters away from the central point at 90 degree angles from each other (i.e., the cardinal directions). Each sample was approximately a half-liter in volume and was collected from the top 15 cm (6 inches) of soil. This composite sample was designed to collect samples representative of the field of view of the radiation detector.

A total of 26 locations were sampled, 5 for determination of background concentrations, 7 in IB's 1 and 2 combined, 9 in IB-3 and 5 in IB-4. At three of these locations, the 5 parts of the composite sample were individually sampled in addition to extraction of an aliquot for analysis from the composite. This was done to permit evaluation of the representativeness of the composite sample compared to the individual portions of the composite as requested by the EPA.

All soil samples were analyzed for Ra-226, Ra-228, and U-238. Th-232 was considered to be in equilibrium with Ra-228 rather than performing a separate analysis for Th-232. Table 1 provides the analysis methods used. These analyses are consistent with the Remedial Investigation data previously collected for radionuclides in IB-1 and IB-2. The uranium analysis method used is based on alpha spectroscopy rather than EPA Method E908.0 (kpa, mass-based measurement). Conversion between the two methods can be made as needed based on the specific activity of U-238. Samples were sent to Eberline Services in Oak Ridge, TN, a NELAP accredited laboratory, for analysis.

Table 1. Radionuclide Analysis Methods

Analyte	**Method**
Ra-226	E903.0
Ra-228	E904.0
U-238	EML U-02 Mod

Subsurface soil samples were collected in areas where it was suspected that there may be bauxite residue and/or gypsum at depth but not on the surface. Field determination of sample locations was made based on gamma survey results and previous subsurface sampling results, with a total of 10 locations selected.

Subsurface soil samples were collected with a Geoprobe™ direct push drill rig using 1.75 inch PVC core liners. The borings were advanced to a depth of 12 feet below ground surface. The liners were opened with a sampling kit including a core holder and a double-hook core cutter for collection of the samples at the desired depth interval(s). The cores were examined for evidence of residue, gypsum, or other materials associated with Alcoa operations. Additionally the cores were scanned with a radiation detector to determine if any depth interval exhibited elevated radiation levels. If such material was found, a sample of that material was collected. Examination of the cores for the radiation survey and sampling resulted in sufficient disturbance of the cores that retention of the remainder in an organized manner was not possible. Samples were analyzed for the same constituents as for the surface samples given in Table 1.

3.2 Gamma Survey completeness

Areas surveyed by ATV were performed on 10-meter or less transects with limited exceptions. In most areas, the transects paralleled terrain features rather than being straight lines. Straight line transects were limited to large open areas, primarily the ball fields and the Paule property in IB-3a. Areas surveyed on foot were surveyed in a manner to achieve 4-5 transects through any given feature. This objective was met for those features large enough to merit multiple transects, the notable exception being the tops of berms. The area where this was applied included IB-1a and the wooded portions of IB-3b.

The radiation detector was checked for proper operation at the beginning of each day by verifying the battery charge, observing expected response to ambient radiation levels and response to the check source located on the side of the meter case. Gamma survey data were downloaded from the dataloggers multiple times per day. A running depiction of the areas that had been covered was maintained and used to plan the surveys for subsequent survey sessions. This routine also allowed for the repetition of surveys where the data were suspect or failed to record. The survey completeness by area is:

- RDA1/IB-1a: All of this RDA was surveyed except for one area on the south side where there was standing water. Most surveys were on foot except for where paths had been cleared through the brush by a bulldozer, and along the flat bauxite residue surface where the outflow to the dike breach is present.
- RDA2/IB-1b: The perimeter of the bauxite residue on the south and west sides was surveyed along with limited portions of the east side. The remaining area contained standing water or was very marshy and was not surveyed. Most of the survey was performed on the ATV.
- RDA 3/IB-1c: Surveys were completed except for a central annular area where the phragmites were sufficiently dense to be inaccessible both on ATC and on foot. Most of the survey was performed on the ATV.
- Gypsum Dikes/IB-2: The portion of IB-2 south of the RDAs was surveyed in its entirety. Most of the survey was performed on the ATV. The north portion of IB-2 along the south edge of IB-4a was not surveyed due to accessibility issues. It was

surrounded by standing water and consisted of very steep terrain not safe for on-foot surveys.

- Paule property/IB-3a: This area was surveyed in its entirety by ATV.
- IB-3b: This area was surveyed primarily on foot except for portions within the Paule property that were cleared. Minor portions were not surveyed due to activities on the Paule property (brush piles, equipment parking, active brush burning pit). On-foot coverage met with established expectations. The area along the border with IB-4e was surveyed but the data rejected due to corruption of the GPS fix data associated with the logged measurements, resulting in no usable data for this area.
- IB-3c: The area was surveyed in its entirety by ATV.
- IB-4a & IB-4b: These areas contained standing water or were marshy to the point of being inaccessible. Only limited data along the perimeter of these areas was obtained.
- Ball fields/IB-4c: This area was surveyed in its entirety by ATV except for the eastern and southern edges where heavy brush was present, which were surveyed on foot.
- IB-4d: This area contained standing water or was marshy to the point of being inaccessible. Only limited data along the perimeter of this area was obtained.
- IB-4e: No data from this area was obtained due to the lack of access agreements with the landowners.

3.3 Background Surveys

Background gamma surveys were performed in the western portion of Frank Holten State Park, the undeveloped area east of IB-3a and the Alton & Southern railroad tracks at the south corner of the site (agricultural field). The northwest portion of the ball fields was also used as a background area as described in the Work Plan. Parallel transects and an enclosing perimeter survey were performed in the agricultural field and at Frank Holten State Park. For the ball fields, the surveyed area north of 706400 feet North and west of 2307900 feet East (Illinois State Plane West, NAD 1983, feet) was used as the background reference area.

4. RESULTS

4.1 Background Gamma Radiation Levels

From each area, the survey results were filtered to exclude points not at least one foot from the previous logged survey location. This serves to limit duplicate measurements at a single location which could bias analysis of the results. Filtering in this manner resulted in 367 measurements at the ball fields, 388 from Frank Holten State Park, and 538 from the agricultural field. The pertinent statistical results from this data set are given in Table 2. Based on these results, any survey results less than 14 µR/hr are considered to be background.

Table 2. Background Statistical Analysis.

Parameter	Value (µR/hr)
Mean	11.6
Standard deviation	1.8
Minimum	7
Maximum	20
95th percentile	14.3

4.2 Background Soil Concentrations

Five background soil concentration samples were collected, 2 from Frank Holten State Park, 2 from the agricultural field southeast of the site, and 1 from the northwest edge of the ballfield. These locations and the measured concentrations are shown in Figure 3. Sample location BKG-4 was selected as a duplicate sample. For this location, the average of the original and duplicate result was used to determine the concentration at this location. Sample location BKG-5 was selected as the background sample location where the individual components of the composite sample were analyzed in addition to the composite. For determination of the average background soil concentration, only the composite result was used for consistency with the other samples. Comparison of the composite with the individual components is discussed in Section 4.7. The average background soil concentrations are given in Table 3.

Table 3. Average Background Radionuclide Concentrations

Radionuclide	Average (pCi/g)	Standard deviation (pCi/g)
Ra-226	2.14	0.66
Ra-228	1.31	0.40
U-238	1.20	0.54

These concentrations are used to determine the net radionuclide concentrations for the samples within each investigation block, i.e., the concentration in excess of background.

4.3 Gamma Survey Results

Figure 4 depicts the results of the gamma survey. The exposure rate ranges are based on the correlation of exposure rate with the Ra-226 concentration as discussed in more detail in Section 4.6. The lowest range is less than or equal to 34 µR/hr. This equates to those areas with a Ra-226 soil concentration of 5 pCi/g or less above background at the 95% confidence level. The next range is 34-44 µR/hr. 44 µR/hr is the average exposure rate that correlates to a Ra-226 soil concentration of 5 pCi/g above background. For the next level, 54 µR/hr equates to those areas with a Ra-226 soil concentration of 5 pCi/g or more *above* background at the 95% confidence level. As expected, the RDAs exhibit the highest radiation levels, with exposed bauxite residue measuring 54 µR/hr and higher. The highest radiation levels are within the IB-1a "canyons." These higher readings are due to the geometric effect of having exposed bauxite residue both underneath the detector and on the sides in close proximity.

Outside of the RDAs, the radiation levels are much lower. Most of the measurements in excess of 54 µR/hr exhibit identifiable patterns. The trends present in the radiation levels outside the RDAs are:

1 Surface deposition of bauxite residue eroded from RDA-1 results in increased radiation levels in the low-lying areas in IB-3c and the northwest portion of IB-3b.

2 Elevated levels are present in the southeast portion of IB-3b and are most likely associated with additional runoff from the area of the RDA-1 dike breach or may

also be associated with runoff from RDA-2 and erosion from the excavation along the south dike wall of RDA-2.

3 Elevated levels are present along the east edge of IB-4b near the railroad tracks.

4 Elevated radiation levels along the east portion of the ball fields correspond to areas where it is suspected that subsurface bauxite residue is present.

Core samples collected in the outflow area from the IB-1a dike breach indicated bauxite residue depths of 1.5 feet in the eastern portion of this area and 0.5 feet in the western portion. The bauxite residue appears to be limited to the top layer of soil and is underlain by cinders and native silts and clays. The vegetation in the areas exhibiting elevated radiation levels is dominated by phragmites with some interspersed light brush. A portion of this outflow area extends into the northern portion of the Paule property that has been cleared. A similar elevated area near the center of the Paule property along the access road to the site had a bauxite residue layer 1 to 2.5 feet below ground surface along with additional thin bauxite layers at greater depth. This location potentially had bauxite residue mixed with the clay in the top one foot as well.

The southeast portion of IB-3b is the lowest elevation area along the southern portion of the site and would logically accumulate runoff from other areas. No core samples were collected in this area as it is inaccessible by vehicle. An attempt to enter this area with a bulldozer by AMEC was unsuccessful, resulting in the bulldozer becoming buried above the height of the tracks immediately upon entry into the area. Under a thin hard crust, the underlying soil was very muddy and saturated with water. The hole made extracting the bulldozer filled with water to within a couple inches of the ground surface by the next day.

The core collected in the eastern portion of the ballfields indicated a layer of bauxite residue 7 feet thick at a depth of 4 feet overlaid by 3 feet of loose cinders and a one foot layer of brown clay at the surface, confirming the data from previous core samples which indicated buried bauxite residue. The measured dose rate was 22 µR/hr, less than the 34 µR/hr action level associated with areas below the 40 CFR 192 ARAR.

4.4 Surface Soil Sampling

21 soil samples were collected, 7 in IB's 1 and 2 combined, 9 in IB-3 and 5 in IB-4. Within IB-1 and IB-2, previous investigations had adequately sampled those areas. These samples were collected with the single purpose of establishing a correlation between soil concentrations and gamma survey exposure rates. The sample locations selected in IB-3 and IB-4 were based both on establishing a correlation between soil concentrations and gamma survey exposure rates and to obtain radiological data in areas where these had not previously been collected. More locations in IB-3 than in IB-4 were selected based on the larger amount of accessible area in IB-3 compared to IB-4.

All the selected locations were chosen based on the results of the gamma surveys. The locations were selected to correspond to the whole range of observed gamma exposure rate measurements for each investigation block and to provide broad geographic coverage of the areas.

The results of this sampling are shown in Figure 3 and in Table A1. The laboratory Level 4 reports are provided in Attachment C. The highlighted Ra-226 concentrations in Figure 3 are locations where the Ra-226 concentrations exceed 5 pCi/g above background, the 40 CFR 192.12(a) ARAR. All of these locations are associated with surface deposits of bauxite residue, both within the RDAs and outside of them. Outside the RDAs, 3 exceedances are in the downstream deposition area from the IB-1a dike breach. At other two locations, IB3-2 and IB3-3, the characteristic red-brown color of the bauxite residue was clearly visible.

None of the locations had concentrations in excess of 15 pCi/g above background. Therefore, all sampled locations would be in compliance with the 40 CFR 192.12(a) ARAR if a cover at least 6 inches thick is applied.

4.5 Subsurface Soil Sampling

Subsurface core samples were collected from areas outside the residue disposal areas. 10 core samples were collected, 7 within IB-3, 2 in IB-4, and 1 in IB-1. These locations, the sampled depth interval, and radionuclide concentrations are shown in Figure 5 and in Table A2. The location in IB-1 was in the outflow area from the dike breach and not within the confines of the original residue disposal area. The locations were selected based on professional judgment of locations that would contribute information potentially useful in designing a remediation plan. To that end, three locations (Cores 1, 2, and 3) were selected in the outflow area from the IB-1a dike breach area to determine the thickness of the surface bauxite residue layer in those areas. Two locations (Cores 4 and 8) were selected on the basis of elevated gamma survey measurements and observed surface deposits of bauxite residue. Two more (Cores 7 and 10) were chosen on the basis of elevated gamma survey measurements in areas which did not exhibit visible surface deposits of bauxite residue. The last three locations (Cores 5, 6, and 9) were selected as locations without elevated gamma survey measurements to characterize areas not otherwise covered.

Each core was surveyed to determine if any depth interval exhibited elevated measurements. No elevated measurements were noted in any of the cores. This is attributed to the limited amount of material from the relatively small diameter cores. The selection of a depth interval to sample was based on examination of the core logs. The core logs are provided in Appendix B. Cores typically contained layers of bauxite residue, cinders, carbon nodules mixed in clay, clays colored red-brown or various shades of gray, and sands and silts of various colors. If bauxite residue was observed in the core, a sample was taken from the depth interval containing the residue. If there was no bauxite residue present, the sampled interval was chosen to collect samples from the full spectrum of material types observed in all the cores.

All subsurface sampled intervals contained Ra-226 concentrations less than the 40 CFR 192.12(a) ARAR. Therefore, no further action is required for these locations. One core was sampled in the top 1 foot interval. This core (#1) is within the outflow area from the

IB-1a dike breach and is less than the 40 CFR 192.12(a) ARAR for subsurface soils but not for surface soils. As with the surface samples, compliance with the 40 CFR 192.12(a) ARAR would be achieved once a cover at least 6 inches thick is applied.

4.6 Correlation of Survey Measurements to Soil Concentrations

Soil Ra-226, Ra-228, and U-238 concentrations were compared with the gamma exposure rate measurements at the same locations. It was assumed that there was a linear relationship between the soil concentration and the exposure rate and that the data were normally distributed. This is consistent with the normally distributed measurement uncertainty used for soil concentrations. A simple linear regression analysis was performed on the data for each radionuclide.

Figure 6 plots the gamma exposure rates versus the sample Ra-226 concentrations. The mean correlation trend line is plotted along with confidence intervals corresponding to Type 1 and Type 2 error rates of 5%, or respective 95% confidence levels. For remediation purposes, Type 1 errors (underestimating the soil concentration) are the more significant. This is equivalent to a 95th percentile upper confidence limit. With a Type 1 error rate of 5%, a Ra-226 surface soil concentration of 7.14 pCi/g, 5 pCi/g above background, equates to an exposure rate of 34.41 µR/hr.

Figure 7 plots the gamma exposure rates versus the sample Ra-228 concentrations. The mean correlation trend line is plotted along with confidence intervals corresponding to Type 1 and 2 error rates of 5%. The correlation for Ra-228 is tighter than for Ra-226. This result is expected as Ra-228 and its decay products include more gamma emitters than does Ra-226 and its decay products. There is no proposed ARAR for Ra-228 soil concentrations. However, should the need arise to estimate Ra-228 soil concentrations from gamma exposure rate data, this correlation will permit such a determination.

For U-238, there is no correlation of exposure rate with soil concentration. This is unsurprising since U-238 decay products prior to Ra-226 do not emit many penetrating gamma rays which would contribute to ambient gamma exposure rates.

4.7 Soil Compositing Comparison

At three locations, the five individual pieces of the 5-point soil composite were analyzed separately. The purpose of this analysis was to determine if the composite sample was representative of the individual samples. To make this determination, two comparisons were made; 1) the average of the individual sample results was compared to the composite results, and 2) the individual results were compared to the uncertainty of the composite results. Since each sample was analyzed for three constituents, there are nine possible points of comparison.

Table 4 presents the comparison of the average of the individual sample results with the composite results. All but one result had a relative difference of less than one. In other words, the average concentration in the individual samples was less than the uncertainty in the composite results in all but one instance. This is well within the expected variability for data that are normally distributed, where approximately 2/3^{rds} of the results would be expected to have a relative difference less than 1.0.

Table 5 compares the distribution of the individual results with the uncertainty of the composite results. Of the 45 individual results, 34 have a relative difference of less than one. For a normally distributed population, the expectation would be that 30 would have a relative difference of less than one. Two individual results have a relative difference of greater than 2, the expected number for a normally distributed population. As with the previous comparison above, this result is consistent with the expected behavior of normally distributed data and well within the expected variability for that data.

Table 4. Comparison of Composite with Individual Sample Average.

	Composite pCi/g	Average pCi/g	Difference pCi/g	Relative Difference
BKG-5 Ra-226	1.35	1.71	0.37	0.80
BKG-5 Ra-228	1.69	1.74	0.05	0.08
BKG-5 U-238	1.10	0.92	0.19	0.69
IB1/2-4 Ra-226	8.05	10.19	2.14	1.54
IB1/2-4 Ra-228	11.74	12.23	0.49	0.49
IB1/2-4 U-238	3.11	2.96	0.15	0.31
IB3-6 Ra-226	2.34	2.11	0.22	0.35
IB3-6 Ra-228	1.64	1.47	0.16	0.28
IB3-6 U-238	1.25	1.04	0.22	0.74

Table 5. Individual Results Relative Difference.

Location	Relative Difference		
	Ra-226	Ra-228	U-238
BKG-5C	0.19	0.48	0.40
BKG-5E	0.78	0.67	1.22
BKG-5N	0.29	0.35	1.23
BKG-5S	0.00	0.54	0.21
BKG-5W	2.74	0.30	0.38
IB1/2-4A	1.22	0.73	0.53
IB1/2-4B	4.13	1.83	0.15
IB1/2-4C	1.28	0.69	0.04
IB1/2-4D	0.42	1.59	0.60
IB1/2-4E	0.64	0.44	0.23
IB3-6A	0.08	0.21	0.21
IB3-6B	0.86	0.08	0.40
IB3-6C	0.86	1.37	1.98
IB3-6D	0.34	0.45	1.38
IB3-6E	0.30	0.72	0.15

5. CONCLUSIONS

Gamma radiation level patterns exhibit logical patterns. The RDAs, with thick layers of bauxite residue, contain the highest radiation levels, with levels consistently more than 54 µR/hr. Outside the RDAs, elevated radiation levels are primarily limited to low-lying areas that have historically collected runoff from the RDAs. This is especially true for runoff from the breached dike of RDA-1. The radiation levels in areas that have collected runoff mostly exceed 34 µR/hr with surface bauxite residue thickness varying from a few inches to a couple feet. It is reasonable to assume that marshy areas or areas with standing water contain similar elevated areas as those that could be surveyed.

The gamma survey also demonstrated sensitivity to near-surface bauxite residue as evidenced by radiation levels and core logging in the area of the ball fields and on the Paule property. Bauxite at a depth of 1 foot was readily detectable on the Paule property, whereas deeper-buried material in the ball fields was less detectable. The material on the ballfields was overlain by low-density dry cinders which provide less shielding than would be provided by a soil cover of similar thickness.

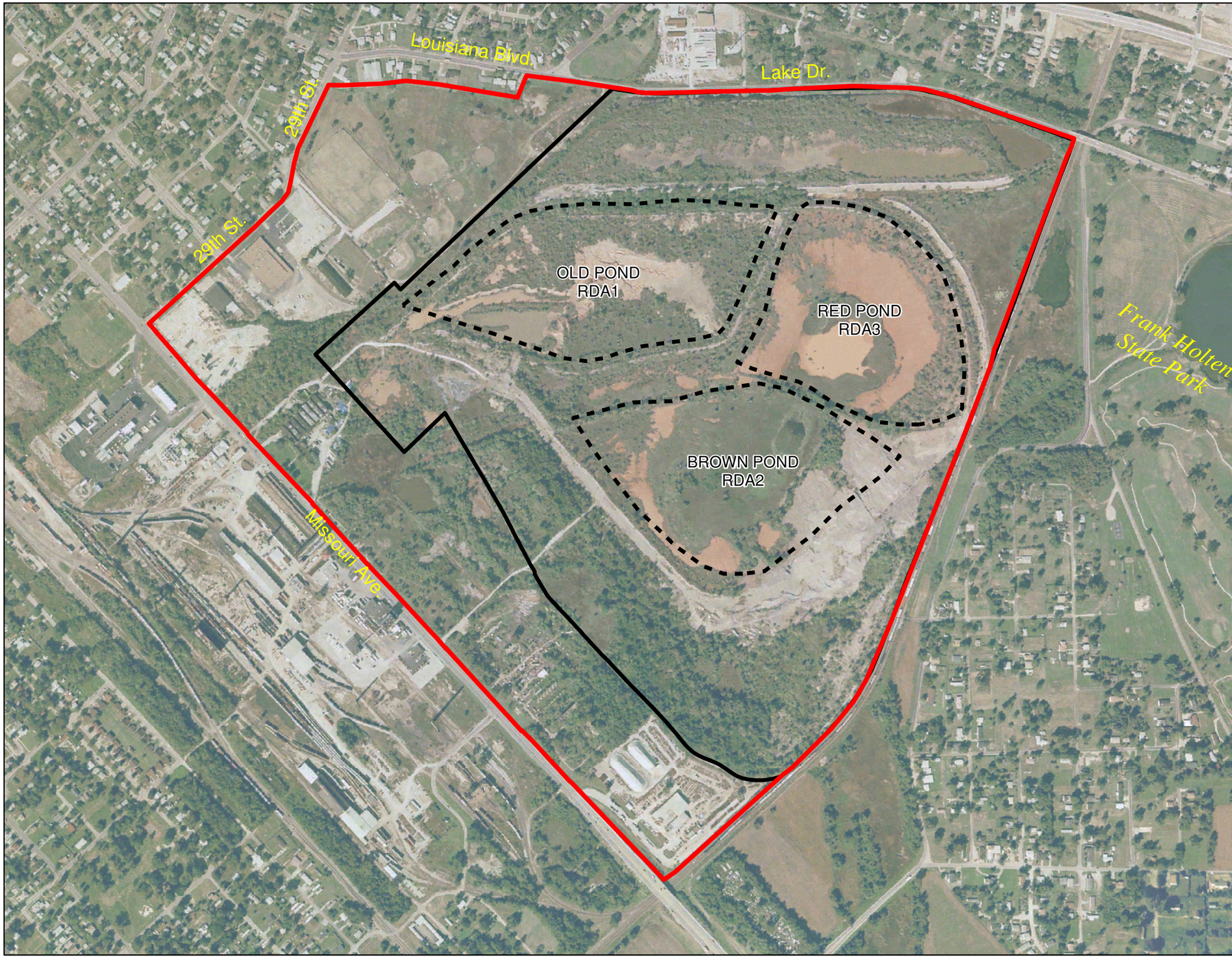
All soil samples in this investigation, as well as in the previous RI investigation, had Ra-226 concentrations less than 15 pCi/g above background. Soil samples of materials other than the bauxite residue had Ra-226 concentrations of less than 5 pCi/g above background. Therefore compliance with the 40 CFR 192.12(a) ARAR can be achieved by covering exposed bauxite residue with at least 6 inches of cover. For relatively thin surface layers of bauxite residue, such as in the outflow area from the IB-1a dike breach and portions of IB-3a and IB-3b, removal of the surficial layer of bauxite residue may be more effective and allow less restriction on the property use.

The measured gamma exposure rates correlated well with both the soil Ra-226 and Ra-228 concentrations, and did not correlate at all with the U-238 concentrations. For comparison to the 40 CFR 192.12(a) surface soils ARAR of 5 Ci/g above background for Ra-226, this equates to a gamma exposure rate of 34.41 µR/hr with a Type I (false

negative) error rate of 5%. Areas with exposure rates below this level averaged over 100 m^2 are in compliance with the 40 CFR 192.12(a) ARAR. Areas with exposure rates between 34 and 44 µR/hr may still be in compliance with the ARAR even though the gamma survey cannot confirm this with sufficient accuracy. ARAR compliance for these areas should be determined via soil sampling or remediation sufficient to reduce the dose rate to less than 34 µR/hr should be performed. Areas with exposure rates above 44 and especially 54 µR/hr require remediation for compliance with the ARAR.

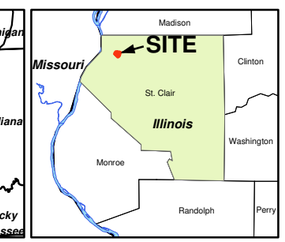
Comparison of the composite samples with the individual components of the composite samples demonstrated that the composite samples are consistent with the average concentration of the individual samples, the differences being within the expected statistical uncertainty. Therefore, the composite sample is an accurate representation of the average concentration of the individual components of the composite sample.

Figures



EXPLANATION

- Site Boundary
- Proposed Operable Unit No. 1 Boundary
- Mud Lakes



N

0 600 1,200

Feet

AERIAL PHOTOGRAPHY: SEPTEMBER 1, 2000

NORTH ALCOA SITE

EAST ST. LOUIS, ILLINOIS

FIGURE 1

SITE LOCATION MAP

PROJECT: 114-021309	DATE: DEC 14, 2011	
REV: 1	BY: SMM	CHECKED: JCM

TETRA TECH

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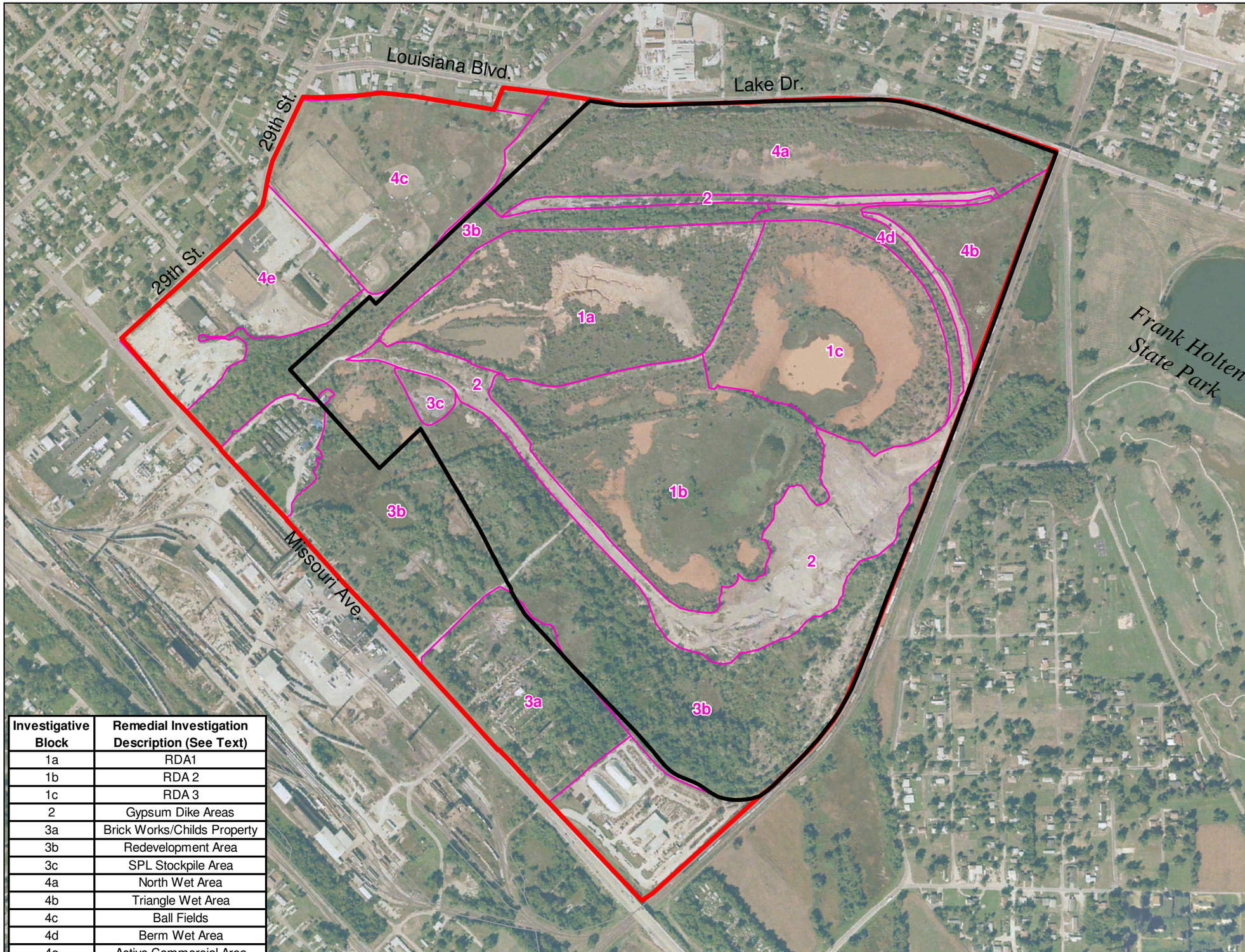
Path: E:\ESL\Rad Data\mxd\Site Map.mxd



Investigative Block	Remedial Investigation Description (See Text)
1a	RDA1
1b	RDA 2
1c	RDA 3
2	Gypsum Dike Areas
3a	Brick Works/Childs Property
3b	Redevelopment Area
3c	SPL Stockpile Area
4a	North Wet Area
4b	Triangle Wet Area
4c	Ball Fields
4d	Berm Wet Area
4e	Active Commercial Area

EXPLANATION

Proposed Operable Unit No. 1 Boundary

Site Boundary

Note:

1. Boundaries of Investigative Blocks were originally set forth in the Remedial Investigation Work Plan (2003). Several properties outside the proposed limits of Operable Unit No. 1 have changed ownership since that time.

N

0 600 1,200

Feet

NORTH ALCOA SITE
EAST ST. LOUIS, ILLINOIS

FIGURE 2

PROPOSED OPERABLE UNIT NO. 1 BOUNDARY

PROJECT: 114-021309	DATE: DEC 14, 2011	
REV: 1	BY: SMM	CHECKED: JCM

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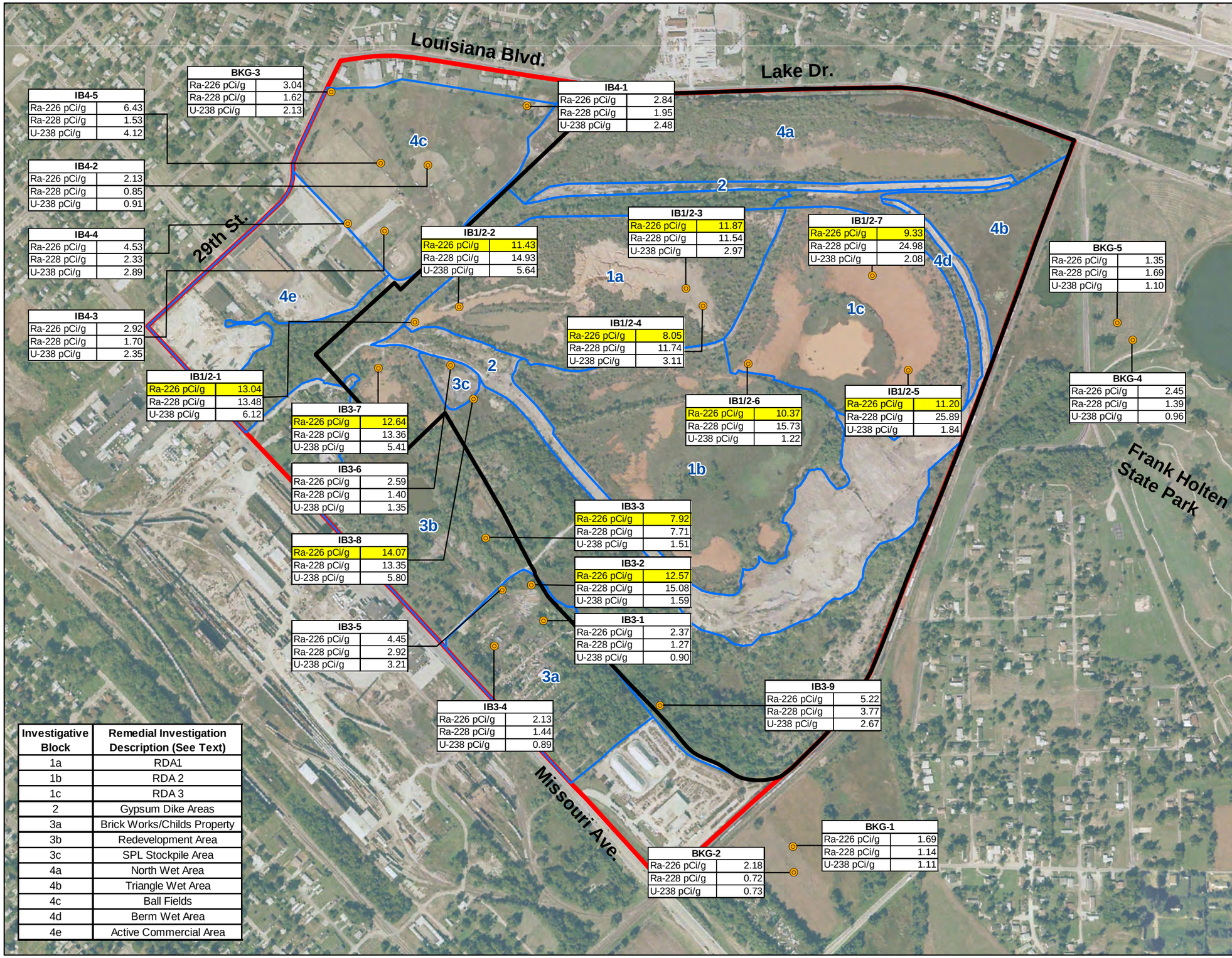
Path: E:\ESL\Rad Data\mxd\Proposed Operable Unit No1 Boundary.mxd

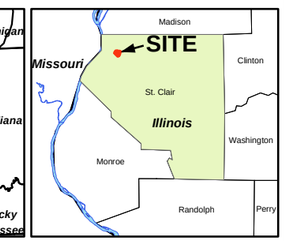


Investigative Block	Remedial Investigation Description (See Text)
1a	RDA1
1b	RDA 2
1c	RDA 3
2	Gypsum Dike Areas
3a	Brick Works/Childs Property
3b	Redevelopment Area
3c	SPL Stockpile Area
4a	North Wet Area
4b	Triangle Wet Area
4c	Ball Fields
4d	Berm Wet Area
4e	Active Commercial Area

EXPLANATION

- Surface Soil Sample
- Proposed Operable Unit No. 1 Boundary
- Investigative Block
- Site Boundary

Note: Highlighted measurements include concentrations greater than 5 pCi/g above background (40 CFR 192.12(a)).



N

0 600 1,200

Feet

AERIAL PHOTOGRAPHY: SEPTEMBER 1, 2000

NORTH ALCOA SITE

EAST ST. LOUIS, ILLINOIS

FIGURE 3

SURFACE SOIL SAMPLE RESULTS

PROJECT: 114-021362	DATE: JAN 6, 2012	
REV: 01	BY: SMM	CHECKED: JCM

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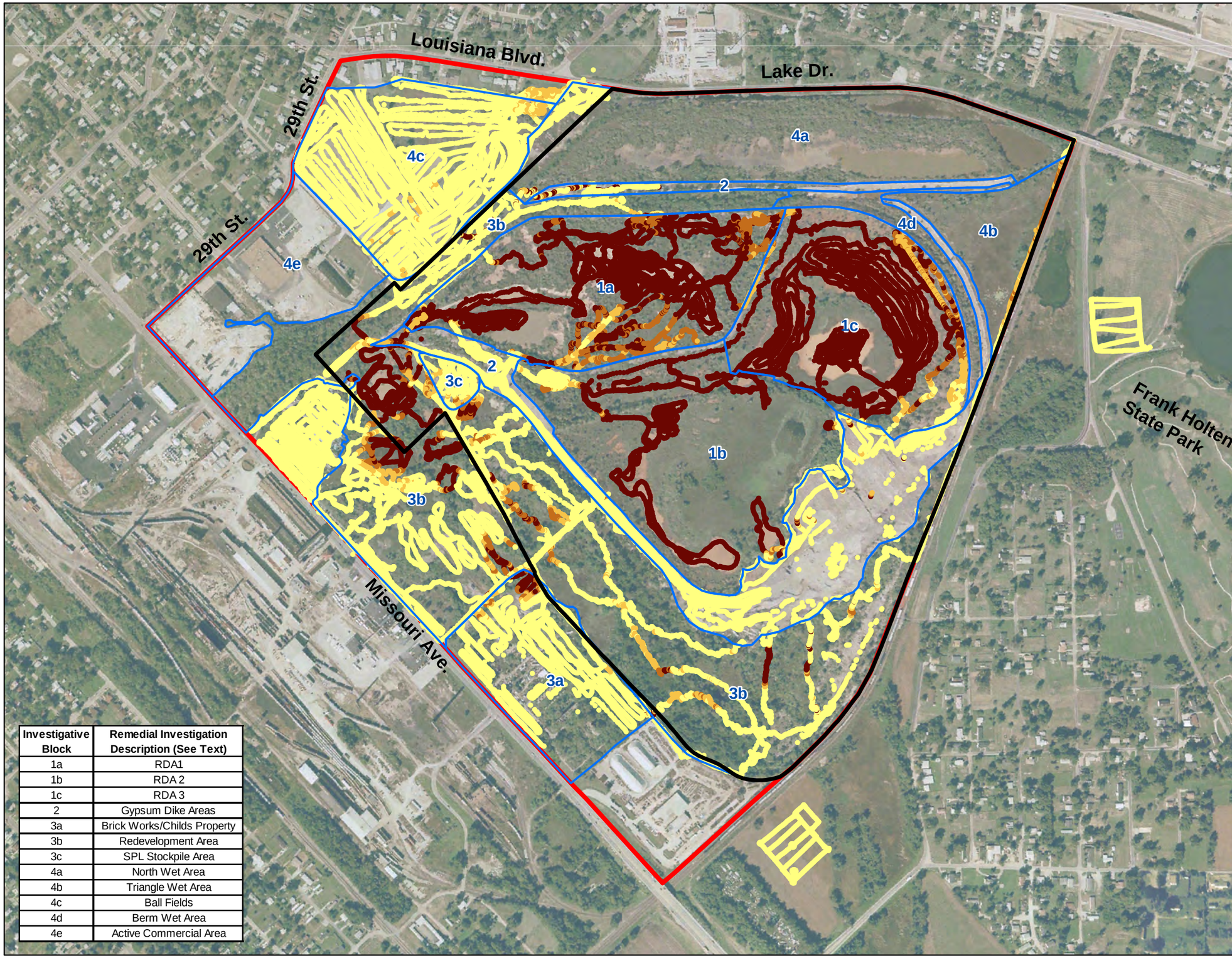

Investigative Block	Remedial Investigation Description (See Text)
1a	RDA1
1b	RDA 2
1c	RDA 3
2	Gypsum Dike Areas
3a	Brick Works/Childs Property
3b	Redevelopment Area
3c	SPL Stockpile Area
4a	North Wet Area
4b	Triangle Wet Area
4c	Ball Fields
4d	Berm Wet Area
4e	Active Commercial Area

EXPLANATION

Proposed Operable Unit No. 1 Boundary

Investigative Block

Site Boundary

Gamma Exposure Rate, µR/hr

- 0 - ≤ 34
- > 34 - ≤ 44
- > 44 - ≤ 54
- > 54

N

0 600 1,200

Feet

AERIAL PHOTOGRAPHY: SEPTEMBER 1, 2000

NORTH ALCOA SITE

EAST ST. LOUIS, ILLINOIS

FIGURE 4

GAMMA SURVEY RESULTS

PROJECT: 114-021362	DATE: JAN 6, 2012	
REV: 01	BY: SMM	CHECKED: JCM

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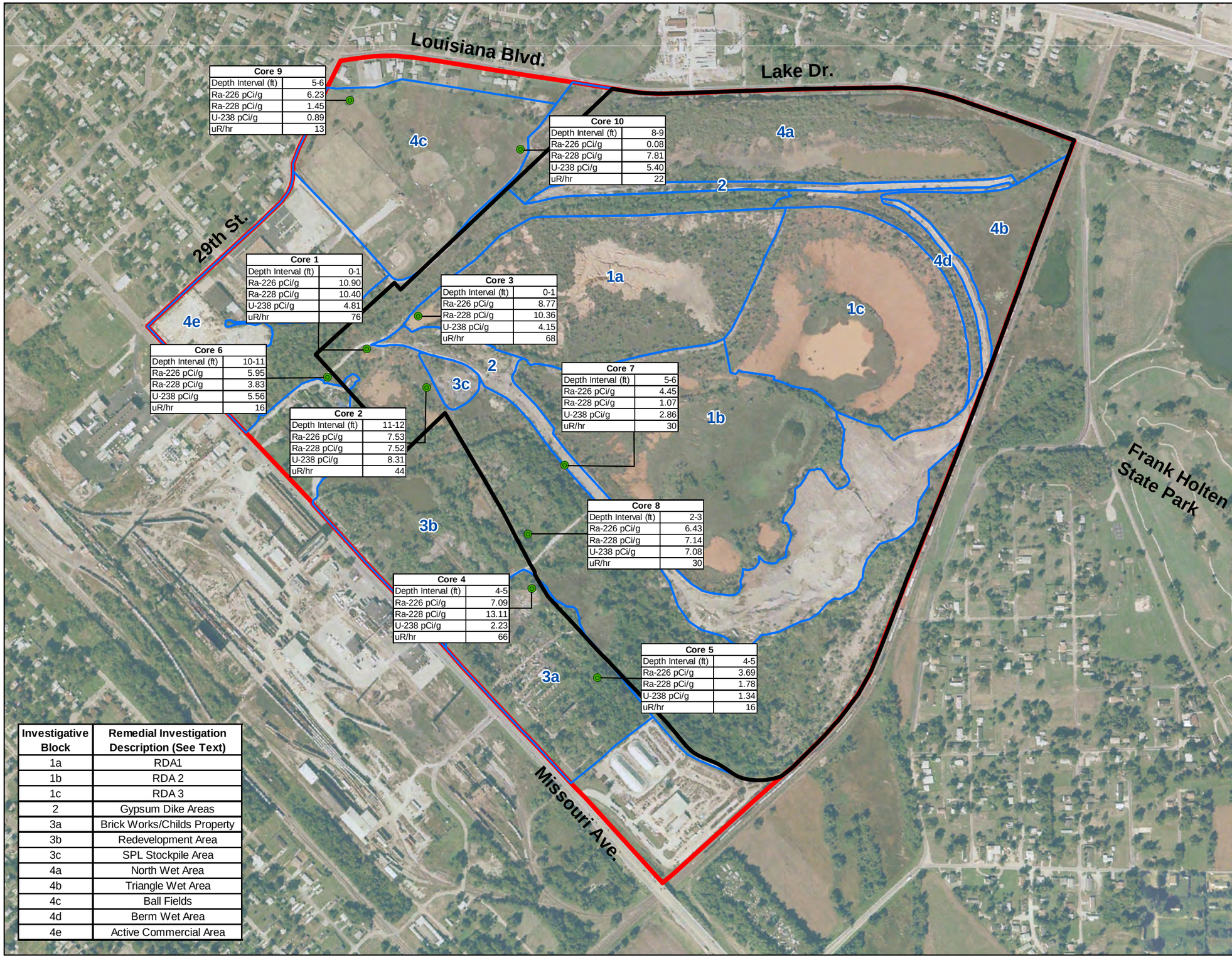
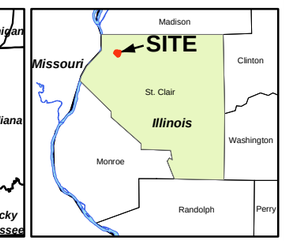


Investigative Block	Remedial Investigation Description (See Text)
1a	RDA1
1b	RDA 2
1c	RDA 3
2	Gypsum Dike Areas
3a	Brick Works/Childs Property
3b	Redevelopment Area
3c	SPL Stockpile Area
4a	North Wet Area
4b	Triangle Wet Area
4c	Ball Fields
4d	Berm Wet Area
4e	Active Commercial Area

EXPLANATION

- Soil Boring Location
- Proposed Operable Unit No. 1 Boundary
- Investigative Block
- Site Boundary



N

0 600 1,200

Feet

AERIAL PHOTOGRAPHY: SEPTEMBER 1, 2000

NORTH ALCOA SITE

EAST ST. LOUIS, ILLINOIS

FIGURE 5

SOIL BORING RESULTS

PROJECT: 114-021362	DATE: DEC 15, 2011	
REV: 01	BY: SMM	CHECKED: JCM

TETRA TECH

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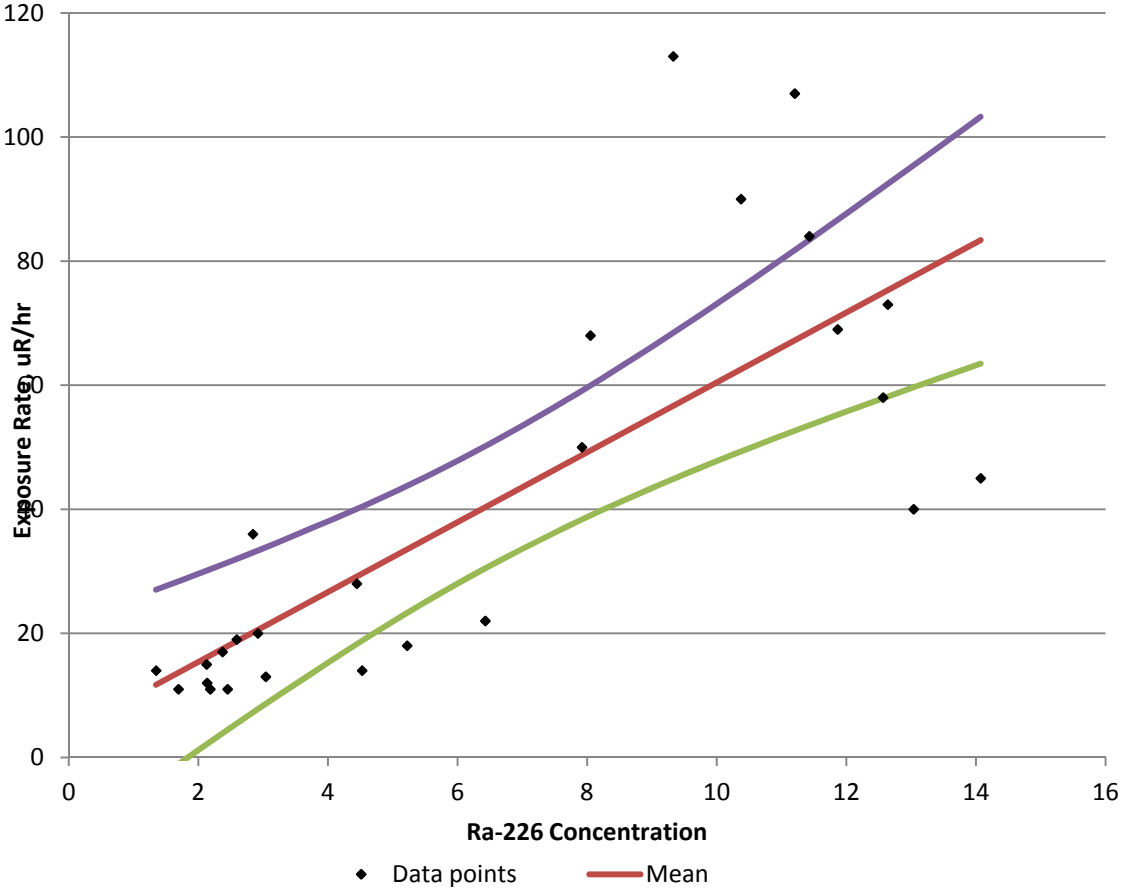

Figure 6. Exposure Rate Correlation with Ra-226 concentration

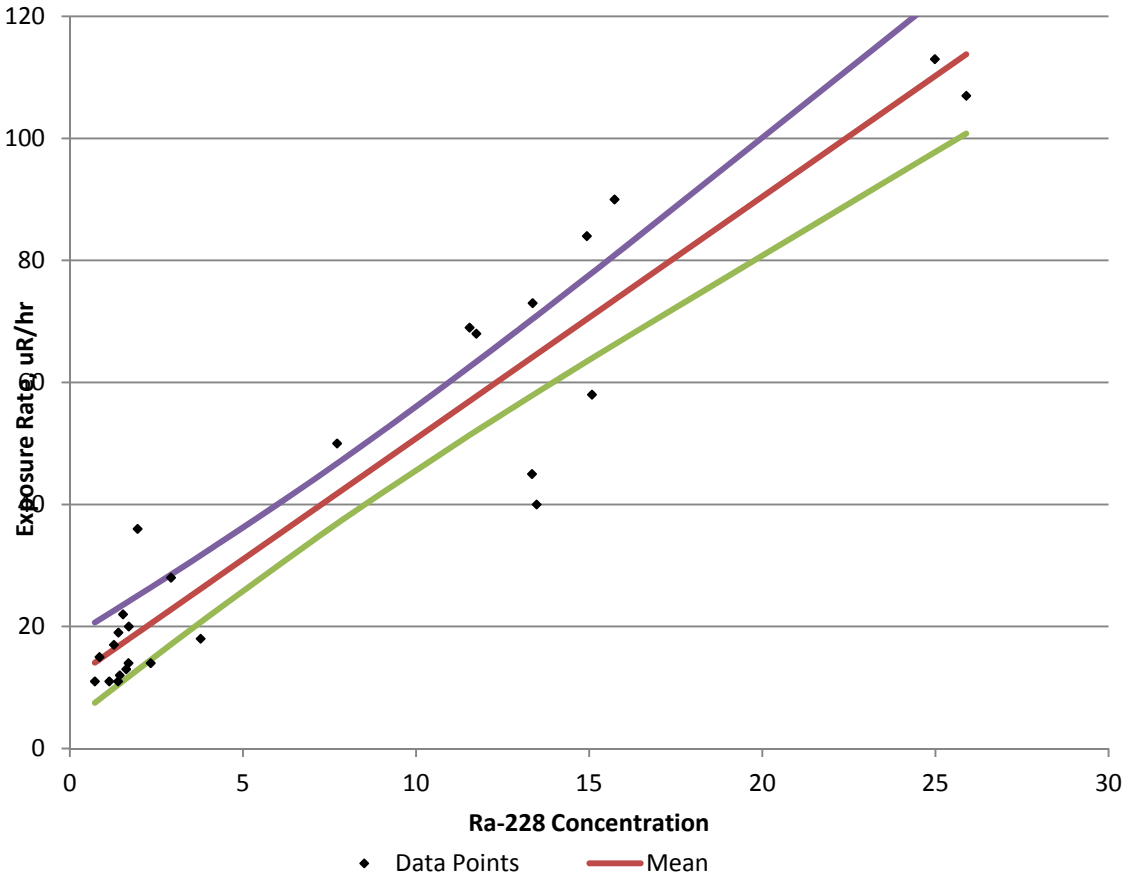

Figure 7. Exposure Rate Correlation with Ra-228 concentration

Appendix A

Soil Sample Analytical Results

Table A1. Surface Soil Sample Results

Sample ID	Easting	Northing	Sample Type	Ra-226 pCi/g	Ra-228 pCi/g	U-238 pCi/g
BKG-1	2310566	701953	TRG	1.69	1.14	1.11
BKG-2	2310572	701791	TRG	2.18	0.72	0.73
BKG-3	2307651	706708	TRG	3.04	1.62	2.13
BKG-4	2312710	705144	DO	1.93	1.43	1.01
BKG-4	2312710	705144	DUP	2.96	1.34	0.91
BKG-5	2312612	705253	TRG	1.35	1.69	1.10
BKG-5C	2312612	705253	TRG	1.43	2.01	0.99
BKG-5E	2312612	705253	TRG	1.70	1.24	0.77
BKG-5N	2312612	705253	TRG	1.48	1.92	0.77
BKG-5S	2312612	705253	TRG	1.35	2.05	1.04
BKG-5W	2312612	705253	TRG	2.60	1.49	1.00
IB1/2-1	2308179	705257	DO	12.51	12.97	6.26
IB1/2-1	2308179	705257	DUP	13.57	14.00	5.98
IB1/2-2	2308459	705354	TRG	11.43	14.93	5.64
IB1/2-3	2309890	705469	TRG	11.87	11.54	2.97
IB1/2-4	2309998	705359	TRG	8.05	11.74	3.11
IB1/2-4A	2309998	705359	TRG	9.75	11.00	2.85
IB1/2-4B	2309998	705359	TRG	13.79	13.59	3.04
IB1/2-4C	2309998	705359	TRG	9.83	11.04	3.09
IB1/2-4D	2309998	705359	TRG	8.64	13.35	2.82
IB1/2-4E	2309998	705359	TRG	8.94	12.19	3.00
IB1/2-5	2311294	704956	TRG	11.20	25.89	1.84
IB1/2-6	2310283	704996	TRG	10.37	15.73	1.22
IB1/2-7	2311068	705552	TRG	9.33	24.98	2.08
IB3-1	2308992	703377	TRG	2.37	1.27	0.90
IB3-2	2308915	703600	TRG	12.57	15.08	1.59
IB3-3	2308627	703896	TRG	7.92	7.71	1.51
IB3-4	2308681	703217	TRG	2.13	1.44	0.89
IB3-5	2308731	703571	TRG	4.45	2.92	3.21
IB3-6	2308404	704985	DO	2.34	1.64	1.25
IB3-6	2308404	704985	DUP	2.84	1.17	1.44
IB3-6A	2308404	704985	TRG	2.29	1.51	1.32
IB3-6B	2308404	704985	TRG	1.79	1.59	1.14
IB3-6C	2308404	704985	TRG	1.79	0.83	0.67
IB3-6D	2308404	704985	TRG	2.55	1.37	0.85
IB3-6E	2308404	704985	TRG	2.15	2.06	1.21
IB3-7	2307949	704969	TRG	12.64	13.36	5.41
IB3-8	2308550	704774	TRG	14.07	13.35	5.80
IB3-9	2309727	702842	TRG	5.22	3.77	2.67
IB4-1	2308887	706620	TRG	2.84	1.95	2.48
IB4-2	2308261	706248	TRG	2.13	0.85	0.91

Sample ID	Easting	Northing	Sample Type	Ra-226 pCi/g	Ra-228 pCi/g	U-238 pCi/g
IB4-3	2307987	705831	TRG	2.92	1.70	2.35
IB4-4	2307755	705877	TRG	4.53	2.33	2.89
IB4-5	2307963	706259	TRG	6.43	1.53	4.12

Table A2. Subsurface Sample Results

Sample ID	Easting	Northing	Sample Type	Ra-226 pCi/g	Ra-228 pCi/g	U-238 pCi/g
CORE 1 0-1	2307876	705088	DO	12.46	10.99	4.76
CORE 1 0-1	2307876	705088	DUP	9.39	9.77	4.85
CORE 2 11-12	2308199	705296	TRG	7.53	7.52	8.31
CORE 3 2-3	2308918	703579	TRG	8.77	10.36	4.15
CORE 4 4-5	2309331	703018	TRG	7.09	13.11	2.23
CORE 5 4-5	2307627	704910	TRG	3.69	1.78	1.34
CORE 6 10-11	2309125	704356	TRG	5.95	3.83	5.56
CORE 7 5-6	2308894	703922	TRG	4.45	1.07	2.86
CORE 8 2-3	2307769	706655	TRG	6.43	7.14	7.08
CORE 9 5-6	2308846	706346	TRG	6.23	1.45	0.89
CORE 10 8-9	2308253	704844	TRG	0.08	7.81	5.40

Appendix B

Core Logs

LUST Incident No.:	Boring Number: Core 1	Page 1 of 1
Site Name: ALCOA Address:	Boring Location	Date: 11/17/11 Start 12:15 Finish 12:45

Sample Number	Sample Device	Sample Recovery	Lithology Symbol	Depth (feet)	Detailed Soil and Rock Description	Natural Moisture Content %	Hand Penetrometer	OVA/PID/FID/OVM	Remarks
		3		1	Lt brn Bauxite wet v. plastic		2.5		
				2	Lt. brn CL w Fe stain and carbon nodules moist		2.5		
				3			2		
		3		4	Buff silt wet		2.5		
				5			2		
		3		6			1		
				7			1		
				8			1		
		3		9	Blk cinders sat loose		0		
				10					
				11	Brn-gray silt moist		0		
				12			1.5		

Note: Stratification lines are approximate; in-situ transition between soil types may be gradual.

Groundwater Data		
▼ Depth While Drilling _____ ▽ Depth After Drilling _____	Auger Depth _____ Rig _____ Rotary Depth _____ Geologist _____ Driller/Co _____ Note: Boring backfilled unless otherwise noted	Illinois Environmental Protection Agency

IL 532-2275
LPC 501 Rev June 2004

The Agency is authorized to require this information under 415 ILCS 5/4 and 21. Disclosure of this information is required. Failure to do so may result in a civil penalty up to $25,000.00 for each day failure continues, a fine up to $50,000.00 and imprisonment up to five years. This form has been approved by the Forms Management Center.

LUST Incident No.:	Boring Number: Core 2	Page 1 of 1
Site Name: ALCOA Address:	Boring Location	Date: 11/12/11 Start 13:15 Finish 13:30

Sample Number	Sample Device	Sample Recovery	Lithology Symbol	Depth (feet)	Detailed Soil and Rock Description	Natural Moisture Content %	Hand Penetrometer	OVA/PID/FID/OVM	Remarks
					Red Brn Bauxite	wet	1		
		2'		1	Blk clayey cinders wet		1.5		
				2			1.5		
				3					
				4	Red-Brn sand wet		0		
		2.5		5	Brn silt		0		
				6	Red-Brn sand saturated		1		
				7	fine grn well rounded well sorted		0		
		3		8			0		
				9			0		
		3		10			0		
				11	Red-Brn silt wet		1		

Note: Stratification lines are approximate; in-situ transition between soil types may be gradual.

Groundwater Data		
▼ Depth While Drilling _____ ▽ Depth After Drilling _____	Auger Depth _____ Rig _____ Rotary Depth _____ Geologist _____ Driller/Co _____ Note: Boring backfilled unless otherwise noted	Illinois Environmental Protection Agency

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LUST Incident No.:	Boring Number: Core 3	Page 1 of 1
Site Name: ALCOA Address:	Boring Location	Date: 11/17/11 Start 13:45 Finish 14:05

Sample Number	Sample Device	Sample Recovery	Lithology Symbol	Depth (feet)	Detailed Soil and Rock Description	Natural Moisture Content %	Hand Penetrometer	OVA/PID/FID/OVM	Remarks
		3		1	Red-Brn Bauxite wet plastic		1.5		
				2			1.5		
				3			1.5		
		3		4			1.5		
				5			1.5		
				6			1.5		
		3		7			1.5		
				8	Brn sand fine grn well rounded well sorted		0		
				9	Saturated		0		
		3		10	Blk cinders Brn sand		0 0		
				11	Brn-gray silt		1		

Note: Stratification lines are approximate; in-situ transition between soil types may be gradual.

Groundwater Data		
▼ Depth While Drilling _____ ▽ Depth After Drilling _____	Auger Depth _____ Rig _____ Rotary Depth _____ Geologist _____ Driller/Co _____ Note: Boring backfilled unless otherwise noted	Illinois Environmental Protection Agency

IL 532-2275
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LUST Incident No.:	Boring Number: Core 4	Page 1 of 1
Site Name: ALCOA Address:	Boring Location	Date: 11/17/4 Start 14:10 Finish 14:35

Sample Number	Sample Device	Sample Recovery	Lithology Symbol	Depth (feet)	Detailed Soil and Rock Description	Natural Moisture Content %	Hand Penetrometer	OVA/PID/FID/OVM	Remarks
					Red-Brn CL dry		4		
		2.5		1	Red-Brn Bauxite wet plastic		1.5		
				2					
				3	Red-Brn CL dry		1		
				4	Red-Brn Bauxite wet		1.5		
		3		5	Brn sand dry v. fine well sorted		0		
				6	Red-Brn sand dry		0		
				7	Red-Brn CL dry		1.5		
		3		8	Brn sand dry		0		
					Red-Brn Bauxite wet				
				9	Dark gray-Blk CL moist		1		
		3		10	Gray CL w/carbon nodules moist plastic		2		
				11			2		
							2		

Note: Stratification lines are approximate; in-situ transition between soil types may be gradual.

Groundwater Data		
▼ Depth While Drilling _____	Auger Depth _____ Rig _____	Illinois Environmental Protection Agency
▽ Depth After Drilling _____	Rotary Depth _____ Geologist _____	
	Driller/Co _____	
	Note: Boring backfilled unless otherwise noted	

IL 532-2275
LPC 501 Rev June 2004

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LUST Incident No.:	Boring Number: Core 5	Page 1 of 1
Site Name: ALCOA Address:	Boring Location	Date: 11/17/4 Start 14:45 Finish 15:20

Sample Number	Sample Device	Sample Recovery	Lithology Symbol	Depth (feet)	Detailed Soil and Rock Description	Natural Moisture Content %	Hand Penetrometer	OVA/PID/FID/OVM	Remarks
				1	Dk gray - Blk CL moist		1		
		3		2	Blk cinders loose moist		0		
				3			0		
				4	Dark gray - Blk CL moist plastic		2		
		3		5	grading to brn-gray		2.5		
				6			2		
				7			1.5		
		3		8	Brn silt moist		1		
				9			1		
		3		10			1		
				11			1		

Note: Stratification lines are approximate; in-situ transition between soil types may be gradual.

Groundwater Data

▼ Depth While Drilling _____

▽ Depth After Drilling _____

Auger Depth _____ Rig _____

Rotary Depth _____ Geologist _____

Driller/Co _____

Note: Boring backfilled unless otherwise noted

Illinois Environmental Protection Agency

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LUST Incident No.:	Boring Number: Core 6	Page 1 of 1
Site Name: ALCOA Address:	Boring Location	Date: 11/17/11 Start 1555 Finish 16:20

Sample Number	Sample Device	Sample Recovery	Lithology Symbol	Depth (feet)	Detailed Soil and Rock Description	Natural Moisture Content %	Hand Penetrometer	OVA/PID/FID/OVM	Remarks
		3		1	Drk gray - Blk cinders loose dry		0		
				2			0		
				3	Lt. Brn silt dry		3		
		3		4	Blk cinders loose dry		0		
				5	Lt Brn-Buff silt wet		1.5		
				6					
		2		7	Red-Brn Cinders Saturated		0		
				8			0		
				9	Drk Brn cinders		0		
		3		10	Blk cinders wet		0		
				11	Buff silt moist		2		
					Brn-gray silt moist		3		

Note: Stratification lines are approximate; in-situ transition between soil types may be gradual.

Groundwater Data		
▼ Depth While Drilling _____ ▽ Depth After Drilling _____	Auger Depth _____ Rig _____ Rotary Depth _____ Geologist _____ Driller/Co _____ Note: Boring backfilled unless otherwise noted	Illinois Environmental Protection Agency

IL 532-2275
LPC 501 Rev June 2004

The Agency is authorized to require this information under 415 ILCS 5/4 and 21. Disclosure of this information is required. Failure to do so may result in a civil penalty up to $25,000.00 for each day failure continues, a fine up to $50,000.00 and imprisonment up to five years. This form has been approved by the Forms Management Center.

LUST Incident No.:	Boring Number: Core 7	Page 1 of 1
Site Name: ALCOA Address:	Boring Location	Date: 11/18/11 Start 8:00 Finish 8:30

Sample Number	Sample Device	Sample Recovery	Lithology Symbol	Depth (feet)	Detailed Soil and Rock Description	Natural Moisture Content %	Hand Penetrometer	OVA/PID/FID/OVM	Remarks
					Brn CL moist		1		
		2		1	Dark Brn silt moist		0.5		
				2	Lt gray gysum dry loose		0		
				3	Dark brn cinders loose dry		0		
		3		4	Blk cinders wet loose		0		
				5			0		
				6			0		
		3		7	Saturated		0		
				8			0		
				9	Blk silt v. moist		1.0		
		3		10			1.0		
				11			1.0		
							1.0		

Note: Stratification lines are approximate; in-situ transition between soil types may be gradual.

Groundwater Data		
▼ Depth While Drilling _____ ▽ Depth After Drilling _____	Auger Depth _____ Rig _____ Rotary Depth _____ Geologist _____ Driller/Co _____ Note: Boring backfilled unless otherwise noted	Illinois Environmental Protection Agency

IL 532-2275
LPC 501 Rev June 2004

The Agency is authorized to require this information under 415 ILCS 5/4 and 21. Disclosure of this information is required. Failure to do so may result in a civil penalty up to $25,000.00 for each day failure continues, a fine up to $50,000.00 and imprisonment up to five years. This form has been approved by the Forms Management Center.

LUST Incident No.:	Boring Number: Core 8	Page 1 of 1
Site Name: ALCOA Address:	Boring Location	Date: 11/18/11 Start 8:45 Finish 9:15

Sample Number	Sample Device	Sample Recovery	Lithology Symbol	Depth (feet)	Detailed Soil and Rock Description	Natural Moisture Content %	Hand Penetrometer	OVA/PID/FID/OVM	Remarks
					Brn CL w/cinders loose moist		0.5		
				1	Blk cinders loose moist		0		
		3		2	Brn CL moist		1.0		
				3			1.0		
				4	Dark gray CL w/carbon nodules moist				
		3		5			1.0		
				6			1.0		
				7			1.0		
		3		8			1.0		
				9			1.0		
		3		10			1.0		
				11	Dark gray silt slimoist		1.0		

Note: Stratification lines are approximate; in-situ transition between soil types may be gradual.

Groundwater Data

▼ Depth While Drilling _____

▽ Depth After Drilling _____

Auger Depth _____ Rig _____

Rotary Depth _____ Geologist _____

Driller/Co _____

Note: Boring backfilled unless otherwise noted

Illinois Environmental Protection Agency

IL 532-2275
LPC 501 Rev June 2004

The Agency is authorized to require this information under 415 ILCS 5/4 and 21. Disclosure of this information is required. Failure to do so may result in a civil penalty up to $25,000.00 for each day failure continues, a fine up to $50,000.00 and imprisonment up to five years. This form has been approved by the Forms Management Center.

LUST Incident No.:	Boring Number: Core 9	Page 1 of 1
Site Name: ALCOA Address:	Boring Location	Date: 11/18/11 Start 9:30 Finish 10:00

Sample Number	Sample Device	Sample Recovery	Lithology Symbol	Depth (feet)	Detailed Soil and Rock Description	Natural Moisture Content %	Hand Penetrometer	OVA/PID/FID/OVM	Remarks
		3		1	Gray CL w/carbon nodules moist		1.5		
				2			2		
				3			3		
		3		4			3		
				5			2.5		
				6			2		
		3		7	Brn sandy silt moist		2		
				8			1.0		
				9			1.0		
		3		10	saturated		2		
				11			2		

Note: Stratification lines are approximate; in-situ transition between soil types may be gradual.

Groundwater Data		
▼ Depth While Drilling _____ ▽ Depth After Drilling _____	Auger Depth _____ Rig _____ Rotary Depth _____ Geologist _____ Driller/Co _____ Note: Boring backfilled unless otherwise noted	Illinois Environmental Protection Agency

IL 532-2275
LPC 501 Rev June 2004

The Agency is authorized to require this information under 415 ILCS 5/4 and 21. Disclosure of this information is required. Failure to do so may result in a civil penalty up to $25,000.00 for each day failure continues, a fine up to $50,000.00 and imprisonment up to five years. This form has been approved by the Forms Management Center.

LUST Incident No.:	Boring Number: Core 10	Page of
Site Name:	Boring Location	Date: 11/18/14 Start 10:20
Address:		Finish

Sample Number	Sample Device	Sample Recovery	Lithology Symbol	Depth (feet)	Detailed Soil and Rock Description	Natural Moisture Content %	Hand Penetrometer	OVA/PID/FID/OVM	Remarks
		2		1	Brn CL moist		2		
				2	Drk Brn-Blk cinders loose dry		0		
				3			0		
				4			0		
		3		5	Red-Brn Bauxite wet		0		
				6			2		
		3		7			2		
				8			2		
				9			2		
		3		10	saturated		2		
				11	Drk gray-Blk CL moist		0.5		
							1.5		

Note: Stratification lines are approximate; in-situ transition between soil types may be gradual.

Groundwater Data

▼ Depth While Drilling _____

▽ Depth After Drilling _____

Auger Depth _____ Rig _____

Rotary Depth _____ Geologist _____

Driller/Co _____

Note: Boring backfilled unless otherwise noted

Illinois Environmental Protection Agency

IL 532-2275
LPC 501 Rev June 2004

The Agency is authorized to require this information under 415 ILCS 5/4 and 21. Disclosure of this information is required. Failure to do so may result in a civil penalty up to $25,000.00 for each day failure continues, a fine up to $50,000.00 and imprisonment up to five years. This form has been approved by the Forms Management Center.

Appendix C

Laboratory Analytical Data Reports

Appendix C – Laboratory Analytical Data Reports will be included on CD in the hardcopy report.

APPENDIX D
PROUCL INPUTS/OUTPUTS AND OU-1 RISK SPREADSHEETS

	A	B	C	D	E	F
1	Appendix D: FFS OU1 IB-3 Surface Soil Data: Input to ProUCL for Table 2-4.					
2						
3	As OU1 IB3 SS Samples	BaA OU1 IB3 SS samples	BaP OU1 IB3 SS samples	BbF OU1 IB3 SS samples	DahA OU1 IB3 SS samples	IP OU1 IB3 SS Samples
4	16.4	270	330	360	65	230
5	11.3	450	450	440	48	380
6	17.5	27	22	34	0.8	12
7	26.2	1200	1400	1600	170	980
8	9.63	200	240	210	95	250
9	23.6	59	54	58	6.8	40
10	19.4	4.4	6.4	7.6	3.1	5.8
11	1.92	8.6	11	12	2	10
12	29.4	16	20	21	3.6	23
13	1.77	22	23	24	4.15	19
14	5.81	7100	5800	5900	510	4800
15	5.3	170	220	240	29	220
16	15.4	23	30	31	4.6	30
17	28.6	5.8	7.3	6.7	1.9	6.6
18	7.39	40	59	51	5	59
19	19.8	4.9	7.1	7.7	1.9	6.4
20	13.7	53	63	52	7.5	65
21	10.2	46	51	54	33	47
22	3.9	140	160	140	16	150
23	20.3	4700	4500	3600	420	3600
24	10.5	0.5	0.5	0.5	3.1	24
25	5.21	42	40	45		
26						
27	Vanadium OU1 IB3 SS	Sample IDs				
28	85.8	3bUP001-090503SO01				
29	56.6	3bUP002-090503SO01				
30	69.3	3bUP003-090503SO01				
31	60.7	3bUP004-090503SO01				
32	36.5	3bUP005-090503SO01				
33	277	3bUP007-090403SO01				
34	191	3bUP009-090503SO01				
35	11.3	3bUP011-090403SO01				
36	335	3bUP015-090403SO01				
37	17.2	3bUP017-090303SO01				
38	27.7	3bUP019-090303SO01				
39	38.7	3bUP020-090303SO01				
40	31.4	3bUP021-090303SO01				
41	151	3bUP022-090303SO01				
42	36.1	3bUP023-090303SO01				
43	813	3bUP024-090303SO01				
44	333	3bUP025-090303SO01				
45	72	3bUP026-090303SO01				
46	30.8	3bUP027-090303SO01				
47	646	3bUP028-090303SO01				
48	67.1	3bUP029-090303SO01				
49	13.3	3bUP030-090303SO01				

	A	B	C	D	E	F	G	H	I	J	K	L
1				Appendix D:	FFS OU1 IB3 Surface Soil COPC Data - ProUCL Output							
2			User Selected Options									
3				From File	WorkSheet.wst							
4				Full Precision	OFF							
5				Confidence Coefficient	95%							
6				Number of Bootstrap Operations	2000							
7												
8												
9	As OU1 IB3 SS Samples											
10												
11						General Statistics						
12						Number of Valid Observations	22			Number of Distinct Observations		22
13												
14						Raw Statistics				Log-transformed Statistics		
15						Minimum	1.77			Minimum of Log Data		0.571
16						Maximum	29.4			Maximum of Log Data		3.381
17						Mean	13.78			Mean of log Data		2.371
18						Geometric Mean	10.71			SD of log Data		0.814
19						Median	12.5					
20						SD	8.528					
21						Std. Error of Mean	1.818					
22						Coefficient of Variation	0.619					
23						Skewness	0.348					
24												
25						Relevant UCL Statistics						
26						Normal Distribution Test				Lognormal Distribution Test		
27						Shapiro Wilk Test Statistic	0.95			Shapiro Wilk Test Statistic		0.919
28						Shapiro Wilk Critical Value	0.911			Shapiro Wilk Critical Value		0.911
29						Data appear Normal at 5% Significance Level				Data appear Lognormal at 5% Significance Level		
30												
31						Assuming Normal Distribution				Assuming Lognormal Distribution		
32						95% Student's-t UCL	16.91			95% H-UCL		22.6
33						95% UCLs (Adjusted for Skewness)				95% Chebyshev (MVUE) UCL		26.71
34						95% Adjusted-CLT UCL (Chen-1995)	16.92			97.5% Chebyshev (MVUE) UCL		31.94
35						95% Modified-t UCL (Johnson-1978)	16.93			99% Chebyshev (MVUE) UCL		42.21
36												
37						Gamma Distribution Test				Data Distribution		
38						k star (bias corrected)	1.871			Data appear Normal at 5% Significance Level		
39						Theta Star	7.366					
40						MLE of Mean	13.78					
41						MLE of Standard Deviation	10.08					
42						nu star	82.33					
43						Approximate Chi Square Value (.05)	62.42			Nonparametric Statistics		
44						Adjusted Level of Significance	0.0386			95% CLT UCL		16.77
45						Adjusted Chi Square Value	61.13			95% Jackknife UCL		16.91
46										95% Standard Bootstrap UCL		16.72
47						Anderson-Darling Test Statistic	0.312			95% Bootstrap-t UCL		16.99
48						Anderson-Darling 5% Critical Value	0.755			95% Hall's Bootstrap UCL		17.07
49						Kolmogorov-Smirnov Test Statistic	0.107			95% Percentile Bootstrap UCL		16.65
50						Kolmogorov-Smirnov 5% Critical Value	0.188			95% BCA Bootstrap UCL		16.67
51						Data appear Gamma Distributed at 5% Significance Level				95% Chebyshev(Mean, Sd) UCL		21.71
52										97.5% Chebyshev(Mean, Sd) UCL		25.14
53						Assuming Gamma Distribution				99% Chebyshev(Mean, Sd) UCL		31.87
54						95% Approximate Gamma UCL (Use when n >= 40)	18.18					
55						95% Adjusted Gamma UCL (Use when n < 40)	18.56					
56												
57						Potential UCL to Use				Use 95% Student's-t UCL		16.91
58												
59	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
60	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
61	and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.											

	A	B	C	D	E	F	G	H	I	J	K	L
62												
63												
64	BaA OU1 IB3 SS samples											
65												
66						General Statistics						
67					Number of Valid Observations	22					Number of Distinct Observations	22
68												
69					Raw Statistics						Log-transformed Statistics	
70					Minimum	0.5					Minimum of Log Data	-0.693
71					Maximum	7100					Maximum of Log Data	8.868
72					Mean	662.8					Mean of log Data	4.063
73					Geometric Mean	58.14					SD of log Data	2.292
74					Median	44						
75					SD	1755						
76					Std. Error of Mean	374.1						
77					Coefficient of Variation	2.647						
78					Skewness	3.187						
79												
80						Relevant UCL Statistics						
81					Normal Distribution Test						Lognormal Distribution Test	
82					Shapiro Wilk Test Statistic	0.426					Shapiro Wilk Test Statistic	0.973
83					Shapiro Wilk Critical Value	0.911					Shapiro Wilk Critical Value	0.911
84					Data not Normal at 5% Significance Level						Data appear Lognormal at 5% Significance Level	
85												
86					Assuming Normal Distribution						Assuming Lognormal Distribution	
87					95% Student's-t UCL	1307					95% H-UCL	8410
88					95% UCLs (Adjusted for Skewness)						95% Chebyshev (MVUE) UCL	2118
89					95% Adjusted-CLT UCL (Chen-1995)	1550					97.5% Chebyshev (MVUE) UCL	2787
90					95% Modified-t UCL (Johnson-1978)	1349					99% Chebyshev (MVUE) UCL	4100
91												
92					Gamma Distribution Test						Data Distribution	
93					k star (bias corrected)	0.277					Data appear Lognormal at 5% Significance Level	
94					Theta Star	2393						
95					MLE of Mean	662.8						
96					MLE of Standard Deviation	1259						
97					nu star	12.19						
98					Approximate Chi Square Value (.05)	5.35					Nonparametric Statistics	
99					Adjusted Level of Significance	0.0386					95% CLT UCL	1278
100					Adjusted Chi Square Value	5.015					95% Jackknife UCL	1307
101											95% Standard Bootstrap UCL	1259
102					Anderson-Darling Test Statistic	1.831					95% Bootstrap-t UCL	4341
103					Anderson-Darling 5% Critical Value	0.854					95% Hall's Bootstrap UCL	5227
104					Kolmogorov-Smirnov Test Statistic	0.249					95% Percentile Bootstrap UCL	1350
105					Kolmogorov-Smirnov 5% Critical Value	0.202					95% BCA Bootstrap UCL	1620
106					Data not Gamma Distributed at 5% Significance Level						95% Chebyshev(Mean, Sd) UCL	2293
107											97.5% Chebyshev(Mean, Sd) UCL	2999
108					Assuming Gamma Distribution						99% Chebyshev(Mean, Sd) UCL	4385
109					95% Approximate Gamma UCL (Use when n >= 40)	1510						
110					95% Adjusted Gamma UCL (Use when n < 40)	1611						
111												
112					Potential UCL to Use						Use 97.5% Chebyshev (Mean, Sd) UCL	2999
113												
114	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
115	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
116	and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.											
117												
118												

	A	B	C	D	E	F	G	H	I	J	K	L
119	BaP OU1 IB3 SS samples											
120												
121					General Statistics							
122					Number of Valid Observations	22				Number of Distinct Observations		22
123												
124					Raw Statistics					Log-transformed Statistics		
125					Minimum	0.5				Minimum of Log Data		-0.693
126					Maximum	5800				Maximum of Log Data		8.666
127					Mean	613.4				Mean of log Data		4.188
128					Geometric Mean	65.91				SD of log Data		2.23
129					Median	52.5						
130					SD	1512						
131					Std. Error of Mean	322.4						
132					Coefficient of Variation	2.466						
133					Skewness	2.963						
134												
135					Relevant UCL Statistics							
136					Normal Distribution Test					Lognormal Distribution Test		
137					Shapiro Wilk Test Statistic	0.452				Shapiro Wilk Test Statistic		0.968
138					Shapiro Wilk Critical Value	0.911				Shapiro Wilk Critical Value		0.911
139					Data not Normal at 5% Significance Level					Data appear Lognormal at 5% Significance Level		
140												
141					Assuming Normal Distribution					Assuming Lognormal Distribution		
142					95% Student's-t UCL	1168				95% H-UCL		7383
143					95% UCLs (Adjusted for Skewness)					95% Chebyshev (MVUE) UCL		2104
144					95% Adjusted-CLT UCL (Chen-1995)	1361				97.5% Chebyshev (MVUE) UCL		2763
145					95% Modified-t UCL (Johnson-1978)	1202				99% Chebyshev (MVUE) UCL		4058
146												
147					Gamma Distribution Test					Data Distribution		
148					k star (bias corrected)	0.296				Data appear Lognormal at 5% Significance Level		
149					Theta Star	2071						
150					MLE of Mean	613.4						
151					MLE of Standard Deviation	1127						
152					nu star	13.03						
153					Approximate Chi Square Value (.05)	5.913				Nonparametric Statistics		
154					Adjusted Level of Significance	0.0386				95% CLT UCL		1144
155					Adjusted Chi Square Value	5.558				95% Jackknife UCL		1168
156										95% Standard Bootstrap UCL		1133
157					Anderson-Darling Test Statistic	1.678				95% Bootstrap-t UCL		3097
158					Anderson-Darling 5% Critical Value	0.846				95% Hall's Bootstrap UCL		3433
159					Kolmogorov-Smirnov Test Statistic	0.254				95% Percentile Bootstrap UCL		1166
160					Kolmogorov-Smirnov 5% Critical Value	0.201				95% BCA Bootstrap UCL		1461
161					Data not Gamma Distributed at 5% Significance Level					95% Chebyshev(Mean, Sd) UCL		2019
162										97.5% Chebyshev(Mean, Sd) UCL		2627
163					Assuming Gamma Distribution					99% Chebyshev(Mean, Sd) UCL		3822
164					95% Approximate Gamma UCL (Use when n >= 40)	1352						
165					95% Adjusted Gamma UCL (Use when n < 40)	1438						
166												
167					Potential UCL to Use					Use 97.5% Chebyshev (Mean, Sd) UCL		2627
168												
169	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
170	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
171	and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.											
172												
173												

	A	B	C	D	E	F	G	H	I	J	K	L
174	BbF OU1 IB3 SS samples											
175												
176						General Statistics						
177						Number of Valid Observations	22				Number of Distinct Observations	22
178												
179						Raw Statistics					Log-transformed Statistics	
180						Minimum	0.5				Minimum of Log Data	-0.693
181						Maximum	5900				Maximum of Log Data	8.683
182						Mean	586.1				Mean of log Data	4.213
183						Geometric Mean	67.53				SD of log Data	2.197
184						Median	51.5					
185						SD	1435					
186						Std. Error of Mean	305.9					
187						Coefficient of Variation	2.448					
188						Skewness	3.118					
189												
190						Relevant UCL Statistics						
191						Normal Distribution Test					Lognormal Distribution Test	
192						Shapiro Wilk Test Statistic	0.462				Shapiro Wilk Test Statistic	0.967
193						Shapiro Wilk Critical Value	0.911				Shapiro Wilk Critical Value	0.911
194						Data not Normal at 5% Significance Level					Data appear Lognormal at 5% Significance Level	
195												
196						Assuming Normal Distribution					Assuming Lognormal Distribution	
197						95% Student's-t UCL	1113				95% H-UCL	6607
198						95% UCLs (Adjusted for Skewness)					95% Chebyshev (MVUE) UCL	2008
199						95% Adjusted-CLT UCL (Chen-1995)	1307				97.5% Chebyshev (MVUE) UCL	2635
200						95% Modified-t UCL (Johnson-1978)	1146				99% Chebyshev (MVUE) UCL	3865
201												
202						Gamma Distribution Test					Data Distribution	
203						k star (bias corrected)	0.304				Data appear Lognormal at 5% Significance Level	
204						Theta Star	1931					
205						MLE of Mean	586.1					
206						MLE of Standard Deviation	1064					
207						nu star	13.35					
208						Approximate Chi Square Value (.05)	6.132				Nonparametric Statistics	
209						Adjusted Level of Significance	0.0386				95% CLT UCL	1089
210						Adjusted Chi Square Value	5.769				95% Jackknife UCL	1113
211											95% Standard Bootstrap UCL	1077
212						Anderson-Darling Test Statistic	1.665				95% Bootstrap-t UCL	2434
213						Anderson-Darling 5% Critical Value	0.844				95% Hall's Bootstrap UCL	2699
214						Kolmogorov-Smirnov Test Statistic	0.266				95% Percentile Bootstrap UCL	1130
215						Kolmogorov-Smirnov 5% Critical Value	0.201				95% BCA Bootstrap UCL	1392
216						Data not Gamma Distributed at 5% Significance Level					95% Chebyshev(Mean, Sd) UCL	1920
217											97.5% Chebyshev(Mean, Sd) UCL	2497
218						Assuming Gamma Distribution					99% Chebyshev(Mean, Sd) UCL	3630
219						95% Approximate Gamma UCL (Use when n >= 40)	1276					
220						95% Adjusted Gamma UCL (Use when n < 40)	1357					
221												
222						Potential UCL to Use					Use 97.5% Chebyshev (Mean, Sd) UCL	2497
223												
224	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
225	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
226	and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.											
227												
228												

	A	B	C	D	E	F	G	H	I	J	K	L
229	DahA OU1 IB3 SS samples											
230												
231					General Statistics							
232					Number of Valid Observations	21				Number of Distinct Observations		19
233												
234					Raw Statistics					Log-transformed Statistics		
235					Minimum	0.8				Minimum of Log Data		-0.223
236					Maximum	510				Maximum of Log Data		6.234
237					Mean	68.12				Mean of log Data		2.544
238					Geometric Mean	12.74				SD of log Data		1.876
239					Median	6.8						
240					SD	138.9						
241					Std. Error of Mean	30.31						
242					Coefficient of Variation	2.039						
243					Skewness	2.628						
244												
245					Relevant UCL Statistics							
246					Normal Distribution Test					Lognormal Distribution Test		
247					Shapiro Wilk Test Statistic	0.538				Shapiro Wilk Test Statistic		0.928
248					Shapiro Wilk Critical Value	0.908				Shapiro Wilk Critical Value		0.908
249					Data not Normal at 5% Significance Level					Data appear Lognormal at 5% Significance Level		
250												
251					Assuming Normal Distribution					Assuming Lognormal Distribution		
252					95% Student's-t UCL	120.4				95% H-UCL		385
253					95% UCLs (Adjusted for Skewness)					95% Chebyshev (MVUE) UCL		196.4
254					95% Adjusted-CLT UCL (Chen-1995)	136.6				97.5% Chebyshev (MVUE) UCL		254.9
255					95% Modified-t UCL (Johnson-1978)	123.3				99% Chebyshev (MVUE) UCL		369.9
256												
257					Gamma Distribution Test					Data Distribution		
258					k star (bias corrected)	0.369				Data appear Lognormal at 5% Significance Level		
259					Theta Star	184.6						
260					MLE of Mean	68.12						
261					MLE of Standard Deviation	112.1						
262					nu star	15.5						
263					Approximate Chi Square Value (.05)	7.61				Nonparametric Statistics		
264					Adjusted Level of Significance	0.0383				95% CLT UCL		118
265					Adjusted Chi Square Value	7.187				95% Jackknife UCL		120.4
266										95% Standard Bootstrap UCL		116.6
267					Anderson-Darling Test Statistic	1.474				95% Bootstrap-t UCL		231.2
268					Anderson-Darling 5% Critical Value	0.827				95% Hall's Bootstrap UCL		317.8
269					Kolmogorov-Smirnov Test Statistic	0.248				95% Percentile Bootstrap UCL		121.5
270					Kolmogorov-Smirnov 5% Critical Value	0.203				95% BCA Bootstrap UCL		134.6
271					Data not Gamma Distributed at 5% Significance Level					95% Chebyshev(Mean, Sd) UCL		200.2
272										97.5% Chebyshev(Mean, Sd) UCL		257.4
273					Assuming Gamma Distribution					99% Chebyshev(Mean, Sd) UCL		369.7
274					95% Approximate Gamma UCL (Use when n >= 40)	138.7						
275					95% Adjusted Gamma UCL (Use when n < 40)	146.9						
276												
277					Potential UCL to Use					Use 95% Chebyshev (Mean, Sd) UCL		200.2
278												
279	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
280	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
281	and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.											
282												
283												

	A	B	C	D	E	F	G	H	I	J	K	L
284	IP OU1 IB3 SS Samples											
285												
286						General Statistics						
287					Number of Valid Observations	21				Number of Distinct Observations		21
288												
289					Raw Statistics					Log-transformed Statistics		
290					Minimum	5.8				Minimum of Log Data		1.758
291					Maximum	4800				Maximum of Log Data		8.476
292					Mean	521.8				Mean of log Data		4.266
293					Geometric Mean	71.27				SD of log Data		1.973
294					Median	47						
295					SD	1257						
296					Std. Error of Mean	274.2						
297					Coefficient of Variation	2.408						
298					Skewness	2.947						
299												
300						Relevant UCL Statistics						
301					Normal Distribution Test					Lognormal Distribution Test		
302					Shapiro Wilk Test Statistic	0.458				Shapiro Wilk Test Statistic		0.932
303					Shapiro Wilk Critical Value	0.908				Shapiro Wilk Critical Value		0.908
304					Data not Normal at 5% Significance Level					Data appear Lognormal at 5% Significance Level		
305												
306					Assuming Normal Distribution					Assuming Lognormal Distribution		
307					95% Student's-t UCL	994.8				95% H-UCL		3039
308					95% UCLs (Adjusted for Skewness)					95% Chebyshev (MVUE) UCL		1333
309					95% Adjusted-CLT UCL (Chen-1995)	1161				97.5% Chebyshev (MVUE) UCL		1737
310					95% Modified-t UCL (Johnson-1978)	1024				99% Chebyshev (MVUE) UCL		2531
311												
312					Gamma Distribution Test					Data Distribution		
313					k star (bias corrected)	0.323				Data appear Lognormal at 5% Significance Level		
314					Theta Star	1617						
315					MLE of Mean	521.8						
316					MLE of Standard Deviation	918.5						
317					nu star	13.55						
318					Approximate Chi Square Value (.05)	6.267				Nonparametric Statistics		
319					Adjusted Level of Significance	0.0383				95% CLT UCL		972.9
320					Adjusted Chi Square Value	5.889				95% Jackknife UCL		994.8
321										95% Standard Bootstrap UCL		963.8
322					Anderson-Darling Test Statistic	1.765				95% Bootstrap-t UCL		2951
323					Anderson-Darling 5% Critical Value	0.838				95% Hall's Bootstrap UCL		3291
324					Kolmogorov-Smirnov Test Statistic	0.24				95% Percentile Bootstrap UCL		980.4
325					Kolmogorov-Smirnov 5% Critical Value	0.204				95% BCA Bootstrap UCL		1193
326					Data not Gamma Distributed at 5% Significance Level					95% Chebyshev(Mean, Sd) UCL		1717
327										97.5% Chebyshev(Mean, Sd) UCL		2234
328					Assuming Gamma Distribution					99% Chebyshev(Mean, Sd) UCL		3250
329					95% Approximate Gamma UCL (Use when n >= 40)	1129						
330					95% Adjusted Gamma UCL (Use when n < 40)	1201						
331												
332					Potential UCL to Use					Use 95% Chebyshev (Mean, Sd) UCL		1717
333												
334	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
335	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
336	and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.											
337												

	A	B	C	D	E	F	G	H	I	J	K	L
338	Vanadium OU1 IB3 SS											
339												
340						General Statistics						
341					Number of Valid Observations	22				Number of Distinct Observations		22
342												
343					Raw Statistics					Log-transformed Statistics		
344					Minimum	11.3				Minimum of Log Data		2.425
345					Maximum	813				Maximum of Log Data		6.701
346					Mean	154.6				Mean of log Data		4.313
347					Geometric Mean	74.7				SD of log Data		1.211
348					Median	63.9						
349					SD	212.5						
350					Std. Error of Mean	45.3						
351					Coefficient of Variation	1.375						
352					Skewness	2.155						
353												
354						Relevant UCL Statistics						
355					Normal Distribution Test					Lognormal Distribution Test		
356					Shapiro Wilk Test Statistic	0.677				Shapiro Wilk Test Statistic		0.953
357					Shapiro Wilk Critical Value	0.911				Shapiro Wilk Critical Value		0.911
358					Data not Normal at 5% Significance Level					Data appear Lognormal at 5% Significance Level		
359												
360					Assuming Normal Distribution					Assuming Lognormal Distribution		
361					95% Student's-t UCL	232.5				95% H-UCL		333.5
362					95% UCLs (Adjusted for Skewness)					95% Chebyshev (MVUE) UCL		340.8
363					95% Adjusted-CLT UCL (Chen-1995)	251.3				97.5% Chebyshev (MVUE) UCL		424.5
364					95% Modified-t UCL (Johnson-1978)	236				99% Chebyshev (MVUE) UCL		588.8
365												
366					Gamma Distribution Test					Data Distribution		
367					k star (bias corrected)	0.734				Data appear Lognormal at 5% Significance Level		
368					Theta Star	210.7						
369					MLE of Mean	154.6						
370					MLE of Standard Deviation	180.5						
371					nu star	32.27						
372					Approximate Chi Square Value (.05)	20.29				Nonparametric Statistics		
373					Adjusted Level of Significance	0.0386				95% CLT UCL		229.1
374					Adjusted Chi Square Value	19.58				95% Jackknife UCL		232.5
375										95% Standard Bootstrap UCL		227.4
376					Anderson-Darling Test Statistic	1.014				95% Bootstrap-t UCL		297.8
377					Anderson-Darling 5% Critical Value	0.78				95% Hall's Bootstrap UCL		308.9
378					Kolmogorov-Smirnov Test Statistic	0.224				95% Percentile Bootstrap UCL		232
379					Kolmogorov-Smirnov 5% Critical Value	0.192				95% BCA Bootstrap UCL		248.1
380					Data not Gamma Distributed at 5% Significance Level					95% Chebyshev(Mean, Sd) UCL		352
381										97.5% Chebyshev(Mean, Sd) UCL		437.5
382					Assuming Gamma Distribution					99% Chebyshev(Mean, Sd) UCL		605.3
383					95% Approximate Gamma UCL (Use when n >= 40)	245.9						
384					95% Adjusted Gamma UCL (Use when n < 40)	254.8						
385												
386					Potential UCL to Use					Use 95% Chebyshev (Mean, Sd) UCL		352
387												
388					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
389					These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)							
390					and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.							

FFS OU-1 RISK TABLE 1:
CALCULATION OF CHEMICAL CANCER HAZARDS - IB-1 TRESPASSER - RME
FORMER ALCOA EAST ST. LOUIS OPERATIONS; EAST SAINT LOUIS, IL

Scenario Timeframe:	Current/Future
Receptor Population:	Trespasser
Receptor Age:	Youth

Medium	ExposureMedium	ExposurePoint	ExposureRoute	COPC	EPCvalue	EPCunits	DoseValue (mg/kg-day)	CSFvalue $(mg/kg\text{-}day)^{-1}$	Excess Lifetime Cancer Risk	Media Risk	
Sediment	Sediment	Sediment	Dermal Contact	arsenic	25	mg/kg	1.87E-08	1.5	2.81E-08		
Sediment	Sediment	Sediment	Dermal Contact	benzo(a)pyrene	0.087	mg/kg	2.82E-10	7.3	2.06E-09		
Sediment	Sediment	Sediment	Ingestion	arsenic	25	mg/kg	2.45E-08	1.5	3.67E-08		
Sediment	Sediment	Sediment	Ingestion	benzo(a)pyrene	0.087	mg/kg	8.51E-11	7.3	6.21E-10		
Sediment	Sediment	Sediment	Ingestion	chromium	990	mg/kg	9.69E-07	NA	NA		
Sediment	Sediment	Sediment	Ingestion	cobalt	3.77	mg/kg	3.69E-09	NA	NA		
Medium Total Risk										6.74E-08	
Surface Soil	Soil	Surface Soil	Dermal Contact	arsenic	26.5	mg/kg	2.36E-08	1.5	3.55E-08		Soil risk
Surface Soil	Soil	Surface Soil	Dermal Contact	chromium	742	mg/kg	2.21E-07	NA	NA		As
Surface Soil	Air	Air	Particulates	arsenic	4.254E-08	mg/kg	2.00E-11	15	3.00E-10		2.30E-07
Surface Soil	Air	Air	Particulates	chromium	1.191E-06	mg/kg	7.99E-11	42	3.36E-09		
Surface Soil	Soil	Surface Soil	Ingestion	arsenic	26.5	mg/kg	1.30E-07	1.5	1.94E-07		
Surface Soil	Soil	Surface Soil	Ingestion	chromium	742	mg/kg	5.19E-07	NA	NA		
Medium Total Risk										2.34E-07	
Water	Water	Surface Water	Dermal Contact	arsenic	0.0893	mg/L	7.08E-09	1.5	1.06E-08		
Water	Water	Surface Water	Dermal Contact	cadmium	0.0295	mg/L	2.34E-09	NA	NA		
Water	Water	Surface Water	Dermal Contact	chromium	3.79	mg/L	3.00E-07	NA	NA		
Medium Total Risk										1.06E-08	
From Draft BHHRA (2010) Table C-1.									Total Theoretical Excess Lifetime Cancer Risk	3.E-07	

FFS OU-1 RISK TABLE 2:
CALCULATION OF CHEMICAL CANCER HAZARDS - IB-2 TRESPASSER - RME
FORMER ALCOA EAST ST. LOUIS OPERATIONS; EAST SAINT LOUIS, IL

Scenario Timeframe:	Current/Future
Receptor Population:	Trespasser
Receptor Age:	Youth

Medium	ExposureMedium	ExposurePoint	ExposureRoute	COPC	EPCvalue	EPCunits	DoseValue (mg/kg-day)	CSFvalue $(mg/kg\text{-}day)^{-1}$	Excess Lifetime Cancer Risk	Media Risk
Surface Soil	Soil	Surface Soil	Dermal Contact	arsenic	11.4	mg/kg	1.0173E-08	1.5	1.53E-08	
Surface Soil	Air	Air	Particulates	arsenic	1.83E-08	mg/m^3	8.59423E-12	15	1.29E-10	
Surface Soil	Soil	Surface Soil	Ingestion	arsenic	11.4	mg/kg	5.5773E-08	1.5	8.37E-08	
									Total Theoretical Excess Lifetime Cancer Risk	1.E-07

From BHHRA (2010) Table C-2.

FFS OU-1 RISK TABLE 3:
CALCULATION OF CHEMICAL CANCER HAZARDS - IB-3 TRESPASSER - RME
FORMER ALCOA EAST ST. LOUIS OPERATIONS; EAST SAINT LOUIS, IL

Scenario Timeframe:	Current/Future
Receptor Population:	Trespasser
Receptor Age:	Youth

Medium	ExposurePoint	ExposureRoute	COPC	EPCvalue	EPCunits	DoseValue (mg/kg-day)	CSFvalue $(mg/kg\text{-}day)^{-1}$	Excess Lifetime	Media Risk	
Sediment	Sediment	Dermal Contact	arsenic	141	mg/kg	1.05543E-07	1.5	1.58E-07		
Sediment	Sediment	Ingestion	arsenic	141	mg/kg	1.37965E-07	1.5	2.07E-07		
			chromium	208	mg/kg	2.03523E-07	NA	NA		
			cobalt	11.2	mg/kg	1.09589E-08	NA	NA		
Medium Total Risk									3.7E-07	
Surface Soil	Surface Soil	Dermal Contact	arsenic	16.2	mg/kg	1.44564E-08	1.5	2.17E-08		Surface Soil
			benzo(a)anthracene	3.39	mg/kg	1.31089E-08	0.73	9.57E-09		
			benzo(a)pyrene	3.697	mg/kg	1.4296E-08	7.3	1.04E-07		As risk
			benzo(b)fluoranthene	3.09	mg/kg	1.19488E-08	0.73	8.72E-09		1.41E-07
			dibenz(ah)anthracene	0.43	mg/kg	1.66278E-09	7.3	1.21E-08		
			indeno(1,2,3-cd)pyrene	3.389	mg/kg	1.3105E-08	0.73	9.57E-09		BaP risk
										2.36E-07
Surface Soil	Air	Particulates	arsenic	1.74E-08	mg/m^3	8.1813E-12	15	1.23E-10		
			benzo(a)anthracene	3.65E-09	mg/m^3	1.71201E-12	NA	NA		other PAH risk
			benzo(a)pyrene	3.98E-09	mg/m^3	1.86705E-12	NA	NA		9.06E-08
			benzo(b)fluoranthene	3.32E-09	mg/m^3	1.56051E-12	NA	NA		
			chromium	8.49E-08	mg/m^3	2.79275E-10	42	1.68E-09		
			dibenz(ah)anthracene	4.62E-10	mg/m^3	2.17158E-13	NA	NA		
			indeno(1,2,3-cd)pyrene	3.64E-09	mg/m^3	1.71151E-12	NA	NA		
Surface Soil	Surface Soil	Ingestion	arsenic	16.2	mg/kg	7.92564E-08	1.5	1.19E-07		
			benzo(a)anthracene	3.39	mg/kg	1.65851E-08	0.73	1.21E-08		
			benzo(a)pyrene	3.697	mg/kg	1.80871E-08	7.3	1.32E-07		
			benzo(b)fluoranthene	3.09	mg/kg	1.51174E-08	0.73	1.10E-08		
			chromium	553	mg/kg	2.70548E-06	NA	NA		
			dibenz(ah)anthracene	0.43	mg/kg	2.10372E-09	7.3	1.54E-08		
			indeno(1,2,3-cd)pyrene	3.389	mg/kg	1.65802E-08	0.73	1.21E-08		
Medium Total Risk									4.7E-07	
Water	Surface Water	Dermal Contact	arsenic	0.0309	mg/L	2.44902E-09	1.5	3.67E-09		
Medium Total Risk									3.7E-09	
Receptor Total Risk								Total Theoretical Excess Lifetime Cancer Risk	8.E-07	

From Draft BHHRA (2010) Table C-3.

FFS OU-1 RISK TABLE 4:
CALCULATION OF CHEMICAL CANCER HAZARDS - IB-4a TRESPASSER - RME
FORMER ALCOA EAST ST. LOUIS OPERATIONS; EAST SAINT LOUIS, IL

Scenario Timeframe:	Current/Future
Receptor Population:	Trespasser
Receptor Age:	Youth

Medium	ExposurePoint	ExposureRoute	COPC	EPCvalue	EPCunits	DoseValue (mg/kg-day)	CSFvalue $(mg/kg\text{-}day)^{-1}$	Excess Lifetime	Media Risk
Sediment	Sediment	Dermal Contact	arsenic	78.7	mg/kg	5.89095E-08	1.5	8.84E-08	
			benzo(a)anthracene	0.32	mg/kg	1.03796E-09	0.73	7.58E-10	
			benzo(a)pyrene	0.3	mg/kg	9.73092E-10	7.3	7.10E-09	
			benzo(b)fluoranthene	0.39	mg/kg	1.26502E-09	0.73	9.23E-10	
			dibenz(ah)anthracene	0.065	mg/kg	2.10837E-10	7.3	1.54E-09	
			indeno(1,2,3-cd)pyrene	0.22	mg/kg	7.13601E-10	0.73	5.21E-10	
Sediment	Sediment	Ingestion	arsenic	78.7	mg/kg	7.70059E-08	1.5	1.16E-07	
			benzo(a)anthracene	0.32	mg/kg	3.13112E-10	0.73	2.29E-10	
			benzo(a)pyrene	0.3	mg/kg	2.93542E-10	7.3	2.14E-09	
			benzo(b)fluoranthene	0.39	mg/kg	3.81605E-10	0.73	2.79E-10	
			chromium	222	mg/kg	2.17221E-07	NA	NA	
			cobalt	3.81	mg/kg	3.72798E-09	NA	NA	
			dibenz(ah)anthracene	0.065	mg/kg	6.36008E-11	7.3	4.64E-10	
			indeno(1,2,3-cd)pyrene	0.22	mg/kg	2.15264E-10	0.73	1.57E-10	
Medium Total Risk									2.2E-07
Surface Soil	Surface Soil	Dermal Contact	arsenic	30	mg/kg	2.6771E-08	1.5	4.02E-08	
Surface Soil	Air	Particulates	arsenic	3.226E-08	mg/m^3	1.51506E-11	1.5	2.27E-10	
Surface Soil	Surface Soil	Ingestion	arsenic	30	mg/kg	1.46771E-07	1.5	2.20E-07	
Medium Total Risk									2.6E-07
Water	Surface Water	Dermal Contact	arsenic	0.213	mg/L	1.68816E-08	1.5	2.53E-08	
Medium Total Risk									2.5E-08
Receptor Total Risk							Total Theoretical Excess Lifetime Cancer Risk		5.E-07

From Draft BHHRA (2010) Table C-7.

FFS OU-1 RISK TABLE 5:
CALCULATION OF CHEMICAL NON-CANCER HAZARDS - IB-1 TRESPASSER - RME
FORMER ALCOA EAST ST. LOUIS OPERATIONS, EAST SAINT LOUIS, IL

Scenario Timeframe:	Current/Future
Receptor Population:	Trespasser
Receptor Age:	Youth

Medium	Exposure Medium	Exposure Point	Exposure Route	COPC	EPC value	EPC units	Dose Value (mg/kg-day)	RfD value (mg/kg-day)	HQ	Pathway HI
Sediment	Sediment	Sediment	Dermal Contact	arsenic	25	mg/kg	1.3099E-07	0.0003	4.37E-04	**HI derm sed**
										0.0004
Sediment	Sediment	Sediment	Ingestion	aluminum	86200	mg/kg	0.00059041	1	5.90E-04	
				arsenic	25	mg/kg	1.7123E-07	0.0003	5.71E-04	
				chromium	990	mg/kg	9.6869E-07	0.003	3.23E-04	
				cobalt	3.77	mg/kg	2.5822E-08	0.0003	8.61E-05	
				manganese	326	mg/kg	2.2329E-06	0.0467	4.78E-05	
				vanadium	938	mg/kg	6.4247E-06	0.009	7.14E-04	**HI ing sed**
										0.0023
Medium Total HI										**0.003**
Surface Soil	Soil	Surface Soil	Dermal Contact	arsenic	26.5	mg/kg	1.6553E-07	0.0003	5.52E-04	**HI derm soil**
										0.0006
Surface Soil	Air	Air	Inhalation	aluminum	0.0001069	mg/m^3	3.5146E-07	0.0014	2.51E-04	
				arsenic	4.254E-08	mg/m^3	1.3984E-10	NA	NA	
				chromium	1.191E-06	mg/m^3	5.5938E-10	0.00003	1.86E-05	
				vanadium	1.358E-06	mg/m^3	4.4645E-09	NA	NA	**HI Inh**
										0.0003
Surface Soil	Soil	Surface Soil	Ingestion	aluminum	66600	mg/kg	0.00228082	1	2.28E-03	
				arsenic	26.5	mg/kg	9.0753E-07	0.0003	3.03E-03	
				chromium	742	mg/kg	3.6301E-06	0.003	1.21E-03	
				vanadium	846	mg/kg	2.8973E-05	0.009	3.22E-03	**HI ing soil**
										0.010
Medium Total HI										**0.01**
Water	Water	Surface Water	Dermal Contact	aluminum	208	mg/L	0.0001154	1	1.15E-04	
				arsenic	0.0893	mg/L	4.9543E-08	0.0003	1.65E-04	
				cadmium	0.0295	mg/L	1.6366E-08	0.000025	6.55E-04	
				chromium	3.79	mg/L	3.0038E-07	0.000075	4.01E-03	
				fluoride	55.2	mg/L	3.0625E-05	0.06	5.10E-04	
				selenium	0.0895	mg/L	4.9654E-08	0.005	9.93E-06	
				vanadium	3.16	mg/L	1.7532E-06	0.000234	7.49E-03	**HI derm SW**
Medium Total HI										**0.01**
									Total of Receptor Hazards Across All Media	**0.03**

arsenic sum surface soil	0.004
vanadium sum SS	0.003

From Draft BHHRA (2010) Table C-28.

FFS OU-1 RISK TABLE 6:
CALCULATION OF CHEMICAL NON-CANCER HAZARDS - IB-2 TRESPASSER - RME
FORMER ALCOA EAST ST. LOUIS OPERATIONS, EAST SAINT LOUIS, IL

Scenario Timeframe:	Current/Future
Receptor Population:	Trespasser
Receptor Age:	Youth

Medium	Exposure Medium	Exposure Point	Exposure Route	COPC	EPC value	EPC units	Dose Value (mg/kg-day)	RfD value (mg/kg-day)	HQ	Pathway HI	
Surface Soil	Soil	Surface Soil	Dermal Contact	arsenic	11.38	mg/kg	7.1086E-08	0.0003	2.37E-04	**HI derm soil 0.0002**	
Surface Soil	Air	Air	Inhalation	arsenic	1.827E-08	mg/m^3	6.0054E-11	NA	NA		
				vanadium	9.984E-07	mg/m^3	3.2824E-09	NA	NA		
										HI Inh NA	arsenic HI 0.002
Surface Soil	Soil	Surface Soil	Ingestion	arsenic	11.38	mg/kg	3.8973E-07	0.0003	1.30E-03		V HI
				vanadium	622	mg/kg	2.1301E-05	0.009	2.37E-03		0.002
										HI ing soil 0.004	
Medium Total HI										**0.004**	

From Draft BHHRA (2010) Table C-29.

FFS OU1 RISK TABLE 7:
CALCULATION OF CHEMICAL NON-CANCER HAZARDS - IB-3 TRESPASSER - RME
FORMER ALCOA EAST ST. LOUIS OPERATIONS, EAST SAINT LOUIS, IL

Scenario Time	Current/Future
Receptor Popu	Trespasser
Receptor Age:	Youth

Medium	Exposure Medium	Exposure Point	Exposure Route	COPC	EPC value	EPC units	Dose Value (mg/kg-day)	RfD value (mg/kg-day)	HQ	Pathway HI	
Sediment	Sediment	Sediment	Dermal Contact	arsenic	141	mg/kg	7.388E-07	0.0003	2.46E-03	**HI derm sed**	
				cadmium	14.35	mg/kg	2.5063E-08		1.00E-03		
										0.0035	
Sediment	Sediment	Sediment	Ingestion	aluminum	122225	mg/kg	0.00083716	1	8.37E-04		
				antimony	4.166	mg/kg	2.8534E-08	0.0004	7.13E-05		
				arsenic	141	mg/kg	9.6575E-07	0.0003	3.22E-03		
				cadmium	14.35	mg/kg	9.8288E-08	0.001	9.83E-05		
				chromium	208	mg/kg	1.4247E-06	0.003	6.78E-05		
				cobalt	11.2	mg/kg	7.6712E-08	0.0003	2.56E-04		
				copper	189	mg/kg	1.2945E-06	0.04	3.24E-05		
				fluoride	2790	mg/kg	1.911E-05	0.06	3.18E-04		
				manganese	477	mg/kg	3.2671E-06	0.0467	7.00E-05		
				vanadium	632	mg/kg	4.3288E-06	0.009	4.81E-04		
				zinc	1560	mg/kg	1.0685E-05	0.3	3.56E-05	**HI ing sed**	
										0.005	
Total HI										**0.009**	
Soil	Soil	Surface Soil	Dermal Contact	arsenic	16.2	mg/kg	1.0119E-07	0.0003	3.37E-04	**HI derm soil**	
										0.0003	
Soil	Air	Air	Inhalation	arsenic	1.742E-08	mg/m^3	5.7269E-11	NA	NA		soil HIs
				chromium	5.946E-07	mg/m^3	1.9549E-09	0.00003	9.31E-06		sum V HI
				vanadium	5.581E-07	mg/m^3	1.8347E-09	NA	NA	**HI Inh**	0.002
										0.00001	
Soil	Soil	Surface Soil	Ingestion	arsenic	16.2	mg/kg	5.5479E-07	0.0003	1.85E-03		sum As HI
				chromium	553	mg/kg	1.8938E-05	0.003	9.02E-04		0.002
				vanadium	519	mg/kg	1.7774E-05	0.009	1.97E-03	**HI ing soil**	
										0.005	
Total HI										**0.005**	
Water	Water	Surface Water	Dermal Contact	arsenic	0.0309	mg/L	1.7143E-08	0.0003	5.71E-05		
				cyanide	9.8	mg/L	5.437E-06	0.02	2.72E-04		
				fluoride	302	mg/L	0.00016755	0.06	2.79E-03	**HI derm SW**	
Total HI										**0.003**	
									Total of Receptor Hazards Across All Media	**0.02**	

From Draft BHHRA (2010) Table C-30.

FFS OU1 RISK TABLE 8:
CALCULATION OF CHEMICAL NON-CANCER HAZARDS - IB-4a TRESPASSER - RME
FORMER ALCOA EAST ST. LOUIS OPERATIONS, EAST SAINT LOUIS, IL

Scenario Timefra	Current/Future
Receptor Popula	Trespasser
Receptor Age:	Youth

Medium	Exposure Medium	Exposure Point	Exposure Route	COPC	EPC value	EPC units	Dose Value (mg/kg-day)	RfD value (mg/kg-day)	HQ	Pathway HI	
Sediment	Sediment	Sediment	Dermal Contact	arsenic	78.7	mg/kg	4.1237E-07	0.0003	1.37E-03	**HI derm sed 0.0014**	
Sediment	Sediment	Sediment	Ingestion	aluminum	64600	mg/kg	0.00044247	1	4.42E-04		
				antimony	3.34	mg/kg	2.2877E-08	0.0004	5.72E-05		
				arsenic	78.7	mg/kg	5.3904E-07	0.0003	1.80E-03		
				chromium	222	mg/kg	1.5205E-06	0.003	7.24E-05		
				cobalt	3.81	mg/kg	2.6096E-08	0.0003	8.70E-05		
				manganese	370	mg/kg	2.5342E-06	0.0467	5.43E-05		
				vanadium	236	mg/kg	1.6164E-06	0.009	1.80E-04		
										HI ing sed 0.003	
Total HI										**0.004**	
Surface Soil	Soil	Surface Soil	Dermal Contact	arsenic	30	mg/kg	1.874E-07	0.0003	6.25E-04	**HI derm soil 0.0006**	
Surface Soil	Air	Air	Inhalation	aluminum	9.656E-05	mg/m^3	3.1745E-07	0.0014	2.27E-04		arsenic HI soil
				arsenic	3.226E-08	mg/m^3	1.0605E-10	NA	NA	**HI Inh 0.00023**	0.004
Surface Soil	Soil	Surface Soil	Ingestion	aluminum	89800	mg/kg	0.00307534	1	3.08E-03		
				arsenic	30	mg/kg	1.0274E-06	0.0003	3.42E-03	**HI ing soil 0.007**	
Total HI										**0.007**	
Water	Water	Surface Water	Dermal Contact	aluminum	156	mg/L	8.6548E-05	1	8.65E-05		
				antimony	0.0092	mg/L	5.1041E-09	0.00006	8.51E-05		
				arsenic	0.213	mg/L	1.1817E-07	0.0003	3.94E-04		
				cyanide	0.73	mg/L	4.05E-07	0.02	2.03E-05		
				fluoride	43.5	mg/L	2.4134E-05	0.06	4.02E-04		
				vanadium	0.426	mg/L	2.3634E-07	0.000234	1.01E-03	**HI derm SW 0.002**	
Total HI											
									Total of Receptor Hazards Across All Media	**0.01**	

From Draft BHHRA (2010) Table C-34.

APPENDIX E
SUMMARY OF REVISED RISK CALCULATIONS FOR POND IN IB-1B USING ORGANIC LAYER COPC CONCENTRATIONS

McKay, Clayton

From: McCulley, Bryan
Sent: Tuesday, March 27, 2012 10:53 AM
To: McKay, Clayton
Subject: FW: Revised Risk Calculations for IB-1b Pond Area

From: DION NOVAK [mailto:Novak.Dion@epamail.epa.gov]
Sent: Friday, March 23, 2012 10:28 AM
To: McKay, Clayton
Cc: McCulley, Bryan; Ronald W. Weddell (Ron.Weddell@alcoa.com); christopher.hill@Illinois.gov; Miller Tom; Carson Robert; Clarence Smith; Timothy Prendiville; JAMES CHAPMAN
Subject: Re: Revised Risk Calculations for IB-1b Pond Area

Ron

Wanted to let you know that Jim Chapman and I reviewed this memorandum and its conclusions. EPA agrees with the data presentation and the conclusions presented as to lack of risk based on these results.

Please include this in the revised FFS.

Please let me know if you have questions.

Dion Novak
US EPA
77 W. Jackson (SR-6J)
Chicago, IL 60604
312-886-4737(P)
312-886-4071(F)

-----"McKay, Clayton" <Clayton.McKay@tetratech.com> wrote: -----
To: DION NOVAK/R5/USEPA/US@EPA
From: "McKay, Clayton" <Clayton.McKay@tetratech.com>
Date: 03/12/2012 05:16PM
Cc: "Ronald W. Weddell (Ron.Weddell@alcoa.com)" <Ron.Weddell@alcoa.com>, "McCulley, Bryan" <Bryan.McCulley@tetratech.com>
Subject: Revised Risk Calculations for IB-1b Pond Area

Hi Dion,

On behalf of Ron Weddell, attached is a memorandum summarizing the revised ecological risk calculations for the pond area in IB-1b. Let me know if you have any questions.

Thank you,

Clayton McKay | **Project Engineer**

Phone: 512.338.2865 | Fax: 512.338.1331 clayton.mckay@tetratech.com

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[attachment "OrganicLayerHQMemo.pdf" removed by DION NOVAK/R5/USEPA/US]

MEMORANDUM

TO: Bryan McCulley – TetraTech

FROM: Joe Allen

DATE: March 12, 2012

SUBJECT **Summary of the Revised Risk Calculations for Pond in IB-1B Using Organic Layer COPC Concentrations**

This memorandum provides a summary of the exposure and Hazard Quotient (HQ) calculations for the recently collected (March, 2012) organic layer samples from the wet areas in IB-1B.

A total of 10 samples (and 1 field duplicate) of the organic material covering the base of the wet areas, both currently inundated and non-inundated, within the IB-1B pond were collected by Tetra Tech in early March, 2012. The purpose of these samples was to provide a measure of chromium, vanadium, and zinc concentrations in the layer of organic material covering the bottom of the IB-1B wet areas. Table 1 provides the chemical data and an estimate of the thickness of the organic material.

The mean and 95% upper confidence limit on the mean (95% UCL) concentration of each of the three constituents of potential concern (COPCs) were calculated using ProUCL (EPA, 2011) and were equal to:

- Chromium
  - Mean = 39.6 mg/kg
  - 95% UCL = 57.2 mg/kg

- Vanadium
  - Mean = 92.3 mg/kg

- 95% UCL = 161 mg/kg

- Zinc
  - Mean = 256 mg/kg
  - 95% UCL = 393 mg/kg

Table 1
IB-1B Wet Area Organic Layer Data

	Cr (mg/kg)	V (mg/kg)	Zn (mg/kg)	Thickness (in.)
1B-UP-015-3000	7.37	37.7	723	4
1B-UP-016-3000	74.9	119	118	4
1B-UP-017-3000	14.7	16.2	36.6	3
1B-UP-018-3000	83.6	78	47	0.25
1B-UP-019-3000	63.9	68.2	85.6	0.25
1B-UP-020-3000	16	17	94.6	0.5
1B-UP-021-3000	70.5	146	171	6
1B-UP-022-3000	19	290	309	6
1B-UP-023-3000	35.6	103	498	6
1B-UP-024-3000	10.8	47.8	479	6

The measured COPC concentrations in the organic layer are considerably lower than COPC concentrations measured in the sediment/residue reported in the Baseline Ecological Risk Assessment (BERA; Alcoa, 2010). Mean and 95% UCL concentrations from the sediment/residue used in the BERA were:

- Chromium
  - Mean = 937 mg/kg
  - 95% UCL = 1070 mg/kg

- Vanadium
  - Mean = 970 mg/kg
  - 95% UCL = 1080 mg/kg

- Zinc
  - Mean = 505 mg/kg
  - 95% UCL = 711 mg/kg

A summary of the estimated exposure and resulting HQ calculations using the mean and 95% UCL organic layer samples is provided in Table 2. The detailed

calculations are provided as Tables 3 through 6. All exposure and HQ calculation parameters are identical to the BERA with the following exceptions.

1. Sediment/Residue exposure point concentrations were replaced with the organic layer data.

2. The night heron receptor exposure was calculated using both 2% and 5% sediment ingestion rate at the request of EPA as a more realistic exposure estimate. A sediment ingestion rate of 10% was used in the BERA.

3. The chromium TRVs were revised from the BERA to 3.8/5.0 mg/kg BW/day (NOAEL/LOAEL) for the avian receptors and 2.4/2.82 mg/kg BW/day (NOAEL/LOAEL) for the muskrat receptor.

A shown in Table 2, all LOAEL HQs were less than 1.0 for all COPC/receptor pairs. For vanadium, a NOAEL HQ greater than 1.0 was calculated for the muskrat receptor only. For zinc, NOAEL HQs greater than 1.0 were calculated for the night heron and mallard (omnivore) receptors.

No unacceptable risks were predicted in the draft-revised BERA (Alcoa 2010) despite several LOAEL HQs greater than 1.0. This conclusion was based on the lines-of-evidence provided including the consideration of limited use of the on-site habitats by receptors. Because of the lower COPC concentrations within the organic layer of the wet areas in IB-1B, if the area is allowed to remain as a water treatment feature without additional cover, risks to the aquatic and semi-aquatic receptors potentially utilizing the IB-1B pond are considerably lower than originally predicted in the BERA regardless of site use by the receptors.

References:

Alcoa Inc., 2010. Draft-Revised Baseline Ecological Risk Assessment. North Alcoa Site. East St. Louis, IL. April.

USPEA, 2011. ProUCL v.4.1.01. http://www.epa.gov/osp/hstl/tsc/software.htm

Table 2
Hazard Quotient Analysis of Organic Sediment Layer in IB-1b Pond for Chromiun, Vanadium, and Zinc
North Alcoa Site; East St. Louis, IL.

		Lowest Sediment Ingestion (Night Heron = 2%; Mallard = 3%; Muskrat = 3%)						5% Sediment Ingestion - Night Heron Only					
		Intake Total (mg/kg BW/day)		HQ Mean Sediment		HQ 95% UCL Sediment		Intake Total (mg/kg BW/day)		HQ Mean Sediment		HQ 95% UCL Sediment	
		Mean Sediment	95% UCL Sediment	NOAEL	LOAEL	NOAEL	LOAEL	Mean Sediment	95% UCL Sediment	NOAEL	LOAEL	NOAEL	LOAEL
Chromium													
IB-1b	Night Heron	0.29	0.41	0.08	0.06	0.11	0.08	0.36	0.52	0.09	0.07	0.14	0.10
IB-1b	Mallard	0.17	0.24	0.04	0.03	0.06	0.05						
IB-1b	Mallard - Omnivore	0.24	0.35	0.06	0.05	0.09	0.07						
IB-1b	Muskrat	0.14	0.21	0.06	0.05	0.09	0.07						
Vanadium													
IB-1b	Night Heron	5.65	9.86	0.50	0.05	0.86	0.09	5.82	10.1	0.51	0.05	0.89	0.09
IB-1b	Mallard	0.19	0.34	0.02	0.00	0.03	0.003						
IB-1b	Mallard - Omnivore	2.95	5.15	0.26	0.03	0.45	0.05						
IB-1b	Muskrat	0.17	0.29	0.79	0.08	1.37	0.14						
Zinc													
IB-1b	Night Heron	30.13	46.23	3.01	0.14	4.62	0.22	30.59	46.94	3.06	0.15	4.69	0.22
IB-1b	Mallard	6.09	9.34	0.61	0.03	0.93	0.04						
IB-1b	Mallard - Omnivore	18.19	27.90	1.82	0.09	2.79	0.13						
IB-1b	Muskrat	5.18	7.94	0.04	0.02	0.07	0.03						

Chromium
Mean Organic Sediment Layer Concentration IB-1b = 39.6 mg/kg
95% UCL Organic Sediment Layer Concentration IB-1b = 57.2 mg/kg

Vanadium
Mean Organic Sediment Layer Concentration IB-1b = 92.3 mg/kg
95% UCL Organic Sediment Layer Concentration IB-1b = 161 mg/kg

Zinc
Mean Organic Sediment Layer Concentration IB-1b = 256 mg/kg
95% UCL Organic Sediment Layer Concentration IB-1b = 393 mg/kg

BERA TRVs

Chromium
Birds
NOAEL TRV = 3.8 mg/kg BW/day
LOAEL TRV = 5 mg/kg BW/day
Mammals
NOAEL TRV = 2.4 mg/kg BW/day
LOAEL TRV = 2.82 mg/kg BW/day

Vanadium
Birds
NOAEL TRV = 11.4 mg/kg BW/day
LOAEL TRV = 114 mg/kg BW/day
Mammals
NOAEL TRV = 0.21 mg/kg BW/day
LOAEL TRV = 2.1 mg/kg BW/day

Zinc
Birds
NOAEL TRV = 10 mg/kg BW/day
LOAEL TRV = 210 mg/kg BW/day
Mammals
NOAEL TRV = 120 mg/kg BW/day
LOAEL TRV = 240 mg/kg BW/day

Table 3

Recalculation of Exposure and Hazard Quotients Using Alternative Exposure Estimates in IB-1b

Mean Organic Sediment Layer Concentration and Adjusted Sediment Ingestion (Muskrat = 3%, Night Heron = 2%)

North Alcoa Site; East St. Louis, IL.

									Proportion of Prey Item in Diet -				Intake From -									
Location	**Receptor**	**COPEC**	**Sediment EPC (mg/kg)**	**Surface Water EPC (mg/L)**	**Bioavailability Factor**	**Ingestion Rate Food (kg food/kg BW/day)[1]**	**Proportion of Sediment in Diet**	**Ingestion Rate of Water (kg water/kg BW/day)**	**Plants**	**Invertebrates**	**Amphibians**	**Area Use Factor**	**Sediment (mg/kg BW/day)**	**Plants (mg/kg BW/day)**	**Invertebrates (mg/kg BW/day)**	**Amphibians (mg/kg BW/day)**	**Surface Water (mg/kg BW/day)**	**Total Intake (mg/kg BW/day)**	**NOAEL TRV (mg/kg BW/day)**	**LOAEL TRV (mg/kg BW/day)**	**HQ NOAEL**	**HQ LOAEL**
IB-1B																						
IB-1B	Mallard	Chromium	3.96E+01	3.00E-03	1	6.00E-02	3.00E-02	0.06	1	0	0	1	7.13E-02	9.74E-02	0.00E+00	0.00E+00	1.80E-04	1.69E-01	3.8	5	4.4E-02	3.4E-02
IB-1B	Mallard - Omnivore	Chromium	3.96E+01	3.00E-03	1	6.00E-02	3.00E-02	0.06	0.5	0.5	0	1	7.13E-02	4.87E-02	1.19E-01	0.00E+00	1.80E-04	2.39E-01	3.8	5	6.3E-02	4.8E-02
IB-1B	Muskrat	Chromium	3.96E+01	3.00E-03	1	5.10E-02	3.00E-02	0.1	1	0	0	1	6.06E-02	8.28E-02	0.00E+00	0.00E+00	3.00E-04	1.44E-01	2.4	2.82	6.0E-02	5.1E-02
IB-1B	Night Heron	Chromium	3.96E+01	3.00E-03	1	6.00E-02	2.00E-02	0.06	0	0.1	0.9	1	4.75E-02	0.00E+00	2.38E-02	2.14E-01	1.80E-04	2.85E-01	3.8	5	7.5E-02	5.7E-02
IB-1B	Mallard	Vanadium	9.23E+01	6.70E-03	1	6.00E-02	3.00E-02	0.06	1	0	0	1	1.66E-01	2.69E-02	0.00E+00	0.00E+00	4.02E-04	1.93E-01	11.4	114	1.7E-02	1.7E-03
IB-1B	Mallard - Omnivore	Vanadium	9.23E+01	6.70E-03	1	6.00E-02	3.00E-02	0.06	0.5	0.5	0	1	1.66E-01	1.34E-02	2.77E+00	0.00E+00	4.02E-04	2.95E+00	11.4	114	2.6E-01	2.6E-02
IB-1B	Muskrat	Vanadium	9.23E+01	6.70E-03	1	5.10E-02	3.00E-02	0.1	1	0	0	1	1.41E-01	2.28E-02	0.00E+00	0.00E+00	6.70E-04	1.65E-01	0.21	2.1	7.8E-01	7.8E-02
IB-1B	Night Heron	Vanadium	9.23E+01	6.70E-03	1	6.00E-02	2.00E-02	0.06	0	0.1	0.9	1	1.11E-01	0.00E+00	5.54E-01	4.98E+00	4.02E-04	5.65E+00	11.4	114	5.0E-01	5.0E-02
IB-1B	Mallard	Zinc	2.56E+02	9.00E-03	1	6.00E-02	3.00E-02	0.06	1	0	0	1	4.61E-01	5.63E+00	0.00E+00	0.00E+00	5.40E-04	6.09E+00	10	210	6.1E-01	2.9E-02
IB-1B	Mallard - Omnivore	Zinc	2.56E+02	9.00E-03	1	6.00E-02	3.00E-02	0.06	0.5	0.5	0	1	4.61E-01	2.81E+00	1.49E+01	0.00E+00	5.40E-04	1.819E+01	10	210	1.8E+00	8.7E-02
IB-1B	Muskrat	Zinc	2.56E+02	9.00E-03	1	5.10E-02	3.00E-02	0.1	1	0	0	1	3.92E-01	4.78E+00	0.00E+00	0.00E+00	9.00E-04	5.18E+00	120	240	4.3E-02	2.2E-02
IB-1B	Night Heron	Zinc	2.56E+02	9.00E-03	1	6.00E-02	2.00E-02	0.06	0	0.1	0.9	1	3.07E-01	0.00E+00	2.98E+00	2.68E+01	5.40E-04	3.013E+01	10	210	3.0E+00	1.4E-01

NOTES:

Mean concentrations of sediment and surface water used.

Sediment concentrations represent organic layer resampling results from 3/2012.

[1] kg food/kg BW/day x proportion sediment in diet = kg sediment/kg BW/day).

Table 4

Recalculation of Exposure and Hazard Quotients Using Alternative Exposure Estimates in IB-1b

Mean Organic Sediment Layer Concentration and Adjusted Sediment Ingestion (Night Heron = 5%)

North Alcoa Site; East St. Louis, IL.

									Proportion of Prey Item in Diet -				Intake From -									
Location	**Receptor**	**COPEC**	**Sediment EPC (mg/kg)**	**Surface Water EPC (mg/L)**	**Bioavailability Factor**	**Ingestion Rate Food (kg food/kg BW/day)[1]**	**Proportion of Sediment in Diet**	**Ingestion Rate of Water (kg water/kg BW/day)**	**Plants**	**Invertebrates**	**Amphibians**	**Area Use Factor**	**Sediment (mg/kg BW/day)**	**Plants (mg/kg BW/day)**	**Invertebrates (mg/kg BW/day)**	**Amphibians (mg/kg BW/day)**	**Surface Water (mg/kg BW/day)**	**Total Intake (mg/kg BW/day)**	**NOAEL TRV (mg/kg BW/day)**	**LOAEL TRV (mg/kg BW/day)**	**HQ NOAEL**	**HQ LOAEL**
IB-1B																						
IB-1B	Night Heron	Chromium	3.96E+01	3.00E-03	1	6.00E-02	5.00E-02	0.06	0	0.1	0.9	1	1.19E-01	0.00E+00	2.38E-02	2.14E-01	1.80E-04	3.57E-01	3.8	5	9.4E-02	7.1E-02
IB-1B	Night Heron	Vanadium	9.23E+01	6.70E-03	1	6.00E-02	5.00E-02	0.06	0	0.1	0.9	1	2.77E-01	0.00E+00	5.54E-01	4.98E+00	4.02E-04	5.82E+00	11.4	114	5.1E-01	5.1E-02
IB-1B	Night Heron	Zinc	2.56E+02	9.00E-03	1	6.00E-02	5.00E-02	0.06	0	0.1	0.9	1	7.69E-01	0.00E+00	2.98E+00	2.68E+01	5.40E-04	3.059E+01	10	210	3.1E+00	1.5E-01

NOTES:

Mean concentrations of sediment and surface water used.

Sediment concentrations represent organic layer resampling results from 3/2012.

Table 5

Recalculation of Exposure and Hazard Quotients Using AlternativeExposure Estimates in IB-1b

95% UCL Organic Sediment Layer Concentration and Adjusted Sediment Ingestion (Muskrat = 3%, Night Heron = 2%)

North Alcoa Site; East St. Louis, IL.

									Proportion of Prey Item in Diet -				Intake From -									
Location	**Receptor**	**COPEC**	**Sediment EPC (mg/kg)**	**Surface Water EPC (mg/L)**	**Bioavailability Factor**	**Ingestion Rate Food (kg food/kg BW/day)[1]**	**Proportion of Sediment in Diet**	**Ingestion Rate of Water (kg water/kg BW/day)**	**Plants**	**Invertebrates**	**Amphibians**	**Area Use Factor**	**Sediment (mg/kg BW/day)**	**Plants (mg/kg BW/day)**	**Invertebrates (mg/kg BW/day)**	**Amphibians (mg/kg BW/day)**	**Surface Water (mg/kg BW/day)**	**Total Intake (mg/kg BW/day)**	**NOAEL TRV (mg/kg BW/day)**	**LOAEL TRV (mg/kg BW/day)**	**HQ NOAEL**	**HQ LOAEL**
IB-1B																						
IB-1B	Mallard	Chromium	5.72E+01	3.00E-03	1	6.00E-02	3.00E-02	0.06	1	0	0	1	1.03E-01	1.41E-01	0.00E+00	0.00E+00	1.80E-04	2.44E-01	3.8	5	6.4E-02	4.9E-02
IB-1B	Mallard - Omnivore	Chromium	5.72E+01	3.00E-03	1	6.00E-02	3.00E-02	0.06	0.5	0.5	0	1	1.03E-01	7.04E-02	1.72E-01	0.00E+00	1.80E-04	3.45E-01	3.8	5	9.1E-02	6.9E-02
IB-1B	Muskrat	Chromium	5.72E+01	3.00E-03	1	5.10E-02	3.00E-02	0.1	1	0	0	1	8.75E-02	1.20E-01	0.00E+00	0.00E+00	3.00E-04	2.07E-01	2.4	2.82	8.6E-02	7.4E-02
IB-1B	Night Heron	Chromium	5.72E+01	3.00E-03	1	6.00E-02	2.00E-02	0.06	0	0.1	0.9	1	6.86E-02	0.00E+00	3.43E-02	3.09E-01	1.80E-04	4.12E-01	3.8	5	1.1E-01	8.2E-02
IB-1B	Mallard	Vanadium	1.61E+02	6.70E-03	1	6.00E-02	3.00E-02	0.06	1	0	0	1	2.90E-01	4.69E-02	0.00E+00	0.00E+00	4.02E-04	3.37E-01	11.4	114	3.0E-02	3.0E-03
IB-1B	Mallard - Omnivore	Vanadium	1.61E+02	6.70E-03	1	6.00E-02	3.00E-02	0.06	0.5	0.5	0	1	2.90E-01	2.34E-02	4.83E+00	0.00E+00	4.02E-04	5.15E+00	11.4	114	4.5E-01	4.5E-02
IB-1B	Muskrat	Vanadium	1.61E+02	6.70E-03	1	5.10E-02	3.00E-02	0.1	1	0	0	1	2.46E-01	3.98E-02	0.00E+00	0.00E+00	6.70E-04	2.87E-01	0.21	2.1	1.4E+00	1.4E-01
IB-1B	Night Heron	Vanadium	1.61E+02	6.70E-03	1	6.00E-02	2.00E-02	0.06	0	0.1	0.9	1	1.93E-01	0.00E+00	9.67E-01	8.70E+00	4.02E-04	9.86E+00	11.4	114	8.6E-01	8.6E-02
IB-1B	Mallard	Zinc	3.93E+02	9.00E-03	1	6.00E-02	3.00E-02	0.06	1	0	0	1	7.08E-01	8.63E+00	0.00E+00	0.00E+00	5.40E-04	9.34E+00	10	210	9.3E-01	4.4E-02
IB-1B	Mallard - Omnivore	Zinc	3.93E+02	9.00E-03	1	6.00E-02	3.00E-02	0.06	0.5	0.5	0	1	7.08E-01	4.32E+00	2.29E+01	0.00E+00	5.40E-04	2.790E+01	10	210	2.8E+00	1.3E-01
IB-1B	Muskrat	Zinc	3.93E+02	9.00E-03	1	5.10E-02	3.00E-02	0.1	1	0	0	1	6.01E-01	7.34E+00	0.00E+00	0.00E+00	9.00E-04	7.94E+00	120	240	6.6E-02	3.3E-02
IB-1B	Night Heron	Zinc	3.93E+02	9.00E-03	1	6.00E-02	2.00E-02	0.06	0	0.1	0.9	1	4.72E-01	0.00E+00	4.58E+00	4.12E+01	5.40E-04	4.62E+01	10	210	4.623E+00	2.2E-01

NOTES:

95% UCL concentrations of sediment used. Mean concentrations of surface water used.

Sediment concentrations represent organic layer resampling results from 3/2012.

Table 6

Recalculation of Exposure and Hazard Quotients Using AlternativeExposure Estimates inIB-1b

95% UCL Organic Sediment Layer Concentration and Adjusted Sediment Ingestion (Night Heron = 5%)

North Alcoa Site; East St. Louis, IL.

									Proportion of Prey Item in Diet -				Intake From -									
Location	**Receptor**	**COPEC**	**Sediment EPC (mg/kg)**	**Surface Water EPC (mg/L)**	**Bioavailability Factor**	**Ingestion Rate Food (kg food/kg BW/day)[1]**	**Proportion of Sediment in Diet**	**Ingestion Rate of Water (kg water/kg BW/day)**	**Plants**	**Invertebrates**	**Amphibians**	**Area Use Factor**	**Sediment (mg/kg BW/day)**	**Plants (mg/kg BW/day)**	**Invertebrates (mg/kg BW/day)**	**Amphibians (mg/kg BW/day)**	**Surface Water (mg/kg BW/day)**	**Total Intake (mg/kg BW/day)**	**NOAEL TRV (mg/kg BW/day)**	**LOAEL TRV (mg/kg BW/day)**	**HQ NOAEL**	**HQ LOAEL**
IB-1B																						
IB-1B	Night Heron	Chromium	5.72E+01	3.00E-03	1	6.00E-02	5.00E-02	0.06	0	0.1	0.9	1	1.72E-01	0.00E+00	3.43E-02	3.09E-01	1.80E-04	5.15E-01	3.8	5	1.4E-01	1.0E-01
IB-1B	Night Heron	Vanadium	1.61E+02	6.70E-03	1	6.00E-02	5.00E-02	0.06	0	0.1	0.9	1	4.83E-01	0.00E+00	9.67E-01	8.70E+00	4.02E-04	1.01E+01	11.4	114	8.9E-01	8.9E-02
IB-1B	Night Heron	Zinc	3.93E+02	9.00E-03	1	6.00E-02	5.00E-02	0.06	0	0.1	0.9	1	1.18E+00	0.00E+00	4.58E+00	4.12E+01	5.40E-04	4.694E+01	10	210	4.7E+00	2.2E-01

NOTES:

95% UCL concentrations of sediment used. Mean concentrations of surface water used.

Sediment concentrations represent organic layer resampling results from 3/2012.

APPENDIX F
RADIATION RISK SHIELDING CALCULATIONS

Radiation Shielding and Risk Calculations

Introduction

One of the proposed remedial action alternatives (RAAs) is to place a two-foot cover over the residue disposal areas (RDAs). These calculations evaluate the effectiveness of such a cover in reducing the risk to future workers. There are three pathways that contribute to the risk from radioactive materials:

- Ingestion
- Inhalation
- External Exposure

Of these three pathways, the ingestion and inhalation pathways are eliminated by placement of a two-foot cover. The ingestion pathway is caused by direct ingestion of dirt. The most common scenario for ingestion is transfer of dirt from the hands to the face and/or mouth or by transfer to food subsequently ingested. The source of the dirt on the hands of a site occupant is the surface soil at the site. This is the soil that is available to become suspended and subsequently deposited as dust on objects or that may be touched by a site occupant crouching, crawling, picking up a dropped object, or similar. Placement of a two-foot cover eliminates this pathway by placing “clean,” i.e., containing concentrations of radioactive materials no greater than normal background conditions, soil at the surface. Therefore, after placement of a cover, the risk from potential ingestion of radioactive material is zero.

The risk from inhalation is likewise reduced to zero. The risk from inhalation is due to surface soil that becomes suspended by the wind or mechanical agitation (movement of vehicles, walking, etc.). As with the ingestion pathway, placement of a two-foot cover eliminates this pathway by placing “clean” soil at the surface. The proposed RAA includes site use restrictions that preclude excavation or disturbance of the subsurface soils and also has provisions to prevent erosion of the surface soils. This eliminates the need to consider soil ingestion/inhalation pathways for other than surface soils.

With external exposure, radioactive materials can contribute to the overall external exposure risk pathway whether in the surface soils or subsurface soils. However, there is a reduction in the contribution to the total risk with an increase in the depth of a particular layer of soil due to the shielding effect of the soil above that layer. Therefore, while placement of a two-foot cover will not totally eliminate the external exposure risk from subsurface radioactive materials, it will serve to reduce the risk from those materials. The calculations below are an evaluation of the theoretical effectiveness of such a cover.

Cover Shielding Effectiveness Calculation Methodology

To evaluate the effectiveness of cover material, the dose at a point 1 meter (3’ 3.4”) above the ground surface from a 1 meter (3’ 3.4”) thick layer of source material (contaminated soil) was modeled with varying layers of clean (non-contaminated) cover material over it. One meter above the ground surface was chosen as representative of the dose to the torso of an adult. A one meter thick layer of contaminated material was chosen as a layer thick enough such that self-shielding results in negligible contribution from material below this thickness to the overall radiation exposure. The calculations of the effectiveness of the cover material validate this assumption.

The Microshield™ version 7.02 software from Grove Software, Inc. was used for these calculations. This software package is widely used to model the radiation dose from a variety of basic geometries such as slabs, points, cylinders, and rectangular volumes. For this application, an infinite slab geometry was used. An infinite slab is a slab with a finite height and infinite length and width. This permits conservative modeling of the radiation dose from broad areas of contaminated soils. With this geometry, multiple layers of materials may be modeled with each layer having unique material properties. The basic inputs to this model are material thicknesses, densities, and compositions.

Two materials were used in the modeling, soil and air. The default material composition and density of air as provided by the Microshield software was used. The elemental composition of soil was taken from Faw and Shultis Table C.5 (1999) and reproduced in Table F.1. This composition was used for both the source material layer and the cover material. A density of 1.6 g/cm^3 was used as this is the expected bulk density of the cover material after placement. While the source material layer may vary from this density, the change in source material density is offset by the change in volumetric radioactive material concentration. In other words, the change in the self-shielding effect is offset by the change in the total amount of radioactive material present.

Table F.1. Elemental Composition of Soil

Element	Weight %
Oxygen	50.90
Aluminum	5.00
Silicon	39.20
Potassium	1.41
Calcium	1.29
Iron	2.20

A typical geometry is show in Figure F.1. It consists of a one meter thick layer of source material (green material), a variable thickness of cover material (blue material), and a one meter air gap (gap from blue material to orange dot) to correspond to a dose point one meter above the ground surface. Although shown as a narrow rectangle, each material is infinite in extent in the Y and Z directions. While the modeling was performed in metric units, the thicknesses of the cover material were based on standard units (inches) to allow for the calculation of the effectiveness of a two-foot thick layer of cover material.

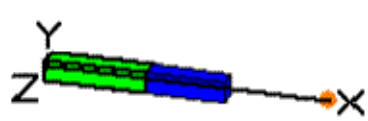


Figure F.1. Typical model geometry.

The radioactive material concentrations in the source material were based on the reasonable maximum exposure (RME) concentrations from the risk assessment. However, the exact concentrations used are not as important as the relative concentration ratios of the various radionuclides as the output of these calculation is a shielding effectiveness expressed as a ratio which results in the magnitude of the radioactive material concentrations being cancelled out.

Results

The results of this modeling for various cover thicknesses are given in Table F.2 and presented graphically in Figure F.2. Figures F.3 through F.13. contain the output for the 24 inch thick cover calculation.

Table F.2. Cover Material Shielding Effectiveness.

Cover Thickness (inches)	Nominal Dose Rate (µR/hr)	Shielding Dose Rate Reduction Ratio
0	113	0
1	79.0	1.43
2	59.1	1.91
3	45.3	2.49
6	22.0	5.14
12	6.22	18
18	2.04	55
24	0.733	154
30	0.278	406
36	0.109	1033
42	0.0439	2569

As can be seen, a two-foot thick cover reduces the external exposure rate from the contaminated material by a factor of 154, more than a two order of magnitude reduction in radiation exposure dose rate. Since the risk is directly proportional to the dose rate, this also results in a factor of 154 reduction in the external exposure risk. It is also important to note that the dose rate above a 2-foot cover from the RME concentrations is less than 1 µR/hr. Variation in natural background is typically ± 2 µR/hr, rendering an increase of less than 2 µR/hr indistinguishable from natural background.

A 36 inch cover (less than one meter) reduces the dose rate by a factor of over 1000. If the source material layer thickness were increased to more than a meter, the material below one meter deep would have less than 1/1000th of the dose rate of the first meter of material, or less than a 0.1% change in the dose rate. This increase is negligible, demonstrating that modeling a one meter thick layer of source material adequately addressed the external dose rate from any arbitrarily thicker layer of source material.

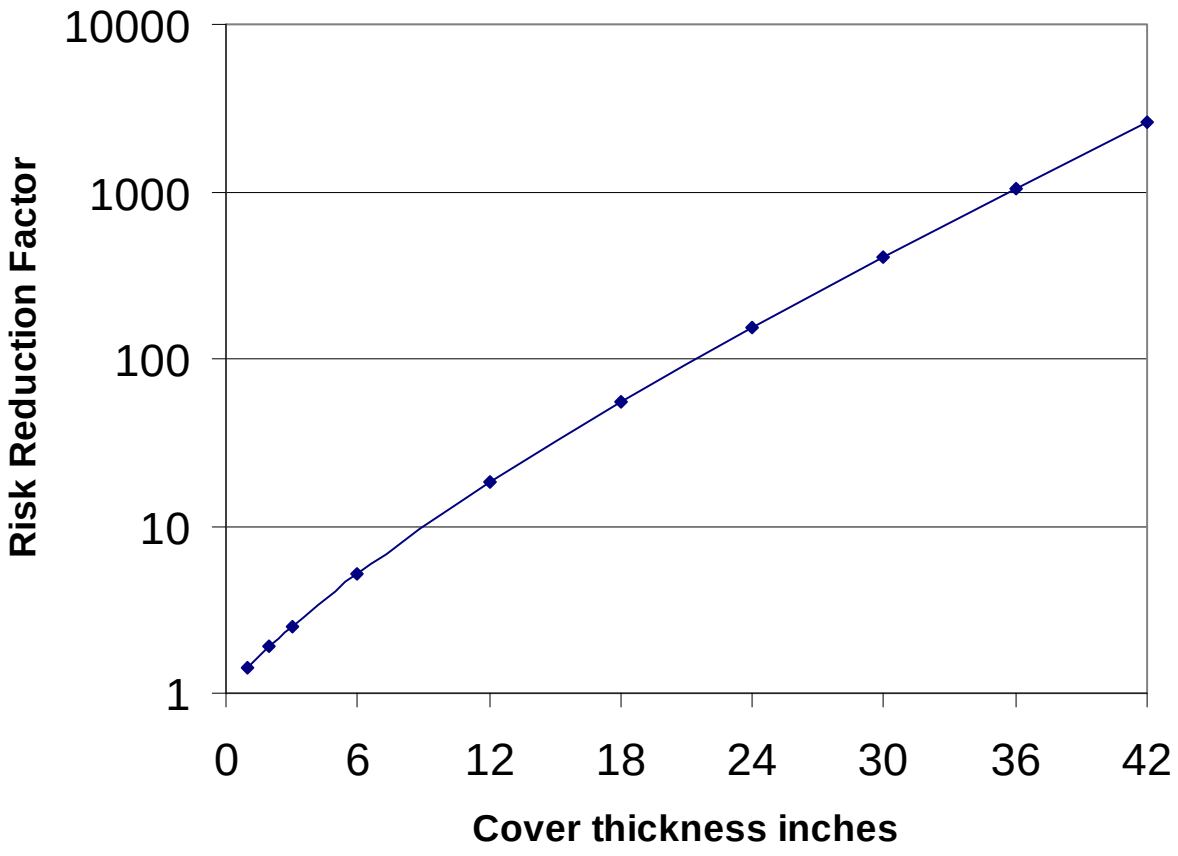


Figure F.2. Cover Material Shielding Effectiveness

References

Faw RE, Shultis JK, *Radiological Assessment: Sources and Doses*, American Nuclear Society, La Grange Park, IL. 1999.

MicroShield 7.02
Foxfire Scientific (07-msd-7.02-1309)

Date	By	Checked

Filename	Run Date	Run Time	Duration
RME no cover.ms7	11-Aug-11	10:01:16 AM	0:00:00

Project Info

Case Title	ESL RME ext exposure
Description	ESL RME external dose
Geometry	16 - Infinite Slab

Source Dimensions

Thickness	100.0 cm (3 ft 3.4 in)

Dose Points

A	X	Y	Z
#1	200.0 cm (6 ft 6.7 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Ac-228	3.84E-05	1.42E+00
Bi-210	7.47E-06	2.76E-01
Bi-212	3.84E-05	1.42E+00
Bi-214	9.39E-06	3.48E-01
Pa-234	5.12E-08	1.89E-03
Pa-234m	3.20E-05	1.18E+00
Pb-210	7.47E-06	2.76E-01
Pb-212	3.84E-05	1.42E+00
Pb-214	9.39E-06	3.48E-01
Po-210	7.44E-06	2.75E-01
Po-212	2.46E-05	9.10E-01
Po-214	9.39E-06	3.47E-01
Po-216	3.84E-05	1.42E+00
Po-218	9.39E-06	3.48E-01
Ra-224	3.84E-05	1.42E+00
Ra-226	9.60E-06	3.55E-01
Ra-228	3.84E-05	1.42E+00
Rn-220	3.84E-05	1.42E+00
Rn-222	9.39E-06	3.48E-01
Th-228	3.84E-05	1.42E+00
Th-230	1.02E-12	3.76E-08
Th-232	3.84E-05	1.42E+00
Th-234	3.20E-05	1.18E+00
Tl-208	1.38E-05	5.10E-01
U-234	4.53E-09	1.68E-04
U-238	3.20E-05	1.18E+00

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.51E+00	5.43E-04	6.31E-04	4.65E-05	5.41E-05
0.04	1.45E-02	3.11E-04	1.18E-03	1.38E-06	5.20E-06
0.05	1.50E-02	6.32E-04	4.07E-03	1.68E-06	1.08E-05
0.06	5.62E-02	3.76E-03	3.57E-02	7.47E-06	7.09E-05
0.08	6.95E-01	8.45E-02	1.04E+00	1.34E-04	1.65E-03
0.1	1.74E-01	3.09E-02	4.03E-01	4.73E-05	6.17E-04
0.15	6.03E-02	1.96E-02	2.25E-01	3.22E-05	3.71E-04
0.2	8.10E-01	3.93E-01	3.46E+00	6.94E-04	6.11E-03
0.3	4.42E-01	3.77E-01	2.70E+00	7.16E-04	5.11E-03
0.4	1.67E-01	2.13E-01	1.20E+00	4.16E-04	2.34E-03
0.5	2.04E-01	3.58E-01	1.72E+00	7.03E-04	3.38E-03
0.6	6.20E-01	1.42E+00	5.84E+00	2.78E-03	1.14E-02
0.8	4.90E-01	1.71E+00	5.86E+00	3.26E-03	1.11E-02
1	9.49E-01	4.64E+00	1.37E+01	8.55E-03	2.52E-02
1.5	2.57E-01	2.33E+00	5.40E+00	3.92E-03	9.08E-03
2	9.74E-02	1.37E+00	2.80E+00	2.11E-03	4.33E-03
3	5.10E-01	1.32E+01	2.36E+01	1.79E-02	3.20E-02
Totals	**7.07E+00**	**2.61E+01**	**6.79E+01**	**4.13E-02**	**1.13E-01**

Figure F.3. Microshield Output for no cover calculation.

MicroShield 7.02
Foxfire Scientific (07-msd-7.02-1309)

Date	By	Checked

Filename	Run Date	Run Time	Duration
RME 1 inch.ms7	11-Aug-11	10:00:41 AM	0:00:00

Project Info

Case Title	ESL RME ext exposure
Description	ESL RME external dose
Geometry	16 - Infinite Slab

Source Dimensions

Thickness	100.0 cm (3 ft 3.4 in)

Dose Points

A	X	Y	Z
#1	202.54 cm (6 ft 7.7 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Shield 1	2.54 cm	Soil	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Ac-228	3.84E-05	1.42E+00
Bi-210	7.47E-06	2.76E-01
Bi-212	3.84E-05	1.42E+00
Bi-214	9.39E-06	3.48E-01
Pa-234	5.12E-08	1.89E-03
Pa-234m	3.20E-05	1.18E+00
Pb-210	7.47E-06	2.76E-01
Pb-212	3.84E-05	1.42E+00
Pb-214	9.39E-06	3.48E-01
Po-210	7.44E-06	2.75E-01
Po-212	2.46E-05	9.10E-01
Po-214	9.39E-06	3.47E-01
Po-216	3.84E-05	1.42E+00
Po-218	9.39E-06	3.48E-01
Ra-224	3.84E-05	1.42E+00
Ra-226	9.60E-06	3.55E-01
Ra-228	3.84E-05	1.42E+00
Rn-220	3.84E-05	1.42E+00
Rn-222	9.39E-06	3.48E-01
Th-228	3.84E-05	1.42E+00
Th-230	1.02E-12	3.76E-08
Th-232	3.84E-05	1.42E+00
Th-234	3.20E-05	1.18E+00
Tl-208	1.38E-05	5.10E-01
U-234	4.53E-09	1.68E-04
U-238	3.20E-05	1.18E+00

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.51E+00	5.94E-19	1.05E-18	5.10E-20	8.99E-20
0.04	1.45E-02	1.10E-05	1.20E-04	4.88E-08	5.30E-07
0.05	1.50E-02	6.02E-05	1.00E-03	1.60E-07	2.67E-06
0.06	5.62E-02	5.69E-04	1.29E-02	1.13E-06	2.55E-05
0.08	6.95E-01	1.90E-02	5.02E-01	3.01E-05	7.94E-04
0.1	1.74E-01	8.25E-03	2.17E-01	1.26E-05	3.32E-04
0.15	6.03E-02	6.24E-03	1.34E-01	1.03E-05	2.20E-04
0.2	8.10E-01	1.37E-01	2.13E+00	2.43E-04	3.77E-03
0.3	4.42E-01	1.48E-01	1.73E+00	2.81E-04	3.29E-03
0.4	1.67E-01	9.03E-02	7.91E-01	1.76E-04	1.54E-03
0.5	2.04E-01	1.61E-01	1.15E+00	3.16E-04	2.26E-03
0.6	6.20E-01	6.69E-01	3.95E+00	1.31E-03	7.70E-03
0.8	4.90E-01	8.65E-01	4.04E+00	1.65E-03	7.69E-03
1	9.49E-01	2.47E+00	9.57E+00	4.55E-03	1.76E-02
1.5	2.57E-01	1.36E+00	3.87E+00	2.28E-03	6.52E-03
2	9.74E-02	8.44E-01	2.05E+00	1.30E-03	3.17E-03
3	5.10E-01	8.70E+00	1.77E+01	1.18E-02	2.40E-02
Totals	**7.07E+00**	**1.55E+01**	**4.79E+01**	**2.40E-02**	**7.90E-02**

Figure F.4. Microshield Output for 1-inch cover calculation.

MicroShield 7.02
Foxfire Scientific (07-msd-7.02-1309)

Date	By	Checked

Filename	Run Date	Run Time	Duration
RME 2 inch.ms7	11-Aug-11	9:59:58 AM	0:00:00

Project Info

Case Title	ESL RME ext exposure
Description	ESL RME external dose
Geometry	16 - Infinite Slab

Source Dimensions

Thickness	100.0 cm (3 ft 3.4 in)

Dose Points

A	X	Y	Z
#1	205.08 cm (6 ft 8.7 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Shield 1	5.08 cm	Soil	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Ac-228	3.84E-05	1.42E+00
Bi-210	7.47E-06	2.76E-01
Bi-212	3.84E-05	1.42E+00
Bi-214	9.39E-06	3.48E-01
Pa-234	5.12E-08	1.89E-03
Pa-234m	3.20E-05	1.18E+00
Pb-210	7.47E-06	2.76E-01
Pb-212	3.84E-05	1.42E+00
Pb-214	9.39E-06	3.48E-01
Po-210	7.44E-06	2.75E-01
Po-212	2.46E-05	9.10E-01
Po-214	9.39E-06	3.47E-01
Po-216	3.84E-05	1.42E+00
Po-218	9.39E-06	3.48E-01
Ra-224	3.84E-05	1.42E+00
Ra-226	9.60E-06	3.55E-01
Ra-228	3.84E-05	1.42E+00
Rn-220	3.84E-05	1.42E+00
Rn-222	9.39E-06	3.48E-01
Th-228	3.84E-05	1.42E+00
Th-230	1.02E-12	3.76E-08
Th-232	3.84E-05	1.42E+00
Th-234	3.20E-05	1.18E+00
Tl-208	1.38E-05	5.10E-01
U-234	4.53E-09	1.68E-04
U-238	3.20E-05	1.18E+00

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.51E+00	7.97E-33	1.55E-32	6.83E-34	1.33E-33
0.04	1.45E-02	8.43E-07	1.45E-05	3.73E-09	6.43E-08
0.05	1.50E-02	1.02E-05	2.69E-04	2.73E-08	7.18E-07
0.06	5.62E-02	1.39E-04	4.87E-03	2.77E-07	9.66E-06
0.08	6.95E-01	6.33E-03	2.50E-01	1.00E-05	3.95E-04
0.1	1.74E-01	3.11E-03	1.20E-01	4.76E-06	1.83E-04
0.15	6.03E-02	2.70E-03	8.16E-02	4.45E-06	1.34E-04
0.2	8.10E-01	6.37E-02	1.36E+00	1.12E-04	2.40E-03
0.3	4.42E-01	7.47E-02	1.16E+00	1.42E-04	2.20E-03
0.4	1.67E-01	4.83E-02	5.44E-01	9.41E-05	1.06E-03
0.5	2.04E-01	8.98E-02	8.11E-01	1.76E-04	1.59E-03
0.6	6.20E-01	3.86E-01	2.82E+00	7.54E-04	5.51E-03
0.8	4.90E-01	5.27E-01	2.97E+00	1.00E-03	5.64E-03
1	9.49E-01	1.56E+00	7.15E+00	2.88E-03	1.32E-02
1.5	2.57E-01	9.19E-01	2.98E+00	1.55E-03	5.02E-03
2	9.74E-02	5.95E-01	1.61E+00	9.19E-04	2.49E-03
3	5.10E-01	6.44E+00	1.42E+01	8.74E-03	1.93E-02
Totals	**7.07E+00**	**1.07E+01**	**3.61E+01**	**1.64E-02**	**5.91E-02**

Figure F.5. Microshield Output for 2-inch cover calculation.

MicroShield 7.02
Foxfire Scientific (07-msd-7.02-1309)

Date	By	Checked

Filename	Run Date	Run Time	Duration
RME 3 inch.ms7	11-Aug-11	9:59:19 AM	0:00:00

Project Info

Case Title	ESL RME ext exposure
Description	ESL RME external dose
Geometry	16 - Infinite Slab

Source Dimensions

Thickness	100.0 cm (3 ft 3.4 in)

Dose Points

A	X	Y	Z
#1	207.62 cm (6 ft 9.7 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Shield 1	7.62 cm	Soil	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Ac-228	3.84E-05	1.42E+00
Bi-210	7.47E-06	2.76E-01
Bi-212	3.84E-05	1.42E+00
Bi-214	9.39E-06	3.48E-01
Pa-234	5.12E-08	1.89E-03
Pa-234m	3.20E-05	1.18E+00
Pb-210	7.47E-06	2.76E-01
Pb-212	3.84E-05	1.42E+00
Pb-214	9.39E-06	3.48E-01
Po-210	7.44E-06	2.75E-01
Po-212	2.46E-05	9.10E-01
Po-214	9.39E-06	3.47E-01
Po-216	3.84E-05	1.42E+00
Po-218	9.39E-06	3.48E-01
Ra-224	3.84E-05	1.42E+00
Ra-226	9.60E-06	3.55E-01
Ra-228	3.84E-05	1.42E+00
Rn-220	3.84E-05	1.42E+00
Rn-222	9.39E-06	3.48E-01
Th-228	3.84E-05	1.42E+00
Th-230	1.02E-12	3.76E-08
Th-232	3.84E-05	1.42E+00
Th-234	3.20E-05	1.18E+00
Tl-208	1.38E-05	5.10E-01
U-234	4.53E-09	1.68E-04
U-238	3.20E-05	1.18E+00

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.51E+00	1.39E-46	1.39E-46	1.20E-47	1.20E-47
0.04	1.45E-02	7.53E-08	1.80E-06	3.33E-10	7.96E-09
0.05	1.50E-02	1.98E-06	7.31E-05	5.29E-09	1.95E-07
0.06	5.62E-02	3.82E-05	1.86E-03	7.60E-08	3.69E-06
0.08	6.95E-01	2.32E-03	1.25E-01	3.67E-06	1.98E-04
0.1	1.74E-01	1.29E-03	6.67E-02	1.97E-06	1.02E-04
0.15	6.03E-02	1.27E-03	5.02E-02	2.09E-06	8.26E-05
0.2	8.10E-01	3.19E-02	8.75E-01	5.62E-05	1.54E-03
0.3	4.42E-01	4.05E-02	7.83E-01	7.68E-05	1.49E-03
0.4	1.67E-01	2.76E-02	3.78E-01	5.38E-05	7.37E-04
0.5	2.04E-01	5.34E-02	5.77E-01	1.05E-04	1.13E-03
0.6	6.20E-01	2.37E-01	2.04E+00	4.62E-04	3.99E-03
0.8	4.90E-01	3.39E-01	2.21E+00	6.44E-04	4.20E-03
1	9.49E-01	1.04E+00	5.43E+00	1.92E-03	1.00E-02
1.5	2.57E-01	6.50E-01	2.34E+00	1.09E-03	3.94E-03
2	9.74E-02	4.36E-01	1.29E+00	6.75E-04	1.99E-03
3	5.10E-01	4.94E+00	1.17E+01	6.70E-03	1.59E-02
Totals	**7.07E+00**	**7.80E+00**	**2.79E+01**	**1.18E-02**	**4.53E-02**

Figure F.6. Microshield Output for 3-inch cover calculation.

MicroShield 7.02
Foxfire Scientific (07-msd-7.02-1309)

Date	By	Checked

Filename	Run Date	Run Time	Duration
RME 6 inch.ms7	11-Aug-11	9:58:41 AM	0:00:00

Project Info

Case Title	ESL RME ext exposure
Description	ESL RME external dose
Geometry	16 - Infinite Slab

Source Dimensions

Thickness	100.0 cm (3 ft 3.4 in)

Dose Points

A	X	Y	Z
#1	215.24 cm (7 ft 0.7 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Shield 1	15.24 cm	Soil	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Ac-228	3.84E-05	1.42E+00
Bi-210	7.47E-06	2.76E-01
Bi-212	3.84E-05	1.42E+00
Bi-214	9.39E-06	3.48E-01
Pa-234	5.12E-08	1.89E-03
Pa-234m	3.20E-05	1.18E+00
Pb-210	7.47E-06	2.76E-01
Pb-212	3.84E-05	1.42E+00
Pb-214	9.39E-06	3.48E-01
Po-210	7.44E-06	2.75E-01
Po-212	2.46E-05	9.10E-01
Po-214	9.39E-06	3.47E-01
Po-216	3.84E-05	1.42E+00
Po-218	9.39E-06	3.48E-01
Ra-224	3.84E-05	1.42E+00
Ra-226	9.60E-06	3.55E-01
Ra-228	3.84E-05	1.42E+00
Rn-220	3.84E-05	1.42E+00
Rn-222	9.39E-06	3.48E-01
Th-228	3.84E-05	1.42E+00
Th-230	1.02E-12	3.76E-08
Th-232	3.84E-05	1.42E+00
Th-234	3.20E-05	1.18E+00
Tl-208	1.38E-05	5.10E-01
U-234	4.53E-09	1.68E-04
U-238	3.20E-05	1.18E+00

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.51E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.04	1.45E-02	7.58E-11	3.53E-09	3.35E-13	1.56E-11
0.05	1.50E-02	1.95E-08	1.50E-06	5.20E-11	3.98E-09
0.06	5.62E-02	1.04E-06	1.05E-04	2.06E-09	2.08E-07
0.08	6.95E-01	1.46E-04	1.59E-02	2.31E-07	2.52E-05
0.1	1.74E-01	1.14E-04	1.16E-02	1.74E-07	1.78E-05
0.15	6.03E-02	1.61E-04	1.18E-02	2.65E-07	1.95E-05
0.2	8.10E-01	4.84E-03	2.36E-01	8.55E-06	4.17E-04
0.3	4.42E-01	7.70E-03	2.46E-01	1.46E-05	4.66E-04
0.4	1.67E-01	6.09E-03	1.31E-01	1.19E-05	2.54E-04
0.5	2.04E-01	1.31E-02	2.14E-01	2.58E-05	4.20E-04
0.6	6.20E-01	6.37E-02	8.04E-01	1.24E-04	1.57E-03
0.8	4.90E-01	1.04E-01	9.48E-01	1.98E-04	1.80E-03
1	9.49E-01	3.52E-01	2.48E+00	6.49E-04	4.58E-03
1.5	2.57E-01	2.59E-01	1.19E+00	4.36E-04	2.00E-03
2	9.74E-02	1.92E-01	6.99E-01	2.97E-04	1.08E-03
3	5.10E-01	2.45E+00	6.85E+00	3.33E-03	9.29E-03
Totals	**7.07E+00**	**3.46E+00**	**1.38E+01**	**5.09E-03**	**2.20E-02**

Figure F.7. Microshield Output for 6-inch cover calculation.

MicroShield 7.02
Foxfire Scientific (07-msd-7.02-1309)

Date	By	Checked

Filename	Run Date	Run Time	Duration
RME 12 inch.ms7	11-Aug-11	9:58:01 AM	0:00:00

Project Info

Case Title	ESL RME ext exposure
Description	ESL RME external dose
Geometry	16 - Infinite Slab

Source Dimensions

Thickness	100.0 cm (3 ft 3.4 in)

Dose Points

A	X	Y	Z
#1	230.48 cm (7 ft 6.7 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Shield 1	30.48 cm	Soil	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Ac-228	3.84E-05	1.42E+00
Bi-210	7.47E-06	2.76E-01
Bi-212	3.84E-05	1.42E+00
Bi-214	9.39E-06	3.48E-01
Pa-234	5.12E-08	1.89E-03
Pa-234m	3.20E-05	1.18E+00
Pb-210	7.47E-06	2.76E-01
Pb-212	3.84E-05	1.42E+00
Pb-214	9.39E-06	3.48E-01
Po-210	7.44E-06	2.75E-01
Po-212	2.46E-05	9.10E-01
Po-214	9.39E-06	3.47E-01
Po-216	3.84E-05	1.42E+00
Po-218	9.39E-06	3.48E-01
Ra-224	3.84E-05	1.42E+00
Ra-226	9.60E-06	3.55E-01
Ra-228	3.84E-05	1.42E+00
Rn-220	3.84E-05	1.42E+00
Rn-222	9.39E-06	3.48E-01
Th-228	3.84E-05	1.42E+00
Th-230	1.02E-12	3.76E-08
Th-232	3.84E-05	1.42E+00
Th-234	3.20E-05	1.18E+00
Tl-208	1.38E-05	5.10E-01
U-234	4.53E-09	1.68E-04
U-238	3.20E-05	1.18E+00

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.51E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.04	1.45E-02	1.32E-16	1.36E-14	5.85E-19	6.02E-17
0.05	1.50E-02	3.06E-12	6.39E-10	8.16E-15	1.70E-12
0.06	5.62E-02	1.19E-09	3.41E-07	2.37E-12	6.78E-10
0.08	6.95E-01	8.57E-07	2.62E-04	1.36E-09	4.15E-07
0.1	1.74E-01	1.30E-06	3.56E-04	1.99E-09	5.45E-07
0.15	6.03E-02	3.68E-06	6.66E-04	6.05E-09	1.10E-06
0.2	8.10E-01	1.57E-04	1.76E-02	2.77E-07	3.11E-05
0.3	4.42E-01	3.82E-04	2.48E-02	7.25E-07	4.71E-05
0.4	1.67E-01	4.00E-04	1.60E-02	7.80E-07	3.13E-05
0.5	2.04E-01	1.06E-03	3.06E-02	2.09E-06	6.01E-05
0.6	6.20E-01	6.08E-03	1.30E-01	1.19E-05	2.54E-04
0.8	4.90E-01	1.27E-02	1.85E-01	2.42E-05	3.51E-04
1	9.49E-01	5.16E-02	5.55E-01	9.51E-05	1.02E-03
1.5	2.57E-01	5.14E-02	3.34E-01	8.64E-05	5.62E-04
2	9.74E-02	4.59E-02	2.25E-01	7.09E-05	3.48E-04
3	5.10E-01	7.26E-01	2.59E+00	9.85E-04	3.51E-03
Totals	**7.07E+00**	**8.96E-01**	**4.11E+00**	**1.28E-03**	**6.22E-03**

Figure F.8. Microshield Output for 12-inch cover calculation.

MicroShield 7.02
Foxfire Scientific (07-msd-7.02-1309)

Date	By	Checked

Filename	Run Date	Run Time	Duration
RME 18 inch.ms7	11-Aug-11	9:57:18 AM	-01:59:6

Project Info

Case Title	ESL RME ext exposure
Description	ESL RME external dose
Geometry	16 - Infinite Slab

Source Dimensions

Thickness	100.0 cm (3 ft 3.4 in)

Dose Points

A	X	Y	Z
#1	245.72 cm (8 ft 0.7 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Shield 1	45.72 cm	Soil	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Ac-228	3.84E-05	1.42E+00
Bi-210	7.47E-06	2.76E-01
Bi-212	3.84E-05	1.42E+00
Bi-214	9.39E-06	3.48E-01
Pa-234	5.12E-08	1.89E-03
Pa-234m	3.20E-05	1.18E+00
Pb-210	7.47E-06	2.76E-01
Pb-212	3.84E-05	1.42E+00
Pb-214	9.39E-06	3.48E-01
Po-210	7.44E-06	2.75E-01
Po-212	2.46E-05	9.10E-01
Po-214	9.39E-06	3.47E-01
Po-216	3.84E-05	1.42E+00
Po-218	9.39E-06	3.48E-01
Ra-224	3.84E-05	1.42E+00
Ra-226	9.60E-06	3.55E-01
Ra-228	3.84E-05	1.42E+00
Rn-220	3.84E-05	1.42E+00
Rn-222	9.39E-06	3.48E-01
Th-228	3.84E-05	1.42E+00
Th-230	1.02E-12	3.76E-08
Th-232	3.84E-05	1.42E+00
Th-234	3.20E-05	1.18E+00
Tl-208	1.38E-05	5.10E-01
U-234	4.53E-09	1.68E-04
U-238	3.20E-05	1.18E+00

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.51E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.04	1.45E-02	2.89E-22	5.74E-20	1.28E-24	2.54E-22
0.05	1.50E-02	5.94E-16	2.78E-13	1.58E-18	7.41E-16
0.06	5.62E-02	1.70E-12	1.12E-09	3.38E-15	2.23E-12
0.08	6.95E-01	6.16E-09	4.34E-06	9.75E-12	6.87E-09
0.1	1.74E-01	1.80E-08	1.10E-05	2.75E-11	1.68E-08
0.15	6.03E-02	1.01E-07	3.79E-05	1.66E-10	6.24E-08
0.2	8.10E-01	6.08E-06	1.33E-03	1.07E-08	2.34E-06
0.3	4.42E-01	2.25E-05	2.53E-03	4.26E-08	4.80E-06
0.4	1.67E-01	3.09E-05	2.00E-03	6.03E-08	3.90E-06
0.5	2.04E-01	1.01E-04	4.45E-03	1.98E-07	8.74E-06
0.6	6.20E-01	6.75E-04	2.15E-02	1.32E-06	4.20E-05
0.8	4.90E-01	1.79E-03	3.68E-02	3.41E-06	7.01E-05
1	9.49E-01	8.67E-03	1.27E-01	1.60E-05	2.35E-04
1.5	2.57E-01	1.16E-02	9.74E-02	1.94E-05	1.64E-04
2	9.74E-02	1.23E-02	7.56E-02	1.90E-05	1.17E-04
3	5.10E-01	2.39E-01	1.03E+00	3.24E-04	1.40E-03
Totals	**7.07E+00**	**2.74E-01**	**1.40E+00**	**3.84E-04**	**2.04E-03**

Figure F.9. Microshield Output for 18-inch cover calculation.

MicroShield 7.02
Foxfire Scientific (07-msd-7.02-1309)

Date	By	Checked

Filename	Run Date	Run Time	Duration
RME 24 inch.ms7	11-Aug-11	9:56:32 AM	0:00:00

Project Info

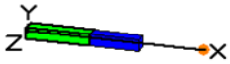
Case Title	ESL RME ext exposure
Description	ESL RME external dose
Geometry	16 - Infinite Slab

Source Dimensions

Thickness	100.0 cm (3 ft 3.4 in)

Dose Points

A	X	Y	Z
#1	260.96 cm (8 ft 6.7 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)



Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Shield 1	60.96 cm	Soil	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Ac-228	3.84E-05	1.42E+00
Bi-210	7.47E-06	2.76E-01
Bi-212	3.84E-05	1.42E+00
Bi-214	9.39E-06	3.48E-01
Pa-234	5.12E-08	1.89E-03
Pa-234m	3.20E-05	1.18E+00
Pb-210	7.47E-06	2.76E-01
Pb-212	3.84E-05	1.42E+00
Pb-214	9.39E-06	3.48E-01
Po-210	7.44E-06	2.75E-01
Po-212	2.46E-05	9.10E-01
Po-214	9.39E-06	3.47E-01
Po-216	3.84E-05	1.42E+00
Po-218	9.39E-06	3.48E-01
Ra-224	3.84E-05	1.42E+00
Ra-226	9.60E-06	3.55E-01
Ra-228	3.84E-05	1.42E+00
Rn-220	3.84E-05	1.42E+00
Rn-222	9.39E-06	3.48E-01
Th-228	3.84E-05	1.42E+00
Th-230	1.02E-12	3.76E-08
Th-232	3.84E-05	1.42E+00
Th-234	3.20E-05	1.18E+00
Tl-208	1.38E-05	5.10E-01
U-234	4.53E-09	1.68E-04
U-238	3.20E-05	1.18E+00

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.51E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.04	1.45E-02	7.16E-28	2.34E-25	3.17E-30	1.04E-27
0.05	1.50E-02	1.31E-19	1.21E-16	3.50E-22	3.21E-19
0.06	5.62E-02	2.63E-15	3.75E-12	5.22E-18	7.44E-15
0.08	6.95E-01	4.86E-11	7.22E-08	7.70E-14	1.14E-10
0.1	1.74E-01	2.73E-10	3.39E-07	4.17E-13	5.19E-10
0.15	6.03E-02	3.02E-09	2.16E-06	4.98E-12	3.56E-09
0.2	8.10E-01	2.55E-07	9.98E-05	4.51E-10	1.76E-07
0.3	4.42E-01	1.43E-06	2.60E-04	2.71E-09	4.92E-07
0.4	1.67E-01	2.58E-06	2.51E-04	5.03E-09	4.88E-07
0.5	2.04E-01	1.03E-05	6.52E-04	2.02E-08	1.28E-06
0.6	6.20E-01	8.06E-05	3.58E-03	1.57E-07	6.98E-06
0.8	4.90E-01	2.71E-04	7.41E-03	5.16E-07	1.41E-05
1	9.49E-01	1.56E-03	2.96E-02	2.87E-06	5.45E-05
1.5	2.57E-01	2.77E-03	2.88E-02	4.65E-06	4.85E-05
2	9.74E-02	3.50E-03	2.59E-02	5.41E-06	4.00E-05
3	5.10E-01	8.31E-02	4.17E-01	1.13E-04	5.66E-04
Totals	**7.07E+00**	**9.13E-02**	**5.14E-01**	**1.26E-04**	**7.33E-04**

Figure F.10. Microshield Output for 24-inch cover calculation.

MicroShield 7.02
Foxfire Scientific (07-msd-7.02-1309)

Date	By	Checked

Filename	Run Date	Run Time	Duration
RME 30 inch.ms7	11-Aug-11	10:02:21 AM	0:00:00

Project Info

Case Title	ESL RME ext exposure
Description	ESL RME external dose
Geometry	16 - Infinite Slab

Source Dimensions

Thickness	100.0 cm (3 ft 3.4 in)

Dose Points

A	X	Y	Z
#1	276.2 cm (9 ft 0.7 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Shield 1	76.2 cm	Soil	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Ac-228	3.84E-05	1.42E+00
Bi-210	7.47E-06	2.76E-01
Bi-212	3.84E-05	1.42E+00
Bi-214	9.39E-06	3.48E-01
Pa-234	5.12E-08	1.89E-03
Pa-234m	3.20E-05	1.18E+00
Pb-210	7.47E-06	2.76E-01
Pb-212	3.84E-05	1.42E+00
Pb-214	9.39E-06	3.48E-01
Po-210	7.44E-06	2.75E-01
Po-212	2.46E-05	9.10E-01
Po-214	9.39E-06	3.47E-01
Po-216	3.84E-05	1.42E+00
Po-218	9.39E-06	3.48E-01
Ra-224	3.84E-05	1.42E+00
Ra-226	9.60E-06	3.55E-01
Ra-228	3.84E-05	1.42E+00
Rn-220	3.84E-05	1.42E+00
Rn-222	9.39E-06	3.48E-01
Th-228	3.84E-05	1.42E+00
Th-230	1.02E-12	3.76E-08
Th-232	3.84E-05	1.42E+00
Th-234	3.20E-05	1.18E+00
Tl-208	1.38E-05	5.10E-01
U-234	4.53E-09	1.68E-04
U-238	3.20E-05	1.18E+00

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.51E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.04	1.45E-02	1.86E-33	9.94E-31	8.23E-36	4.40E-33
0.05	1.50E-02	3.06E-23	5.20E-20	8.15E-26	1.39E-22
0.06	5.62E-02	4.46E-18	1.25E-14	8.85E-21	2.48E-17
0.08	6.95E-01	4.05E-13	1.21E-09	6.41E-16	1.91E-12
0.1	1.74E-01	4.35E-12	1.05E-08	6.66E-15	1.61E-11
0.15	6.03E-02	9.51E-11	1.24E-07	1.57E-13	2.04E-10
0.2	8.10E-01	1.13E-08	7.53E-06	1.99E-11	1.33E-08
0.3	4.42E-01	9.54E-08	2.67E-05	1.81E-10	5.06E-08
0.4	1.67E-01	2.26E-07	3.15E-05	4.40E-10	6.14E-08
0.5	2.04E-01	1.10E-06	9.58E-05	2.16E-09	1.88E-07
0.6	6.20E-01	1.01E-05	5.97E-04	1.97E-08	1.17E-06
0.8	4.90E-01	4.28E-05	1.50E-03	8.15E-08	2.85E-06
1	9.49E-01	2.92E-04	6.90E-03	5.39E-07	1.27E-05
1.5	2.57E-01	6.88E-04	8.59E-03	1.16E-06	1.45E-05
2	9.74E-02	1.03E-03	8.95E-03	1.60E-06	1.38E-05
3	5.10E-01	2.99E-02	1.72E-01	4.06E-05	2.33E-04
Totals	**7.07E+00**	**3.20E-02**	**1.98E-01**	**4.40E-05**	**2.78E-04**

Figure F.11. Microshield Output for 30-inch cover calculation.

MicroShield 7.02
Foxfire Scientific (07-msd-7.02-1309)

Date	By	Checked

Filename	Run Date	Run Time	Duration
RME 36 inch.ms7	11-Aug-11	10:03:16 AM	-01:59:6

Project Info

Case Title	ESL RME ext exposure
Description	ESL RME external dose
Geometry	16 - Infinite Slab

Source Dimensions

Thickness	100.0 cm (3 ft 3.4 in)

Dose Points

A	X	Y	Z
#1	291.44 cm (9 ft 6.7 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Shield 1	91.44 cm	Soil	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Ac-228	3.84E-05	1.42E+00
Bi-210	7.47E-06	2.76E-01
Bi-212	3.84E-05	1.42E+00
Bi-214	9.39E-06	3.48E-01
Pa-234	5.12E-08	1.89E-03
Pa-234m	3.20E-05	1.18E+00
Pb-210	7.47E-06	2.76E-01
Pb-212	3.84E-05	1.42E+00
Pb-214	9.39E-06	3.48E-01
Po-210	7.44E-06	2.75E-01
Po-212	2.46E-05	9.10E-01
Po-214	9.39E-06	3.47E-01
Po-216	3.84E-05	1.42E+00
Po-218	9.39E-06	3.48E-01
Ra-224	3.84E-05	1.42E+00
Ra-226	9.60E-06	3.55E-01
Ra-228	3.84E-05	1.42E+00
Rn-220	3.84E-05	1.42E+00
Rn-222	9.39E-06	3.48E-01
Th-228	3.84E-05	1.42E+00
Th-230	1.02E-12	3.76E-08
Th-232	3.84E-05	1.42E+00
Th-234	3.20E-05	1.18E+00
Tl-208	1.38E-05	5.10E-01
U-234	4.53E-09	1.68E-04
U-238	3.20E-05	1.18E+00

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.51E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.04	1.45E-02	5.04E-39	4.20E-36	2.23E-41	1.86E-38
0.05	1.50E-02	7.22E-27	2.27E-23	1.92E-29	6.06E-26
0.06	5.62E-02	7.65E-21	4.18E-17	1.52E-23	8.30E-20
0.08	6.95E-01	3.49E-15	1.97E-11	5.52E-18	3.12E-14
0.1	1.74E-01	7.13E-14	3.25E-10	1.09E-16	4.97E-13
0.15	6.03E-02	3.10E-12	7.11E-09	5.10E-15	1.17E-11
0.2	8.10E-01	5.15E-10	5.69E-07	9.08E-13	1.00E-09
0.3	4.42E-01	6.57E-09	2.74E-06	1.25E-11	5.20E-09
0.4	1.67E-01	2.04E-08	3.97E-06	3.97E-11	7.73E-09
0.5	2.04E-01	1.21E-07	1.41E-05	2.37E-10	2.77E-08
0.6	6.20E-01	1.30E-06	9.99E-05	2.53E-09	1.95E-07
0.8	4.90E-01	6.96E-06	3.04E-04	1.32E-08	5.77E-07
1	9.49E-01	5.63E-05	1.62E-03	1.04E-07	2.98E-06
1.5	2.57E-01	1.76E-04	2.58E-03	2.96E-07	4.33E-06
2	9.74E-02	3.13E-04	3.11E-03	4.83E-07	4.81E-06
3	5.10E-01	1.10E-02	7.10E-02	1.49E-05	9.63E-05
Totals	**7.07E+00**	**1.16E-02**	**7.87E-02**	**1.58E-05**	**1.09E-04**

Figure F.12. Microshield Output for 36-inch cover calculation.

MicroShield 7.02
Foxfire Scientific (07-msd-7.02-1309)

Date	By	Checked

Filename	Run Date	Run Time	Duration
RME 42 inch.ms7	11-Aug-11	10:06:49 AM	0:00:00

Project Info

Case Title	ESL RME ext exposure
Description	ESL RME external dose
Geometry	16 - Infinite Slab

Source Dimensions

Thickness	100.0 cm (3 ft 3.4 in)

Dose Points

A	X	Y	Z
#1	306.68 cm (10 ft 0.7 in)	0.0 cm (0.0 in)	0.0 cm (0.0 in)

Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Shield 1	106.68 cm	Soil	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Ac-228	3.84E-05	1.42E+00
Bi-210	7.47E-06	2.76E-01
Bi-212	3.84E-05	1.42E+00
Bi-214	9.39E-06	3.48E-01
Pa-234	5.12E-08	1.89E-03
Pa-234m	3.20E-05	1.18E+00
Pb-210	7.47E-06	2.76E-01
Pb-212	3.84E-05	1.42E+00
Pb-214	9.39E-06	3.48E-01
Po-210	7.44E-06	2.75E-01
Po-212	2.46E-05	9.10E-01
Po-214	9.39E-06	3.47E-01
Po-216	3.84E-05	1.42E+00
Po-218	9.39E-06	3.48E-01
Ra-224	3.84E-05	1.42E+00
Ra-226	9.60E-06	3.55E-01
Ra-228	3.84E-05	1.42E+00
Rn-220	3.84E-05	1.42E+00
Rn-222	9.39E-06	3.48E-01
Th-228	3.84E-05	1.42E+00
Th-230	1.02E-12	3.76E-08
Th-232	3.84E-05	1.42E+00
Th-234	3.20E-05	1.18E+00
Tl-208	1.38E-05	5.10E-01
U-234	4.53E-09	1.68E-04
U-238	3.20E-05	1.18E+00

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.51E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.04	1.45E-02	1.40E-44	1.40E-44	6.20E-47	6.20E-47
0.05	1.50E-02	1.79E-30	1.00E-26	4.76E-33	2.67E-29
0.06	5.62E-02	1.35E-23	1.42E-19	2.69E-26	2.81E-22
0.08	6.95E-01	3.08E-17	3.38E-13	4.88E-20	5.34E-16
0.1	1.74E-01	1.22E-15	9.97E-12	1.86E-18	1.53E-14
0.15	6.03E-02	1.03E-13	4.09E-10	1.70E-16	6.73E-13
0.2	8.10E-01	2.40E-11	4.30E-08	4.24E-14	7.59E-11
0.3	4.42E-01	4.63E-10	2.82E-07	8.79E-13	5.35E-10
0.4	1.67E-01	1.88E-09	5.00E-07	3.66E-12	9.75E-10
0.5	2.04E-01	1.36E-08	2.08E-06	2.67E-11	4.08E-09
0.6	6.20E-01	1.70E-07	1.67E-05	3.32E-10	3.27E-08
0.8	4.90E-01	1.16E-06	6.16E-05	2.20E-09	1.17E-07
1	9.49E-01	1.11E-05	3.80E-04	2.04E-08	7.00E-07
1.5	2.57E-01	4.58E-05	7.74E-04	7.71E-08	1.30E-06
2	9.74E-02	9.64E-05	1.09E-03	1.49E-07	1.68E-06
3	5.10E-01	4.13E-03	2.95E-02	5.60E-06	4.01E-05
Totals	**7.07E+00**	**4.28E-03**	**3.19E-02**	**5.85E-06**	**4.39E-05**

Figure F.13. Microshield Output for 42-inch cover calculation.

APPENDIX G
PRELIMINARY ENGINEERING COST ESTIMATES

TABLE G-1

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RAA-1 RESTRICTED ACCESS
PRELIMINARY ENGINEERING COST ESTIMATE
NORTH ALCOA SITE, EAST ST. LOUIS, ILLINOIS

Site: North Alcoa Site Description: Implement physical and institutional controls (fencing and deed restrictions).
Location: East St. Louis, Illinois
Phase: Feasibility Study (-30% to +50%)
Base Year: 2011
Date: April 9, 2012

CAPITAL COSTS					
Scenario Specific Scope Item	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Notes**
Site Preparation					
Mobilization/Demobilization	1	LS	$10,000	$10,000	
Site security	14000	LF	$25	$350,000	Around IB-1,- 2,- 4a, and -4d
	Total			**$360,000**	
CAPITAL SUBTOTAL	$360,000				
CONTINGENCY	25%	of	$360,000	$90,000	10% scope and 15% bid
CAPITAL SUBTOTAL WITH CONTINGENCY	$450,000				
Consulting Services					
Project Management	5%	of	$450,000	$23,000	
Remedial Design	8%	of	$450,000	$36,000	
Construction Management	6%	of	$450,000	$27,000	
Institutional Controls	1	LS	$10,000	$10,000	
TOTAL CAPITAL COSTS	**$546,000**				
ANNUAL O&M COSTS					
Scenario Specific Scope Item	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Notes**
None	-	-	-	-	
Other Total				**$0**	
ANNUAL O&M COSTS SUBTOTAL	$0				
CONTINGENCY	25%	of	$0	$0	10% scope and 15% bid
TOTAL ANNUAL O&M COSTS	**$0**				
PERIODIC COST					
Scenario Specific Scope Item	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Notes**
Contractor	1	LS	$15,000	$15,000	Repair Fence
Consultant	1	LS	$10,000	$10,000	Subcontractor Oversight
Other Total				**$25,000**	
PERIODIC COST SUBTOTAL	$25,000				
CONTINGENCY	25%	of	$25,000	$7,000	10% scope and 15% bid
PERIODIC COST TOTAL WITH CONTINGENCY	$32,000				
Consulting Services					
Project Management	5%	of	$32,000	$2,000	
Progress Report	1	LS	$10,000	$10,000	
TOTAL PERIODIC COST	**$44,000**				

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COSTS	ANNUAL COSTS	DF (7%)	PRESENT VALUE	NOTES
Capital Cost	0	$546,000	$546,000	1.000	$546,000	
Periodic Cost	5	$44,000	$44,000	0.713	$31,371	
Periodic Cost	10	$44,000	$44,000	0.508	$22,367	
Periodic Cost	15	$44,000	$44,000	0.362	$15,948	
Periodic Cost	20	$44,000	$44,000	0.258	$11,370	
Periodic Cost	25	$44,000	$44,000	0.184	$8,107	
Periodic Cost	30	$44,000	$44,000	0.131	$5,764	
		$900,000			$650,000	

TOTAL PRESENT VALUE OF ALTERNATIVE **$650,000**

TABLE G-2

RAA-2 CONTAINMENT WITH PLACEMENT OF ARAR COMPLIANT SOIL COVER AND ON-SITE STORM WATER MANAGEMENT
PRELIMINARY ENGINEERING COST ESTIMATE
NORTH ALCOA SITE, EAST ST. LOUIS, ILLINOIS

Site: North Alcoa Site
Location: East St. Louis, Illinois
Phase: Feasibility Study (-30% to +50%)
Base Year: 2011
Date: April 9, 2012

Description: Placement of ARAR-compliant 2 foot soil cover over IB-1, -2, 3b (western extent), and -4a excluding storm water management areas, revegetation of the gypsum dikes and an environmental easement/commercial covenant to control future intrusive activities in these areas.

CAPITAL COSTS					
Scenario Specific Scope Item	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Notes**
Site Preparation					
Mobilization/Demobilization	1	LS	$228,146	$228,146	Discussions with subcontractor
Site security	16,000	LF	$12	$188,052	Discussions with subcontractor
Site office	12	MO	$3,207	$38,478	Discussions with subcontractor
Utilities	1	LS	$27,281	$27,281	Discussions with subcontractor
	Total			**$481,957**	
Areas 1a, 1b, 1c, 2, 3b, 4a, and 4d					
Regrading					
Clearing and Grubbing	35	AC	$11,491	$402,184	Discussions with subcontractor
Cut	269,357	CY	$3.5	$945,268	Discussions with subcontractor
Fill	794,739	CY	$11	$8,863,488	Discussions with subcontractor
Hauling	322,697	CY	$3	$1,050,215	Discussions with subcontractor
Soil Layer Placement	100,667	CY	$32	$3,229,397	Discussions with subcontractor
Vegetation	100	AC	$5,857	$585,664	Discussions with subcontractor
	Total			**$15,076,216**	
North Drainage Ditch (4A only)					
Clear and Grub	2	AC	$4,000	$8,000	Discussions with subcontractor
Drainage Improvement (cut)	15,000	CY	$8	$120,000	Discussions with subcontractor
Fill	2,500	CY	$18	$45,000	Discussions with subcontractor
Surface Preparation	13,000	SY	$3	$39,000	Discussions with subcontractor
Riprap	333	CY	$36	$11,988	Discussions with subcontractor
Vegetation	2	AC	$5,000	$10,000	Discussions with subcontractor
Dewatering (4A only)					
Remove existing water (assumes 1' depth)	3,500,000	GAL	$0.02	$70,000	Discussions with subcontractor
	Total			**$303,988**	
Other					
Surface water Management					
Storm water Piping	833	LF	$139	$115,919	Discussion with subcontractor
Drainage Swales	50,000	LF	$6	$302,363	Discussion with subcontractor
Access Roads					
Structural Backfill	6,000	LF	$50	$302,555	Discussion with subcontractor
Maintenance of Access Roads	6,000	LF	$42	$254,855	Discussion with subcontractor
	Total			**$975,692**	
CAPITAL SUBTOTAL	$16,837,853				
CONTINGENCY	25%	of	$16,837,853	$4,209,463	10% scope and 15% bid
CAPITAL SUBTOTAL WITH CONTINGENCY	$21,047,317				
Construction Subcontractor Oversight					
Surveying	120	AC	$1,648	$197,712	Discussion with subcontractor
General Contractor Management		LS		$1,110,752	Discussion with subcontractor
Permits		LS		$259,405	Discussion with subcontractor
Performance Bond	1%	of	$21,047,317	$210,473	Discussion with subcontractor
Consulting Services					
Remedial Design		LS		$1,250,000	Discussion with subcontractor
Construction Management		LS		$445,045	Discussion with subcontractor
TOTAL CAPITAL COSTS	**$24,520,704**				
ANNUAL O&M COSTS					
Scenario Specific Scope Item	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Notes**
Contractor	1	YR	$15,000	$15,000	O&M from similar sites
Consultant	1	YR	$15,000	$15,000	O&M from similar sites
Other Total				**$30,000**	
ANNUAL O&M COSTS SUBTOTAL	$30,000				
CONTINGENCY	25%	of	$30,000	$37,500	10% scope and 15% bid
TOTAL ANNUAL O&M COSTS	**$38,000**				
PERIODIC COST					
Scenario Specific Scope Item	**Quantity**	**Unit**	**Unit Cost**	**Cost**	**Notes**
None	-	-	-	-	
Other Total				**$0**	
PERIODIC COST SUBTOTAL	$0				
CONTINGENCY	25%	of	$0	$0	10% scope and 15% bid
TOTAL PERIODIC COST	**$0**				

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COSTS	ANNUAL COSTS	DF (7%)	PRESENT VALUE	NOTES
Capital Cost	0	$24,520,704	$24,520,704	1.00	$24,520,704	
Annual O&M	30	$1,140,000	$38,000	12.41	$471,544	
		$78,476,000			$24,992,247	
TOTAL PRESENT VALUE OF ALTERNATIVE					**$24,992,247**	