AECOM

Supplemental Soil Characterization Work Plan

Pines Area of Investigation

AOC II

Docket No. V-W-’04-C-784

April 2014

Disclaimer

This document is a draft document prepared under a federal administrative order on consent. This document has not undergone formal review by U.S. Environmental Protection Agency (USEPA), however, this document has incorporated comments provided by USEPA on the previous draft version of the report (see Appendix D). The opinions, findings, and conclusions expressed are those of the author and not necessarily those of USEPA.

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List of Acronyms

%	Percent (per hundred)
AOC I	Administrative Order on Consent, 2003 and as amended, 2004; Docket No. V-W-03-730
AOC II	Administrative Order on Consent, 2004; Docket No. V-W-’04-C-784
bgs	Below Ground Surface
BTV	Background Threshold Value
C	Celsius
CCB	Coal Combustion By-product
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Co-60	Cobalt-60
COC	Constituent of Concern
CoC	Chain of Custody
COPC	Constituent of Potential Concern
cpm	Counts per Minute
Cs-137	Cesium-137
DQO	Data Quality Objective
EPC	Exposure Point Concentration
FCO	Field Change Order
FS	Feasibility Study
ft	Feet
GPS	Global Positioning Satellite
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
HSC	Health and Safety Coordinator
ICP-MS	Inductively Coupled Plasma – Mass Spectroscopy
ID	Identification
IDW	Investigation Derived Waste
IDEM	Indiana Department of Environmental Management
ISM	Incremental Sampling Methodology
ITRC	Interstate Technology and Regulatory Council
K-40	Potassium-40
LOI	Loss on Ignition
m	Meter

m^2	Square Meters
m/s	Meter per Second
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
MDCR	Minimum Detectable Count Rate
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MWSE	Municipal Water Service Extension
NaI	Sodium Iodide
NIPSCO	Northern Indiana Public Service Company
NORM	Naturally Occurring Radioactive Material
Pb-210	Lead-210
pCi/g	picoCuries per gram
Pa-231	Protactinium-231
PLM	Polarized Light Microscopy
Po-210	Polonium-210
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goal
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QMP	Quality Management Plan
Ra-226	Radium-226
Ra-228	Radium-228
RAL	Removal Action Level
RAO	Remedial Action Objective
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SERA	Screening Level Ecological Risk Assessment
SMS	Site Management Strategy
SOP	Standard Operating Procedure
SOW	Statement of Work
SSC	Supplemental Soil Characterization

Th-22	Thorium-228
Th-230	Thorium-230
Th-232	Thorium-232
U-234	Uranium-234
U-235	Uranium-235
U-238	Uranium-238
urem/hr	Microrem per Hour
USEPA	United States Environmental Protection Agency
USNRC	United States Nuclear Regulatory Commission
WGS	World Geodetic System
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence

1 Introduction

In April 2004, the United States Environmental Protection Agency (USEPA) and the Respondents (Brown Inc., Ddalt Corp., Bulk Transport Corp., and Northern Indiana Public Service Company (NIPSCO)) signed an Administrative Order on Consent (AOC II) (Docket No. V-W-'04-C-784) to conduct a Remedial Investigation and Feasibility Study (RI/FS) at the Pines Area of Investigation, located in the environs of the Town of Pines, Indiana, as set forth in Exhibit I to AOC II (AOC II, 2004). AOC II (Section VII. 22) and its attachment, the Statement of Work (SOW) (Task 8), require the Respondents to conduct a Feasibility Study (FS) as part of the RI/FS process. A Revised Draft FS (AECOM, 2014a) was submitted to USEPA in February 2014, which documented that additional soil investigations will be conducted. This Supplemental Soil Characterization (SSC) Work Plan outlines the procedures and methods for the additional soil investigation.

1.1 Background

Between 2000 and 2004, Indiana Department of Environmental Management (IDEM) and USEPA conducted sampling of private wells in a portion of the Town of Pines. Boron and molybdenum were detected in some samples at concentrations above USEPA Removal Action Levels (RALs) (USEPA, 1998). USEPA suspected that these concentrations above USEPA RALs were derived from coal combustion by-products (CCBs) because CCBs were disposed of in Yard 520 and CCBs were reported to have been used as fill in areas within the Area of Investigation outside of Yard 520.

To address the boron and molybdenum detections above the USEPA RALs, the Respondents agreed to extend Michigan City's municipal water service from Michigan City to designated areas in the Town of Pines. This agreement was documented in an Administrative Order on Consent, referred to as AOC I, dated February 2003 (AOC I, 2003). The Respondents approached the USEPA about extending the municipal water service to a larger area, under the AOC I, amended, dated April 2004 (AOC I, 2003). In all, the Respondents provided municipal water to 263 residences and businesses in this area. In addition to extending the municipal water service, AOC I, amended, includes a provision to offer bottled water to those residences within the Area of Investigation not connected to municipal water.

Concurrently with AOC I, amended, USEPA and the Respondents entered into a second AOC, referred to as AOC II (AOC II, 2004). Under AOC II, the Respondents committed to conduct an RI/FS for the Area of Investigation. The objectives of the RI/FS, as stated in AOC II, include:

(a) to determine the nature and extent of contamination at the Site and any threat to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances, pollutants or contaminants related to coal combustion by-products ("CCB") at or from the Site.

(b) to collect data necessary to adequately characterize…(i) whether the water service extension installed pursuant to AOC I and AOC I as amended is sufficiently protective of current and reasonable future drinking water use of groundwater in accordance with Federal, State, and local requirements, (ii) any additional human health risks at the [Area of Investigation] associated with exposure to CCBs; and (iii) whether CCB-derived constituents may be causing unacceptable risks to ecological receptors; and,

(c) to determine and evaluate alternatives for remedial action to prevent, mitigate, control or eliminate risks posed by any release or threatened release of hazardous substances, pollutants, or contaminants related to CCBs at or from the Site, by conducting a Feasibility Study.

Thus, AOC II recognizes that a major response action was conducted under AOC I, and that one objective of the remaining investigation was to determine if this response was sufficiently protective, or if additional response actions should be considered.

Performance of these objectives is accomplished through ten tasks, as described in Part VII of AOC II (Work to be Performed). Tasks 1 through 8 have been completed, and are documented in the following reports:

- Site Management Strategy (SMS) (AECOM, 2005a). This document summarized the available information about the geology and hydrogeology of the area and the historical placement of CCBs within the Area of Investigation, presented a preliminary conceptual model, identified data gaps, and outlined the general approach to the RI/FS.
- RI/FS Work Plan, Volumes 1-7 (AECOM, 2005d).
- Additional sampling work plans for the RI Field Investigation, including the Municipal Water Service Extension (MWSE) Sampling and Analysis Plan (SAP) (AECOM, 2005c), and the Yard 520 SAP (AECOM, 2005b).
- RI Report (AECOM, 2010). This report provided the results of the RI Field Investigation activities and a conceptual site model for the CCB-derived constituents in environmental media at the Area of Investigation.
- Human Health Risk Assessment (HHRA) Report (AECOM, 2012c). The HHRA evaluated the data collected during the RI within the context of the human health conceptual site model to estimate potential risks to human health. Constituents of Concern (COCs) for further evaluation during the FS were identified.
- Screening Level Ecological Risk Assessment (SERA) Report (AECOM, 2012d). The SERA evaluated the data collected during the RI within the context of the ecological conceptual site model to estimate potential risks to aquatic and terrestrial environments. The results of the SERA indicate no or low potential for ecological risk to aquatic and terrestrial receptors within the Area of Investigation.
- Remedial Action Objectives Technical Memorandum (AECOM, 2012a). This document identified remedial action objectives (RAOs) specific to the Area of Investigation and considered factors listed in the AOC II SOW.
- Alternatives Screening Technical Memorandum (AECOM, 2012b). This document presented potential remedial alternatives to address the RAOs. The technologies and/or alternatives identified in the Alternatives Screening Memorandum were carried through to more detailed analysis in the FS.
- Feasibility Study (AECOM, 2014a). The FS incorporated the final approved RAOs and Alternatives Screening evaluation. The FS also included a detailed analysis of the alternatives carried forward from the Alternatives Screening that represent viable approaches to remedial actions that may be selected for the Area of Investigation. The detailed analysis consisted of an

assessment of individual alternatives relative to the nine Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) evaluation criteria set forth in 40 CFR 300.43(e)(9)(iii), green and sustainable remediation principles, and a comparative analysis that focuses upon the relative performance of each alternative against those criteria. The FS is currently under review by the USEPA.

USEPA has requested that supplemental FS activities be conducted, specifically, conducting additional evaluations to support the conclusions of the HHRA. This SSC Work Plan provides the details for additional soil sampling as well as gamma surveys to be conducted on various properties within the Area of Investigation.

1.2 SSC Objectives

The objective of the proposed additional investigation is to verify the residential exposure scenario results presented in the USEPA-approved HHRA (AECOM, 2012c). Specifically, the HHRA developed exposure point concentrations (EPCs) based on estimates of the presence of CCBs on specific properties, as described in detail in the HHRA. The purpose of the soil sampling described in this work plan is to verify the estimated EPCs based on actual sampling of the exposure media (residential soil). The investigation includes gamma radiological surveys of background areas and properties within the Area of Investigation, sampling to verify the results of the CCB visual inspection program conducted as part of the RI (AECOM, 2010), and sampling of surface and subsurface soils at a defined subset of properties located within the Area of Investigation.

1.3 Investigation Approach

To meet the objectives stated above, three data collection tasks will be conducted:

1. Gamma surveys
2. CCB visual inspection confirmation sampling
3. Soil sampling at a statistically-defined subset of properties to evaluate potential risk for specific constituents

The gamma surveys have been designed to collect gamma dose and gamma count rate information to support decisions regarding the collection of soil samples for radionuclide analysis. Such radionuclide analyses were included in the Area of Investigation in both the MWSE and RI sampling programs. The purpose of including the gamma surveys here is to provide a comparison to gamma surveys conducted by others (Jensen, 2009). The gamma surveys, with sodium iodide (NaI) count rate and gamma dose rate measurements collected at background locations and investigation areas, are intended to address public concerns regarding potential risk due to naturally occurring radioactive materials (NORM) in CCB materials. The results of the SSC surveys will be used to guide the selection of some of the soil sampling described in this Work Plan.

The results of the previous CCB visual inspections were used in the HHRA to estimate the percentage of CCBs on specific properties. The CCB visual inspection confirmation sampling will include paired visual inspection and laboratory particle analyses to confirm that the CCB visual inspections are accurate within a reasonable tolerance.

The EPCs used in the HHRA will be confirmed by collecting soil samples from a subset of properties where CCBs were observed during the previous CCB visual inspection and submitting these samples for laboratory analysis of a list of analytical parameters (inorganics and radionuclides). The analytical results from these samples will be used to evaluate potential risks at these locations, using the same scenarios evaluated in the HHRA.

A stepwise approach to conducting these tasks has been developed with USEPA, as summarized below, including identification of the constituents in the analytical program.

1.3.1 Access Agreements

Most of the land within the Area of Investigation is not owned by or under the control of the Respondents. Therefore, access agreements between the Respondents and individual property owners will be needed to perform the field investigation. It is expected that some sampling locations may need to be modified as a result of access issues.

To ensure that the field work can be conducted expeditiously, safely, and with minimal impact to the community, field work will not begin until all necessary access agreements (either written or verbal) have been obtained.

1.3.2 Gamma Surveys

The objective of conducting the gamma surveys is to establish a distribution of responses for the background areas, and then to compare the background responses to the property-specific distribution of responses to identify if there are significant differences between the property-specific and background surveys. Gamma surveys will be conducted at background locations (10)[1], locations where third-party gamma surveys were previously conducted (approximately 13; Jensen, 2009), and at private properties where CCBs have previous been visually identified (approximately 45). Gamma surveys will only be performed on properties where access has been granted; therefore, the final number of surveys will be determined prior to mobilization for field activities.

Two types of gamma surveys will be conducted, a sodium iodide (NaI) gamma count rate walk-over survey and a gamma dose rate survey, as described in Section 3.2. The data from the NaI gamma count rate walk-over survey are collected continuously during a walk-over of the property and data are obtained in units of counts per minute (cpm). During the gamma dose rate survey, data are collected at specific locations within a survey unit, and data are obtained in units of microrem per hour (urem/hr).

Statistical analyses of the subject property and background area data sets will be conducted as an office activity, not in the field. Thus, no actions will be taken in the field based on subject property surveys (e.g., sampling, marking areas, communicating with the public, etc.). At the end of the gamma survey field work, the results will be reviewed in conjunction with USEPA to determine if any anomalous locations may warrant discrete sample collection during the soil sampling phase of the field work. If identified, these locations will be sampled following the same procedures described in Section 3.4.

1.3.3 CCB Visual Inspection Verification

During the CCB visual inspections on private properties, the estimated CCB content in surface soils was recorded using the following categories: 0-25 percent (%) CCBs, 26-50% CCBs, 51-75% CCBs

[1] The background locations are those identified to be CCB-free (no fly ash or bottom ash present in the soil samples) using rigorous physical testing procedures, as documented in the FS (AECOM, 2014a).

and 76-100% CCBs. The purpose of this task is to confirm the accuracy of these estimates by submitting soil samples for confirmatory laboratory inspection. A total of 15 samples will be collected from locations where CCB visual inspections were previously completed. There were no samples estimated to contain CCBs in the 76-100% category during the visual inspections on private properties. Approximately five samples from each of the remaining three CCB percent categories will be collected. The samples will be submitted to a laboratory for particulate matter analysis in order to confirm the visual inspection results. Section 3.3 describes the sample collection and laboratory verification in greater detail.

1.3.4 Private Property Soil Sampling

The objective of the proposed private property soil sampling (discussed in greater detail in Section 3.4) is to provide data to evaluate the potential human health risk associated with CCB-derived constituents at properties within the Area of Investigation in the context of the methods used in the HHRA (AECOM, 2012c). Several approaches for sampling were evaluated, and the sampling program selected for use here, in conjunction with discussions with USEPA, is based on the recommended approach presented in Section 4 of USEPA's Superfund Lead-Contaminated Residential Handbook (USEPA, 2003). Incremental Sampling Methodology (ISM), as described by the Interstate Technology & Regulatory Council (ITRC) (ITRC, 2012) was also considered. However, that methodology does not accommodate the judgmental sampling that is included in this SSC Work Plan, as described below and it would be a much more intrusive activity on private properties. Therefore, it was not selected.

Following the quadrant sampling approach as outlined by USEPA (2003), in general, each property selected for sampling will be divided into four approximately equally sized quadrants, conceptually two in the front yard and two in the back yard. Additional "quadrants" may be used to address up to three specific property uses, if present (i.e., a vegetable or flower garden, an unpaved driveway where CCBs are present, and/or a child's play area, based on presence of swing sets or other outdoor play equipment). Within each quadrant, five equally spaced sample locations will be identified. Samples collected at each of the five locations will be composited over specific depth intervals, such that one sample from each sampling depth from each quadrant will be obtained. Samples will be submitted for laboratory analysis, as described below.

1.3.4.1 Identification of Analytical Constituents

The constituents to be addressed by the property-specific sampling have been identified based on discussions with USEPA. The results of the USEPA-approved HHRA were used to identify a subset of constituents, termed the COCs, to be addressed in the FS. The COCs were identified following USEPA guidance for the Superfund program from the constituents of potential concern (COPCs) quantitatively evaluated in the HHRA. To identify the COPCs quantitatively evaluated in the HHRA, the maximum detected concentrations of all the constituents were compared to the USEPA Regional Screening Levels (RSLs) for residential soil adjusted downward for a target hazard quotient of 0.1, where appropriate. The COCs were selected, at USEPA's request, based on the hypothetical screening scenario that a residential yard is comprised of 100 percent (%) CCBs and using a target risk level of 1 in one million and a target end-point specific hazard index of 1. The COCs identified in the HHRA based on these criteria include:

- Arsenic
- Chromium, hexavalent
- Iron
- Thallium

- Lead-210 (Pb-210)
- Radium-226 (Ra-226)
- Radium-228 (Ra-228)
- Uranium-238 (U-238)

Thus, a conservative step-wise process has been used to identify the COCs to be addressed in the FS. However, at the request of USEPA, the constituents to be the focus of the property-specific sampling in this SSC Work Plan are the COPCs quantitatively evaluated in the HHRA. These are:

- Aluminum
- Arsenic
- Chromium (total)
- Chromium, hexavalent
- Cobalt
- Iron
- Thallium
- Vanadium
- Radionuclides

The original investigation work approved by USEPA analyzed CCB and background soil samples for 12 radionuclides that could be present in CCBs:

- Actinium-227 (Ac-227)
- Pb-210
- Polonium-210 (Po-210)
- Protactinium-231 (Pa-231)
- Ra-226
- Ra-228
- Thorium-228 (Th-228)
- Thorium-230 (Th-230)
- Thorium-232 (Th-232)
- Uranium-234 (U-234)
- Uranium-235 (U-235)
- U-238

However, at the request of USEPA, a library of select gamma-emitting NORM from the U-238 series, Th-232 series, and U-235 series, plus some additional non-NORM (e.g., Potassium-40 (K-40) (refer to Appendix B) will be used in the analytical program for the property-specific sampling under this SSC Work Plan. In addition, total uranium (calculated from U-235 and U-238) by inductively coupled plasma mass spectroscopy (ICP-MS) will also be included with the metals analyses.

The library of radioisotopes is provided in the project Quality Assurance Project Plan (QAPP) Addendum, which is provided as Appendix B of this SSC Work Plan. Appendix E provides information from many sources on constituent concentrations in CCBs.

Table 7 of the February 2014 FS provided the preliminary remediation goals (PRGs) for the COCs identified in the HHRA, as well as the background threshold values (BTVs) for the COCs. Table 1 of this report provides the PRGs and BTVs for the COPCs included here. The derivation of the BTVs for both COCs and COPCs was presented in the FS, and used ProUCL Version 5.0 (http://www.epa.gov/osp/hstl/tsc/software.htm).

1.3.4.2 Identification of Soil Sampling Locations

The information from the gamma surveys and the CCB visual verification studies will be compiled and evaluated to aid in the identification of appropriate properties for soil sampling. A statistical procedure has been used to determine the number of properties to sample (Appendix A) to provide a representative subset of properties. The statistical calculations were conducted using those COPCs where detected results were available and where the maximum detected concentration was above the site-specific PRGs developed for the project (see Table 1). These are listed below, along with the calculated number of properties which provide a representative subset:

- Arsenic – Statistics indicate that 9 properties would be needed to be sampled
- Iron – Statistics indicate that 10 properties would be needed to be sampled
- Thallium – Statistics indicate that 8 properties would be needed to be sampled
- Pb-210 – Statistics indicate that 9 properties would be needed to be sampled
- Ra-226 – Statistics indicate that 8 properties would be needed to be sampled
- Ra-228 – Statistics indicate that 5 properties would be needed to be sampled
- U-238 – Statistics indicate that 8 properties would be needed to be sampled

The following constituents were not evaluated as part of the statistical procedure because results were below PRGs: aluminum, chromium (total), chromium (hexavalent), cobalt, Pa-231, Th-228, Th-230, Th-232, U-234, U-235, and vanadium. Hexavalent chromium, although identified as a COPC was not included in the statistical calculations as the concentrations in all the MWSE samples were nondetect; Po-210 is addressed by Pb-210 as it is within the Pb-210 decay chain.

Based on the calculations, soil sampling will be conducted at nine properties, including both residential and non-residential properties where CCBs are known or believed to be present. Each of the nine properties will be sampled for the full COPC parameter list identified in Section 1.3.4.1 above, including the complete library of radioisotopes. Of the nine properties, three will be selected based on the results of the gamma radiological surveys, three will be selected based on the results of the CCB visual inspection program, and three will be identified with input from the community. USEPA will participate in the property selection and will have final approval of the locations.

1.3.5 Analysis and Reporting

Laboratory analysis and data evaluation are discussed within the context of each data collection activity in Section 3. A SSC Report will be generated after the conclusion of the field program.

1.4 Data Quality Objectives

This SSC Work Plan has been designed such that sample collection and analytical activities are conducted in accordance with technically acceptable protocols and that the data collected meet data quality objectives (DQOs). All sampling and analyses performed shall conform to USEPA direction, approval, and guidance regarding sampling, quality assurance/quality control (QA/QC), data validation, and chain-of-custody (CoC) procedures, and in accordance with the project QAPP and Addendum, which is provided as Appendix B of this SSC Work Plan. Laboratory data generated under this SSC Work Plan will be subject to data validation review to ensure that the data are of sufficient quality to evaluate in the context of the HHRA.

The SSC field investigation is designed to verify the residential exposure scenario results presented in the HHRA. Therefore, the sampling and analysis program incorporates the following quality assurance (QA) elements:

- A sampling program designed to obtain sufficient data to determine levels of constituents in media of interest,
- The use of sample collection and handling procedures that will ensure the representativeness and integrity of the samples,
- An analytical program designed to generate definitive data of sufficient quality and sensitivity to meet the project objectives (see Section 1.2), and
- Data deliverables that will allow verification and validation of the data and reproducibility of the reported results.

The design of the SSC was based on the DQO process (USEPA, 2000a), a multi-step, iterative process that ensures that the type, quantity, and quality of environmental data used in decision-making is appropriate for its intended application. This process is summarized below.

DQO Step	Description
State the Problem	The use of CCBs as fill in areas within the Area of Investigation outside of Yard 520 results in the potential for direct contact to CCB-derived constituents in the environment. A Remedial Investigation (RI) was performed, and residential exposure scenarios were developed and evaluated using these data and presented in the HHRA. The residential exposure scenarios in the HHRA were based on certain assumptions about the distribution of CCBs on private properties.
Identify the Decision	Verify that EPCs based on estimates of CCBs on specific properties are valid through sampling and analysis of the exposure media (residential soils).
Identify Inputs to the Decision	An SSC will be performed to verify the EPCs. The SSC includes gamma count rate and gamma dose rate surveys, CCB visual inspection confirmation, and soil sampling. Specific information to be collected includes: • Comparison of background location gamma count rate and dose rate surveys to property specific gamma count rate and dose rate surveys; • Sampling and analysis to verify the CCB percentage identified during CCB visual inspections; and • Sampling and analysis to quantify COPC concentrations on specific properties.
Define Study Boundaries	Pines Area of Investigation, as identified in the attachment to AOC II. Also included are a limited number of background locations outside the Area of Investigation. Specifically, background locations, locations where third-party gamma surveys were conducted within the Area of Investigation, and properties where CCBs were identified as present during the visual inspections define the study boundaries.

DQO Step	Description
Develop a Decision Rule	Gamma count rate and dose rate survey results will be used to: determine if there are significant differences in results between background and investigation areas; identify locations to collect discrete samples, if any; and to inform the selection of properties to be included in the quadrant sampling program. Data from the discrete sampling, if any, and the quadrant sampling program will be evaluated and compared to the PRGs and BTVs provided in the SSC Work Plan. The analytical results from these samples will be used to evaluate potential risks at these locations, using the same scenarios evaluated in the HHRA.
Specify Decision Error Limits	The sampling program is based on judgmental and not random or statistical sampling. The focus of the sampling is on properties where CCBs were previously identified to be present, on background locations, and locations where third-party gamma surveys were conducted. Gamma count rate and dose rate surveys will be conducted at all properties (where access is granted). From these, a subset of properties will be selected for soil sampling based on judgmental criteria. Soil sampling will be conducted using a quadrant approach, but will also include judgmental sampling at locations where play areas, gardens, or driveways with CCBs are located.
Optimize the Study Design	Because the sample locations will be pre-determined, the iterative process for optimizing the sample design will not be used. For all data collected as part of this SSC, data will be considered acceptable if they are collected according to this SSC Work Plan and they meet data validation criteria, as appropriate. Only acceptable data will be considered appropriate for decision making purposes. For the CCB confirmation sampling, if at least four out of five samples in each category (0-25%, 25-50%, and 50-75% CCBs) fall within or below the range identified in the CCB Visual Inspection program, the visual inspection results will be considered confirmed. For the gamma count rate and dose rate survey data, the Wilcoxon Rank-Sum Test will be used to compare the specific property survey results to the background survey results to identify if there are significant differences in the data distributions or if there are outlier measurements that could be considered for discrete sampling. Care will be taken to minimize the influence of serial correlation on this evaluation. A statistical design that selects a subset from a fixed finite population (the total number of properties in this case) was used to select the representative number of properties to sample for each of the COPCs (see Appendix A). The specific properties will be selected based on judgmental criteria (not randomly selected), including the results of the gamma count rate and dose rate surveys.

At the completion of the work outlined in this SSC Work Plan, it is possible that additional information may be needed to meet objectives. At this time, it is not possible to anticipate what additional work may be needed, as it is dependent on the results of the activities proposed. Decisions about the need for additional data, if any, will be made in conjunction with USEPA.

2 Project Personnel

The lines of authority and communication for this project are presented in the project organization chart (Figure 6). The responsibilities of key field personnel are outlined below.

2.1 AECOM Project Manager

The AECOM Project Manager is responsible for technical, financial, and scheduling matters, and for timely delivery of all products/results pertaining to the SSC Work Plan. The AECOM Project Manager also will be responsible for project coordination between the Respondents and USEPA as required.

2.2 AECOM Health and Safety Manager

The AECOM Health and Safety Manager is responsible for the preparation, interpretation, and where appropriate, modification of the Health and Safety Plan (HASP). Modifications to the HASP which might result in less stringent precautions cannot be undertaken by the AECOM Project Manager or the AECOM Field Health and Safety Coordinator (HSC) without the approval of the AECOM Health and Safety Manager. Specific duties of the AECOM Health and Safety Manager include:

- Approving and amending the HASP for this project;
- Advising the AECOM Project Manager and AECOM Field HSC on matters relating to health and safety on this site;
- Recommending appropriate personal protective equipment (PPE) and respiratory equipment to protect personnel from potential site hazards;
- Facilitating accident investigations, and;
- Maintaining regular contact with the AECOM Project Manager and AECOM Field HSC to evaluate site conditions and new information that might require modifications to the HASP.

2.3 AECOM Project Quality Assurance (QA) Officer

The AECOM Project QA Officer has overall responsibility for quality assurance oversight. The AECOM Project QA Officer communicates directly to the AECOM Project Manager. Specific responsibilities include:

- Preparing the QAPP addendum for the sampling;
- Reviewing and approving QA procedures, including any modifications to existing approved procedures;
- Ensuring that QA audits of the various phases of the project are conducted as required;
- Providing QA technical assistance to project staff, ensuring that data validation/data assessment is conducted in accordance with the QAPP; and
- Reporting on the adequacy, status, and effectiveness of the QA program to the AECOM Project Manager.

2.4 AECOM SSC Sampling Task Manager

The AECOM SSC Sampling Task Manager has the overall responsibility for implementing the sampling activities described in this SSC Work Plan and for reporting these activities in the SSC Report. Specific responsibilities of the AECOM SSC Sampling Task Manager include, but are not limited to, the following:

- Ensuring that AECOM's Field Technical Staff perform their designated duties in accordance with this SSC Work Plan and the HASP (Volume 4 of the RI/FS Work Plan [AECOM, 2005d], as updated for the SSC [AECOM, 2014b]);
- Ensuring required QA/QC procedures are properly implemented and documented;
- Ensuring that sampling activities are completed within the approved schedule;
- Communicating any request for modifications to the approved SSC Work Plan to the AECOM Project Manager and USEPA; and
- Promptly notifying the AECOM Project Manager if unforeseen field conditions and/or analytical issues are encountered that affect achievement of the project DQOs.

2.5 AECOM Field Operations Leader

The AECOM Field Operations Leader is responsible for implementing sampling activities according to the SSC Work Plan and under the direction of the SSC Sampling Task Manager. Other responsibilities may include gathering and analyzing data, and preparing pertinent sections of the SSC Report. The AECOM Field Operations Leader may act as AECOM Field Health and Safety Coordinator and/or designate this role to another member of the AECOM Field Technical Staff. See below for additional information on this role. The AECOM Field Operations Leader reports directly to the AECOM SSC Sampling Task Manager.

2.6 AECOM Field Technical Staff

The AECOM Field Technical Staff are responsible for implementing sampling activities according to this SSC Work Plan. Other responsibilities may include gathering and analyzing data, and preparing various task reports. The field technical staff report directly to the AECOM Field Operations Leader.

2.7 AECOM Field Health and Safety Coordinator (HSC)

The Field Operations Leader or designee will serve as the field HSC. The HSC is responsible for enforcing the requirements of the HASP once field work begins. By design, the HSC has the authority to immediately correct all situations where noncompliance with the HASP is noted and, as with all AECOM personnel, to immediately stop work in cases where an immediate danger is perceived. Some of the HSC's specific responsibilities include:

- Verifying that all AECOM staff working on or visiting the site have read and signed the signature copy of the HASP;
- Conduct daily tailgate safety meetings and document the topics covered and AECOM staff in attendance;
- Procuring and distributing the PPE needed for field activities;
- Verifying that all PPE and health and safety equipment is in good working order;

- Notifying the AECOM Project Manager and the AECOM Health and Safety Manager of all noncompliance situations and immediate danger situations;
- Assuring changes to the HASP are approved by the AECOM Health and Safety Manager;
- Supervising and monitoring the safety performance of all personnel to ensure that required safety and health procedures are followed, and correcting any deficiencies;
- Conducting accident/incident investigations and preparing accident/incident investigation reports; and
- Initiating emergency response procedures.

2.8 AECOM Laboratory Coordinator

The AECOM Laboratory Coordinator is responsible for laboratory procurement, monitoring the progress of sample analysis, and is the primary point of contact with the laboratories. The AECOM Laboratory Coordinator is also responsible for communicating any issues that could affect achievement of the DQOs to the AECOM SSC Sampling Task Manager and the AECOM Project QA Manager.

3 Data Collection, Analysis, and Evaluation

As discussed previously, three data collection activities will be conducted: gamma surveys, verification of the CCB visual inspection results, and property soil sampling. Details of these activities are further described below.

3.1 Sampling/Investigation Locations

The soil investigations will be conducted in previously identified background locations (AECOM, 2014a), at locations where other parties have performed radiological screening (Jensen, 2009), and at specific properties within the Area of Investigation. The proposed locations are shown on Figure 1 and described below:

- Ten background locations selected from the project background soil studies (see Table 2 and Figure 7). The background locations are a subset of those locations identified to be CCB-free (no fly ash or bottom ash present in the soil samples) using rigorous physical testing procedures, as documented in the FS (AECOM, 2014a). The background locations were selected to be representative of the range of background soil conditions (e.g., geology, proximity to roads) in order to approximate the range of conditions at the properties identified as having CCBs present during the CCB visual inspections.
- Forty-five properties identified as having CCBs present during the CCB visual inspections (see Table 3 and Figure 9). Note that two of the properties are located in wetland areas where the level and frequency of exposure would be much lower than for residential and commercial properties, and were therefore not used in the HHRA percent CCB calculations.
- Thirteen properties included as part an October 2009 Gamma Count Rate Survey (Jensen, 2009) (see Table 4 and Figure 8). The properties selected from this survey are those within the boundary of the Area of Investigation and those that do not already overlap with the 45 properties listed above. The thirteen locations have been estimated as best as possible from the information included in the 2009 report. These properties are being included at the request of USEPA in response to community request, and the data will be collected following USEPA-approved established procedures outlined in this SSC Work Plan and the QAPP Addendum (see Appendix B).

Gamma count rate and dose rate surveys will be conducted at all the locations listed above and shown on Figure 1 (where access is granted by the property owner). Based on the results of the gamma surveys and other information, a subset of nine properties will be selected for soil sampling. The estimated numbers of sampling/investigation locations for the different activities are summarized in the table below.

Location Type	Project Basis for Inclusion	Total Number of Locations/Properties	Number of Samples/Investigations by Sampling/Investigation Type		
			Gamma Survey	CCB Verification Sampling	Soil Sampling
Background Locations	Project Background Soil Locations	10	10	NA (a)	NA (a)
Properties within the Area of Investigation	CCB Visual Inspections	45	45 (b)	15	9 properties; Samples TBD (c)
Properties within the Area of Investigation	October 2009 Gamma Count Rate Survey (d)	13	13 (b)	NA	NA

(a) CCB Verification Sampling and Soil Analytical Sampling were conducted as part of the Remedial Investigation.
(b) Final numbers of survey properties will depend on access granted by property owners.
(c) Nine properties total to be sampled. Final identification of properties will be based on results of gamma count rate and dose rate surveys and CCB verification sampling. Total numbers of soil samples will depend on specific conditions on the properties selected.
(d) Work conducted independently by third party; not a component of the USEPA-approved Remedial Investigation.

3.2 Gamma Surveys

3.2.1 Objective

The objective of the gamma surveys is to establish a distribution of responses for the background areas to be able to compare those responses to the property-specific distribution of responses to identify if there are significant differences. To accomplish this objective, gamma count rate walk-over surveys and gamma dose rate surveys will be performed. The gamma surveys will be conducted on 10 background locations (Figure 7), 45 properties identified during the CCB visual inspections (Figure 9), and 13 locations from the October 2009 Gamma Count Rate Survey (Jensen, 2009) (Figure 8); the final number of locations will depend on the number of access agreements obtained. All the locations and properties are shown on Figure 1. To perform the gamma dose rate surveys, each property will be divided into “survey units” (see Section 3.2.3 below). For some properties, more than one survey unit may be necessary based on the size of each property.

To ensure that survey and sample locations are selected with as much information as possible, a preliminary walk-over assessment of each property where access is obtained will be conducted to identify potential issues or features that may affect performing the gamma surveys, as well as features that may support the selection of soil sample locations (i.e., identify play areas, gardens, driveway composition, obstructions).

For the properties identified on Figure 9, the goal is for the gamma surveys to cover the full area of the property, where practicable. For some of the very large properties, the survey area may be focused on areas that encompass where CCBs were identified in the visual inspections. Designation of the survey area for these properties will be made with USEPA during the preliminary walk-over assessment prior to conducting the field work.

For the background locations and the third-party gamma survey locations, the size of the survey areas will be decided in the field with USEPA during the preliminary walk-over assessment prior to conducting the field work, taking into account access agreements and obstacles. The goal is to maximize the area of these surveys to be comparable to the property survey areas, to the extent practicable.

3.2.2 Gamma Count Rate Walk-over Survey

The following radionuclides were identified as COCs based on the HHRA (AECOM, 2012c):

- Pb-210
- U-238
- Ra-226
- Ra-228

Of these COCs, the short-lived decay products of Ra-226 and Ra-228 are detectable with gamma count rate walk-over survey equipment using a NaI detector. The concentration criterion in Subpart B of 40 CFR Part 192 for surface soil (5 picoCuries per gram (pCi/g) of Ra-226 over background) is a health-based standard. Gamma walkover survey methods will be capable of detecting Ra-226 and Ra-228 at or below this level.

Each survey unit will receive a complete coverage gamma count rate walk-over scan of accessible areas with a 2-inch by 2-inch NaI gamma scintillation detector and a digital scaler/ratemeter (i.e., Ludlum Model 44-10 detector and Model 2221 scaler/ratemeter). NaI detectors will be calibrated by the manufacturer (Ludlum) or a rental vendor who specializes in radiation survey equipment to optimize detection efficiency for the gamma energies associated with the decay products of Ra-226, where lead-214 (Pb-214) and bismuth-214 (Bi-214) are generally regarded as the notable gamma emitters. The response of each NaI detector used in the walk-over surveys will be correlated to a source block set (4 stacked blocks) with known total radium concentration. A 10 pCi/g total radium source block set is located at the former Kerr McGee Rare Earths Facility in West Chicago, Illinois, and is under the control of the West Chicago Environmental Response Trust. This Work Plan assumes that access to this source block set will be provided. Appendix F provides an alternate calibration method to be used should the block set not be available.

The minimum detectable concentration (MDC) goal is 2.5 pCi/g total radium above background. The MDC will be determined for each instrument based on the minimum detectable count rate (MDCR) for the detector calculated from the ambient background count rate. The MDCR is determined using the methods provided in the US Nuclear Regulatory Commission (USNRC) guidance NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)" (USEPA, 2000b). From the calculated MDCR (in cpm), the correlation factors determined using the radium block set (cpm per pCi/g) will be used to approximate the MDC for total radium. If the MDC is not sufficiently low, the MDCR and MDC can be reduced by slowing down the rate of the walk-over survey.

The gamma count rate walk-over surveys will be conducted in accordance with the following AECOM Standard Operating Procedures (SOPs): AECOM RS-TPG SOP 001 – Portable Detection Equipment, AECOM RS-TPG SOP 007 – Grid Systems and Surveys, and AECOM RS-TPG SOP 011 – Radiation Surveys, provided in Appendix C. Each NaI detector will be connected to a data logging global positioning satellite (GPS) receiver that will log gamma radiation count rates (in cpm) and position. Data logging and data management are described in Section 3.2.4. To maintain an unbiased collection of data and to reduce the impact of non-independent measurements, survey technicians will turn off the audible response of the detector during the surveys. Therefore, only processed data will be used to identify potentially elevated areas of radioactivity. Survey technicians will make detailed sketches of each subject property and identify the location of different types of groundcovers (e.g., grass, concrete, gravel, pavers, mulch, etc.). To provide complete coverage of the survey area, the detector and GPS system will be walked along transects of the survey unit spaced 2 feet apart. The detector will be transported using one of the following methods:

- Pushed along the transect in a cart at a pace slow enough to meet the MDC goal, but no faster than 1 meter per second with the detector positioned not more than 6 inches above the ground. This provides a field of view greater than two feet in diameter for an unshielded detector and ensures complete coverage, or
- Carried along a transect and moved side to side over the ground surface in a serpentine pattern keeping the detector close to the ground as possible but not more than 6 inches off the ground.

3.2.3 Gamma Dose Rate Survey

The gamma dose rate survey will consist of measuring gamma dose at a pre-determined number of discrete survey locations within each survey unit. For the purposes of the work here, the survey unit will be the size of each property to be surveyed (see Figure 9). As noted above for the surveys conducted on background locations and the third-party gamma survey locations, the size of the survey areas will be decided in the field with USEPA during the preliminary walk-over assessment prior to conducting the field work, taking into account access agreements and obstacles. The goal is to maximize the area of these surveys to be comparable to the property survey areas, to the extent practicable.

The number and location of discrete survey locations will be determined using the Random-Start Triangular Grid Measurement Pattern described in MARSSIM (USEPA, 2000b). The number of measurement locations is calculated as follows:

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$$

where:

N = number of data points

$Z_{1-\alpha}$ = Alpha Decision Error Percentile

$Z_{1-\beta}$ = Beta Decision Error Percentile

P_r = Probability factor

Given a probability factor assumed to be 0.92 (based on an assumed standard deviation of survey data), and acceptable Alpha/Beta decision factors chosen to be 1.645 based on target 5% Type 1 and Type 2 Errors, the number of survey locations per survey unit is preliminarily estimated to be 10. The actual number of survey point locations (N) will be calculated during field activities based on the actual standard deviation of the data measured in the field but no fewer than 10 measurements per survey area will be collected. On the first subject property a set of at least 10 dose rate measurements will be collected and the results will be used to calculate a standard deviation (“actual standard deviation”). The number of measurements for the remaining properties will be adjusted as necessary based on revised calculations using this actual standard deviation.

Within each survey unit, the discrete sample locations are laid out on a grid, with the spacing between points determined using the following equations:

$$L = \sqrt{\frac{A}{0.866 * N}}$$

where:
L = Lateral location spacing
A = Survey unit area (square meters (m^2), up to 2000 m^2 for Class I land areas (USEPA, 2000b))
N = Number of survey locations (10);

and:

$$R = 0.866L$$

where:
R = Horizontal location spacing
L = Lateral location spacing

The starting position on the grid is determined using a random number to represent x and y coordinates of the starting position. The remainder of the grid is then laid out using the lateral and horizontal spacing (L and R) described above. Figure 2 provides an example of a survey unit with 10 measurement locations.

At each location, the dose rate will be measured in urem/hr at 1 m above the ground and at 0.3 m above the ground. Dose rate surveys will be performed using a tissue-equivalent gamma dose rate meter (e.g., Thermo Scientific™ Micro Rem meter). The dose rate meter will calibrated by the manufacturer; daily dose response checks (typically done with a Cs-137 button source), will be performed. The dose measurements and GPS location will be recorded at each survey location. The gamma dose rate surveys and daily source response checks will be conducted in accordance with AECOM RS-TPG SOP 001 – Portable Detection Equipment, AECOM RS-TPG SOP 007 – Grid Systems and Surveys, and AECOM RS-TPG SOP 011 – Radiation Surveys, provided in Appendix C.

3.2.4 Data Analysis

As stated in Section 3.2.2, gamma count rate data and GPS position will be recorded during gamma walk-over surveys. Data will be logged once every two seconds. The gamma survey data from background and private property surveys will be processed and presented on maps following data collection. The Wilcoxon Rank-Sum Test will be used to compare the private property survey results to the background area survey results to identify if there are significant differences in the data distributions. The statistical approach should account for the effects of serial correlation in the gamma survey data.

While not expected, in the event that GPS position data cannot be logged because of interferences, the gamma count rate data will continue to be logged. These data sets will lack position data but will be analyzed in the same fashion as described above. These areas will show up on the survey maps as areas without data. These areas will be delineated on the survey maps and labeled with mean and maximum count rates from the applicable gamma count rate data set.

The gamma walk-over survey results will be reviewed in conjunction with USEPA to determine if any anomalous locations may warrant additional discrete sample collection. If identified, these locations will be sampled following the same procedures described in Section 3.4.

3.3 CCB Visual Inspection Confirmation

The 2007 CCB visual inspections on private properties recorded the estimated content of CCBs in each of the 6-inch surface soil cores using the following categories: 0-25% CCBs, 26-50% CCBs, 51-75% CCBs, and 76-100% CCBs. Very small amounts of CCBs were also recorded as “trace”, but these can be considered a subset of the 0-25% CCB category. Only a few samples were classified in the 51-75% CCB category, and no samples were classified in the 76-100% CCB category. Table 3 presents a summary of the visual inspection results for the 45 properties where CCBs were identified at the surface. Note that the table also includes two properties that were inspected but had no CCBs identified, for a total of 47 properties listed; the two properties with no CCBs identified were not used in the HHRA (AECOM, 2012c) or the SERA (AECOM, 2012d). These properties are included on the table because they were originally included in the sequential numbering of the properties with CCBs identified; note that an additional 25 properties were inspected and had no CCBs identified, but were not included in the original numbering. Of the 45 properties with CCBs identified, 43 properties were identified as residential, park, or possible future residential; all but two of these properties were included in the HHRA. The two excluded properties are located in apparent wetland areas, where the level and frequency of exposure is assumed to be much lower than for the remaining properties.

To provide confirmation of the visual estimates, soil samples will be collected at selected locations on properties where CCB visual inspections were completed and where access is obtained, and will be analyzed by a laboratory for comparison to the percentages estimated during the visual inspections.

3.3.1 Objective

Collection of samples for laboratory particulate matter analysis will be completed to confirm the visual observations; that is, that the CCB percentage in each sample quantified by laboratory methods falls into the same category as estimated in the field. A hypothetical example of how the results may be compared is provided in Figure 3.

3.3.2 Sample Collection

Following the identical procedures used during the visual inspections, discrete 6-inch surface core samples will be collected and inspected from locations previously visually inspected, and the field estimate results will be recorded. The proposed sample locations are listed on Table 5 and shown on Figure 4; these have been selected to target approximately five samples from locations previously logged in each of the three categories: 0-25% CCBs, 26-50% CCBs, and 51-75% CCBs, for a total of approximately 15 samples. The sample collection and visual inspection will be conducted by the same field team members that conducted the original inspections. These samples will be submitted for laboratory confirmation of the visual inspection results.

3.3.3 Laboratory Analysis

The samples will be submitted to the RJ Lee Group (Monroeville, PA) for particulate matter analysis using polarized light microscopy (PLM), X-ray diffraction (XRD), X-ray fluorescence (XRF), and loss on ignition (LOI) techniques (hereafter referred to collectively as PLM). The RJ Lee Group has performed all previous particulate evaluations for this project. Particles which are identified by the microscopist as either fly ash or bottom ash will be counted. Further details on the PLM analysis are provided in the QAPP Addendum, which is provided as Appendix B of this SSC Work Plan.

3.3.3.1 PLM Identification Uncertainty

PLM can identify a material as bottom ash that resulted from the combustion of coal by the diagnostic presence of glassy fragments. Thus, the identification of bottom ash is a positive identification of CCB material in that sample. However, while bottom ash can be positively identified by the RJ Lee Group as being of coal origin, it must be recognized that there are many sources of bottom ash of coal origin. Bottom ash and boiler slag are used beneficially in such common applications as roofing shingles, concrete masonry units, manufactured soils and compost, snow and ice control, and as mineral fillers in asphalt (ACAA, 2008, http://www.acaa-usa.org/displaycommon.cfm?an=1&subarticlenbr=109). Thus, the presence of bottom ash in a soil sample within the environs of the Area of Investigation is not unexpected.

RJ Lee Group also relies on morphology to identify fly ash, but that morphology is not unique to CCB materials, thus the methodology cannot distinguish the origin of a fly ash particle from among several possible sources. The bulk of a fly ash sphere is made up of aluminum silicates. Any material that combusts, including coal, wood, grasses, charcoal briquettes, and other starting materials with sufficient aluminum and silica content, can produce fly ash particles.

3.3.4 Data Analysis

The results of the field estimates and laboratory results will be plotted to determine if the laboratory results confirm the visual observations; that is, that the CCB percentage in each sample falls into the same category as estimated in the field. A hypothetical example of how the results may be compared is provided in Figure 3. If the laboratory-identified results for at least four out of five samples in each category (0-25%, 25-50%, and 50-75% CCBs) fall within or below the range identified in the CCB Visual Inspection program, the inspection process will be considered confirmed. If the field estimates tend to overestimate the CCB percentages, then the inspection process will be considered to provide a conservative and still useful estimate of CCB content.

If the laboratory results provide confirmation of the visual inspection results, no further particulate matter analysis will be conducted. If the laboratory results do not confirm the visual inspection results, the Respondents will meet and/or discuss with USEPA and identify if there is a need for additional actions.

The CCB visual inspection verification activities will be conducted prior to the property soil sampling activities described in Section 3.4 below.

3.4 Private Property Soil Sampling

3.4.1 Objective

The proposed private property sampling and analysis activities discussed in this section are designed to provide data to evaluate the potential human health risk associated with CCB-derived constituents at properties within the Area of Investigation in the context of the methods used in the HHRA (AECOM, 2012c).

3.4.2 Properties to be Investigated

The information from the gamma surveys and the CCB visual inspection verification studies will be compiled and evaluated to aid in the identification of appropriate properties for soil sampling. To meet the objectives, it is not necessary to investigate all properties where CCBs may be located. Instead, a subset of these properties is sufficient to characterize potential risk, particularly if the subset includes properties most likely to have the highest concentrations of CCB-derived constituents. Characterization of these properties provides a conservative estimate of risk for all properties.

Statistical theory and USEPA guidance (e.g., USEPA, 2002) can be used to identify the number of properties that are sufficient to provide a representative subset. A statistical procedure from USEPA guidance (USEPA, 2002) has been used to determine the number of residential properties to sample. The calculations used in this statistical procedure are presented in Appendix A. The number of properties is dependent on the statistical characteristics (e.g., mean, standard deviation) of the parameter being measured, in this case, COPC concentrations. Since the statistical characteristics are different for different parameters, the calculated number of properties can also be different. The calculations were conducted using the CCB data collected during the MWSE, as reported in the RI Report (AECOM, 2010) and the HHRA Report (AECOM, 2012c). The calculations were performed for those COPCs where detected results were available and where the maximum detected concentration was above the site-specific PRGs developed for the project (see Table 1). These parameters are listed below, along with the number of properties calculated to provide a representative subset:

- Arsenic – Statistics indicate that 9 properties would be needed to be sampled
- Iron – Statistics indicate that 10 properties would be needed to be sampled
- Thallium – Statistics indicate that 8 properties would be needed to be sampled
- Pb-210 – Statistics indicate that 9 properties would be needed to be sampled
- Ra-226 – Statistics indicate that 8 properties would be needed to be sampled
- Ra-228 – Statistics indicate that 5 properties would be needed to be sampled
- U-238 – Statistics indicate that 8 properties would be needed to be sampled

Thus, the calculated number of properties to be sampled ranges from five to ten. The following constituents were not included in the calculations because concentrations in the MWSE dataset were below PRGs: aluminum, chromium (total), chromium (hexavalent), cobalt, Th-228, Th-230, Th-232, U-234, U-235, and vanadium. The details of the calculations are presented in Appendix A.

Soil sampling will be conducted at both residential and non-residential properties where CCBs are known or believed to be present selected from the 45 properties as discussed in Section 3.1, based on the visual inspection program, and on properties to be selected based on the results of the gamma surveys. Nine properties will be selected for sampling, including three to be selected based on the results of the gamma surveys, three to be based on the results of the CCB visual inspection program, and three to be identified with input from the community. Each of the nine properties will be sampled for the full parameter list (Section 3.4.4). USEPA will participate in the property selection and will have final approval of the locations. The gamma count rate and dose rate survey results will also be reviewed in conjunction with USEPA to determine if any anomalous locations may warrant additional discrete sample collection.

The residential exposure evaluated in the HHRA was based on conditions observed at properties that could be used for residential purposes, and properties where residential-type exposures could occur, such as a park. The EPC used in the HHRA for the residential exposure, consistent with USEPA guidance, is an estimate of the mean or average concentration in an exposure area, which for this investigation, is the residential property.

Thus, the sampling program has been designed to collect data to provide an estimate of this mean concentration for each constituent, following USEPA guidance that addresses residential soil sampling. The sampling program is based on the recommended approach presented in Section 4 of USEPA's Superfund Lead-Contaminated Residential Handbook (USEPA, 2003). While certain aspects of the methodology pertain specifically to lead (i.e., sampling drip zones, which may be impacted by lead paint from rooftops), much of the methodology is appropriate for residential sampling in general. This approach was followed by USEPA for residential sampling for arsenic at the Jacobsville, Indiana Superfund site (USEPA, 2006). Other sampling approaches, such as incremental sampling, were considered, but can lead to much more intrusive activities, and do not accommodate the judgmental sampling, identified below, that USEPA has requested be included in the sampling program.

Generally, each property selected for sampling, as discussed in Section 3.4.3, and for which access is ultimately granted, will be divided into four approximately equally sized quadrants, conceptually two in the front yard and two in the back yard. Additional "quadrants" may be added to the initial four to address three specific property uses:

- A vegetable or flower garden
- An unpaved driveway where CCBs are present (Table 3 presents driveway composition data recorded during the original CCB visual inspections; these observations will be confirmed in the property walk-over phase of this SSC Work Plan)
- A child's play area, based on presence of swing sets or other outdoor play equipment

Therefore, in addition to the four quadrants that will be evaluated for each property, additional "quadrants" (i.e., an appropriate sampling area) will be targeted for sampling if the additional specific property uses are present on a specific property.

The layout of the quadrants for each property will be agreed upon with USEPA prior to conducting the field work and verified with USEPA in the field. Potential exposures resulting from general yard maintenance activities are addressed by the quadrant sampling. The vegetable or flower garden quadrants will be located in areas to be identified with USEPA in the field, taking into consideration signs of active maintenance in a specific well-defined area. Any areas where the homeowner does not want the sampling to be performed on (e.g., a freshly planted area) will be omitted from the quadrants.

3.4.3 Sample Collection

Within each quadrant defined as described above, approximately five equally spaced sample locations will be identified. As the goal of the sampling is to develop an exposure point concentration for use in a human health risk assessment, the five sample locations will not be biased by the presence or absence of CCBs. Samples collected at each of the five locations will be composited over specific depth intervals, such that one sample from each sampling depth from each quadrant will be obtained.

Sample depths have been identified based on the objective of evaluating the potential for exposure and potential risk in the context of the USEPA-approved HHRA Report (AECOM, 2012c). Sample depths will be:

- 0 to 6 inches below ground surface (bgs) – to be referred to as surface soil, which reflects the majority of the soil to which potential receptors could be exposed.
- 6 to 18 inches bgs – to be referred to as near surface soil. The near surface soil depth interval is included to estimate potential exposures to soils that could be easily contacted during normal

household activities such as gardening and playing. As it is unlikely that there are significant exposure differences from 6 to 12 inches and 12 to 18 inches, subdividing the near surface soil depth interval further is not necessary to address potential exposure.

- 1.5 feet (ft) (or 18 inches) to 5 ft bgs, or to maximum depth possible if less than 5 ft bgs (e.g., based on hole collapse or refusal with hand tools) – to be referred to as subsurface soil. This depth interval reflects the depth to which potential exposures may occur on a less frequent basis, such as during a fence or deck installation. This sample will only be collected if CCBs are visually observed within this depth interval in the quadrant.

Thus, in each quadrant, a total of up to three samples will be obtained, each representing a composite over one of the three depth intervals.

Figure 5 presents a generalized sampling plan for a property with no garden, unpaved driveway, or child's play area.

Samples will be collected using hand tools such as a hand auger, as described in more detail in Section 4.3.4. A 0 to 6 inch bgs composite surface sample and a 6 to 18 inch composite near surface sample will be submitted for analysis for all quadrants sampled. If CCBs are not visually observed within the deeper subsurface horizon (1.5 to 5 ft bgs) at any of the five sample locations in a quadrant, then no sample from this horizon will be submitted for analysis. If CCBs are present based on a visual inspection at one or more sample locations within the deeper subsurface horizon in a quadrant, then a 5-point composite sample from that horizon will be submitted for analysis. The field logs will note the depth at which CCBs are no longer observed, or whether they extend beyond the total depth.

Based on historical information about CCB placement (AECOM, 2010) and discussions with USEPA, it is likely that if CCBs are present at a greater depth, their characteristics will be similar to the 1.5 to 5 ft horizon. Therefore, the 1.5 to 5 ft horizon is expected to be representative of the materials at greater depths. For this reason, sampling will not be conducted at deeper depths in order to avoid the use of a drill rig, which would result in considerable damage to property surfaces, and to avoid compromising subsurface features, such as septic systems, which are likely present on the majority of properties to be sampled.

Detailed soil sampling procedures are provided in Section 4.3.4. QA/QC sampling requirements are presented in the QAPP Addendum (Appendix B).

3.4.4 Laboratory Analysis

Soil samples will be analyzed for designated inorganics, hexavalent chromium, and radionuclides. The samples will be submitted to the ALS Group (formerly Columbia Analytical Services, Inc.) for select designated inorganics and hexavalent chromium analyses, and GEL Laboratories, LLC for the radionuclide gamma spectroscopy analysis and total uranium by ICP-MS. Further details on the analytical methods are provided in the project QAPP Addendum, which is provided as Appendix B of this SSC Work Plan.

As described in Section 1.3.4 samples will be analyzed for the following constituents:

- Aluminum
- Arsenic
- Chromium (total)

- Chromium (hexavalent)
- Cobalt
- Iron
- Thallium
- Vanadium
- Total Uranium (calculated from U-235 and U-238 ICP-MS data)
- Radionuclides (library of select gamma-emitting naturally occurring radioisotopes from the U-238 series, Th-232 series, and U-235 series, plus select other non-NORM (e.g., K-40) (refer to Appendix B))

3.4.5 Data Analysis

The analytical data for the soil samples will be validated in accordance with project requirements specified in the QAPP (see Appendix B). The validated data will be uploaded into the project database.

The analytical data collected from the sampling program will be evaluated consistent with the methods used in the HHRA (AECOM, 2012c). Appropriate exposure scenarios will be applied to each property (i.e., a residential exposure scenario will be conducted for properties that are used residentially or could be in the future, while a non-residential scenario will be evaluated for any properties for which a residential exposure scenario is unlikely). In addition, the data will be compared to the BTVs presented in Table 1.

4 Field Procedures

This section of the SSC Work Plan describes the specific procedures that will apply to the SSC Work Plan field program. Section 4.1 discusses the general management procedures that will be performed during the field program; Section 4.2 discusses the general field operations that will apply to the field program; and Section 4.3 discusses the specific field investigation methodologies for the sampling activities outlined in Section 3.

4.1 Field Management Procedures

This section of the SSC Work Plan describes the management procedures that will be followed for the field program. It describes the agreements and contracts that need to be in place prior to commencement of the field program, procedures for security and control of the work location, and work restrictions.

4.1.1 Access Agreements

As described in Section 1.3.1, access agreements will be required prior to conducting the field program.

Most of the land within the Area of Investigation is not owned by or under the control of the Respondents. Therefore, access agreements between the Respondents and individual property owners will be needed to perform the field investigation. Once access is obtained, property owners will be contacted prior to implementing the field work regarding access to their property. It is expected that some sampling locations may need to be modified if site access cannot be obtained.

4.1.2 Access, Control, and Security

A central field office will be maintained on County Road 500 East on property owned by Brown Inc., for the duration of the field work. The field office will provide office space and space for equipment storage and sample handling. The field office will be locked or otherwise secured overnight and when un-manned to maintain security and custody control. The field office may be equipped with power, lights, heat, telephone, photocopier, fax machine, sanitary facilities, and a potable water supply. If any of these services are not available at the field office, they may be obtained as needed at the Brown Inc. facility, located at 720 West US Highway 20 in Michigan City.

The field team will consolidate and secure supplies and equipment in a vehicle or designated storage area prior to departure each day. To the extent possible, the field team will conduct the work such that all samples from any sampling point are collected during a single day in the field.

Most of the sample locations will be on private property not under control of the Respondents. Once sampling locations have been finalized and access agreements obtained, a list of property owners and contact information will be developed. Relevant property owners will be contacted prior to and at the completion of any work on their property unless they request otherwise. Efforts will be made to leave work areas tidy at the end of each day or as soon as possible thereafter.

Because much of the Area of Investigation is a residential area, there are likely to be pedestrians present in the vicinity of active work areas. For safety reasons, a clearly-marked exclusion zone may be set up around work areas in residential neighborhoods. Members of the public will not be allowed to enter the exclusion zone (for more detail, see the HASP, which is Volume 4 of the RI/FS Work Plan [AECOM, 2005d], as updated for the SSC [AECOM, 2014b]).

Owners will be notified prior to the commencement of the SSC field activities on their property.

4.1.3 Work Restrictions

Adverse weather conditions may result in the postponement of proposed investigation activities. Snow, ice, lightning, or heavy rain could potentially impair field staff from performing work activities in accordance with this Work Plan or could potentially put staff at an increased risk of injury. The AECOM Field Operations Leader, AECOM Field HSC, and AECOM SSC Sampling Task Manager will make a determination whether or not to postpone field activities based on the weather. Postponed field activities will be rescheduled at the earliest date feasible, and the rescheduling will be coordinated with USEPA.

4.2 General Field Operations

This section of the SSC Work Plan describes general field activities and operations that apply to the field program. Pertinent SOPs are included in Appendix C of this SSC Work Plan.

4.2.1 Field Changes

Procedural changes in the field may be needed when the proposed survey/sample locations are changed or when sampling procedures and/or field analytical procedures require modification due to unexpected conditions. The AECOM field staff in consultation with the AECOM SSC Sampling Task Manager and AECOM Project QA Officer will recommend any changes. For major changes to procedures, approval from USEPA will be required prior to implementation. It is expected that USEPA staff and/or contractors will be present for the majority of the field activities. It will be the responsibility of the AECOM SSC Sampling Task Manager and the AECOM Project Manager to ensure that the field change and/or any necessary corrective action have been implemented.

If a field change will supplement the existing sampling plan using existing and approved procedures in this SSC Work Plan, changes approved by the AECOM SSC Sampling Task Manager will be documented. If a field change results in fewer samples, alternate locations, etc., which may cause project DQOs not to be achieved; all levels of AECOM project management and USEPA be notified and a consensus decision on how to proceed agreed upon and documented.

Field changes will be implemented and documented in the field logbook. Field changes will also be documented on a field change order (FCO) form according to AECOM SOP No. 100Pines – Field Change Order Procedures (Appendix C). No staff member will implement field changes without prior communication through the proper channels.

4.2.2 Field Documentation and Chain-of-Custody

Field activities will be documented using various forms, field logbooks, and/or electronic data collection devices.

4.2.2.1 Field Record

Field logbooks will provide the primary means of recording the data collecting activities performed during implementation of the field activities. As such, entries will be described in as much detail as possible so that a particular situation can be reconstructed without reliance on memory.

Field logbooks will be bound field survey books or notebooks. Logbooks will be assigned to field personnel, but will be stored in the project files when not in use. Each logbook will be identified by a project-specific document number.

Entries into the logbook will contain a variety of information. At the beginning of each entry, the date, start time, weather, names of all sampling team members present, and the signature of the person making the entry will be entered. The names of visitors to the work location, and the purpose of their visit, will also be recorded in the field logbook.

Measurements made and samples collected will be recorded. All entries will be made in permanent ink, signed and dated, and no erasures or obliterations will be made. If an incorrect entry is made, the information will be crossed out with a single strike mark and the correct entry will be made, signed and dated by the person making the correction. Whenever a sample is collected, or a measurement is made, a detailed description of the sampling location, which may include compass and distance measurements, or latitude and longitude information (e.g., obtained by using GPS) will be recorded. All equipment used to make measurements will be identified, along with the date of equipment calibration, if applicable. The coordinate system that the GPS unit displays will be recorded. The units used by other recording equipment will also be documented.

Information specific to sample collection will include:

- Sample identification number;
- Time and date of sample collection;
- Sample description (medium, color, texture, etc., including visual evidence of CCBs);
- Depth of sample interval (bgs);
- Sample type; and
- Location (e.g., GPS coordinates and description).

To streamline data recording, information will be recorded on standardized forms when this approach is logical. Examples of several forms are included in the SOPs in Appendix C.

Descriptions of geologic materials and CCBs will be logged in accordance with Indiana guidance (IDEM, 1988; see Appendix C).

Photographs will be taken of each gamma survey location to document the survey conditions. Where surveys are taken on private property, care will be taken to limit the field of view to just the surveyed areas, and to not include houses or buildings to the extent practical. For the property sampling, photographs will be taken of each quadrant to document conditions before and after the sampling. Photographs will be taken of all soil samples as retrieved and then also after homogenization in order to create a photographic record of the soil sampling. Additional photographs will be taken throughout the field program as appropriate. Whenever photographs are taken, a digital camera will be used, and the camera picture frame number, date, direction facing, and subject will be recorded in the logbook and/or on the appropriate field form.

Electronic data logged during walkover surveys will be downloaded from the data logger onto a computer daily. The downloaded electronic data will also be saved onto a network server daily. Electronic data will not be copied manually into a field logbook.

Copies of CoC forms will be maintained as part of the field records as described in Section 4.2.3, and AECOM SOP No. 1007Pines – Chain-of-Custody Procedures (Appendix C).

4.2.2.2 Sample Labeling

Immediately upon collection, an adhesive sample label will be affixed to each container, including the unique sample identification (ID) (as described below), the time and date of sample collection, the sampler's initials, parameters to be analyzed, and preservation, if applicable. The project name will not be shown on the label. The unique sample identification will be an alphanumeric code consisting of the following elements:

- Name of sampling location in five digits (e.g., SS002, etc.). These location names will correspond to field logs, as well as sample locations posted on maps. Location names will be reviewed with the SSC Sampling Task Manager prior to initiating field work.
- Single letter signifying depth of sample (A, B, C, etc. for samples taken at increasing depth, X if this field is not being used). The actual depth measured in the field in feet will be recorded in the field records.
- Two letters signifying the sample matrix (SS for surface soil (0 to 6-in depth), NS for near surface soil (6 to 18-in depth) and SB for subsurface soil (>18-in depth)).
- Sampling date consisting of the number corresponding to the month (2 digits), day (2 digits) and year (2 digits), for example, 090813 for samples collected on September 8, 2013.
- Letter denoting the type of sample. Codes for this field include: S – sample; D – field duplicate; B – equipment rinsate blank.

No dashes will be used to separate fields. An example sample ID would be: SS001XSS101104D indicating a surface soil sample collected at location SS001 on October 11, 2004. This sample is a field duplicate, and the X represents the depth, which is not being used since only one sample is being collected from that location. The actual depth will be recorded in the field logbook.

Samples designated as matrix spike/matrix spike duplicates (MS/MSDs) will be noted as such in the comments field of the CoC form.

The sample identification code will be recorded on the label, in the field logbook and other field forms, on the CoC form, and will be carried through the analytical process to reporting.

4.2.2.3 Sample Custody

The field sampler(s) are responsible for the care and custody of the samples including shipping to the laboratory. Field samplers will complete the CoC in accordance with AECOM SOP No. 1007Pines – Chain-of-Custody Procedures (Appendix C).

4.2.2.4 Sample Packaging and Shipping

Samples will be packaged for shipment to the laboratory under the CoC procedures described in AECOM SOP No. 1007Pines – Chain-of-Custody Procedures and AECOM SOP No. 7510Pines – Packaging and Shipment of Environmental Samples (Appendix C).

After sample containers are labeled and filled, samples may be placed in plastic zipper-lock bags to contain material in the event of container spillage during shipment. Containers will then be packaged in a cooler for shipment, using inert packing material (e.g., bubble wrap, rubber foam, or equivalent) to prevent breakage during shipment. For samples submitted for metals analysis, the cooler will be packed with sufficient ice to maintain a temperature of 4° ±2° Celsius (C) for overnight delivery. Samples submitted for radiological analysis and for PLM analysis will not be required to be shipped on ice. A multi-form CoC form will be completed. An example CoC form is presented in AECOM SOP No. 1007Pines – Chain-of-Custody Procedures (see Appendix C). The original CoC will be placed in a zipper-lock bag that is taped to the lid inside each cooler of samples being submitted to the laboratory for analyses. The back copy of the CoC will be maintained with the field records. The cooler will be locked or sealed, and custody seals placed on the outside of the cooler in such a way that the cooler cannot be opened without breaking the seals.

Sampling, analytical holding times, and shipping and receiving of samples will require close attention and coordination between field staff and laboratory staff. During the time period between collection and shipment, samples will be stored in ice-filled coolers or refrigerated, if applicable, and maintained under sample custody. Samples will be shipped to the laboratory via commercial overnight courier (e.g., Federal Express).

4.2.3 Project Files

The project file will be the central repository for all documents relevant to sampling and analysis activities as described in this SSC Work Plan. The management of documents and records pertaining to the overall RI/FS will be in accordance with the Quality Management Plan (QMP) (Volume 7 of the RI/FS Work Plan [AECOM, 2005d]).

The project files for the SSC Work Plan will include at a minimum:

- Plans;
- Field logbooks;
- Field forms;
- Electronic data from gamma count rate walk-over surveys and dose rate surveys;
- Photographs;
- Drawings;
- Laboratory data deliverables;
- Progress reports, QA reports, interim project reports, etc.; and
- Custody documentation (CoC forms, airbills, etc.).

Records associated with this investigation will be retained with all the project records for the duration of AOC II and for a minimum of 10 years after its termination. USEPA, NIPSCO and Brown Inc. will be notified in writing 90 days prior to destruction of the records (per AOC II Section XIII. 44.).

4.2.4 Mobilization/Demobilization

Mobilization includes equipment procurement and transport to the field office and/or specific work location, subcontractor coordination, utility awareness and clearance, and setup of decontamination and waste storage areas. Equipment requirements will be finalized by the AECOM SSC Sampling Task Manager following acceptance of this SSC Work Plan. The AECOM SSC Sampling Task Manager will review the scope of work and assemble equipment to implement the complete field investigation. The AECOM SSC Sampling Task Manager, or their designee, will also be responsible for packaging and loading equipment, and ensuring that all equipment is operable and calibrated. The field office will serve as a temporary storage area for equipment.

Analytical laboratory services will be subcontracted. Following the procurement of these services, the Laboratory Coordinator will be responsible for coordinating the analytical services, as well as the acquisition and delivery of sample bottles to the Area of Investigation. Utility clearances will be coordinated by the AECOM Field Operations Leader (see Section 4.3.1).

Demobilization will involve the decontamination of equipment and removal from the work location once field activities have been completed. All wastes will be properly managed as discussed in Section 4.2.6 below.

4.2.5 Decontamination

Appropriate decontamination procedures will be used for health and safety reasons and to minimize the potential for cross-contamination.

4.2.5.1 Sampling Equipment

All non-dedicated sampling equipment will be decontaminated prior to sampling and between samples, in accordance with AECOM SOP No. 7600Pines – Decontamination of Field Equipment (see Appendix C). Dedicated (i.e., disposable) sampling equipment will not be decontaminated. In general, equipment used will be decontaminated using the following procedure:

- Tap water rinse to remove gross contamination;
- Non-phosphate, non-borate detergent (e.g., DETERGENT8®) and water rinse;
- Tap water rinse;
- Distilled/deionized water rinse;
- 10% nitric acid rinse;
- Distilled/deionized water rinse; and
- Air dry.

As a final step, all decontaminated equipment will be screened with a pancake probe or other suitable detector to confirm that residual radioactivity is within background levels. If the decontaminated equipment will be stored until later use, it will be wrapped in aluminum foil to prevent recontamination. Water generated during decontamination of sampling equipment will be handled as described in Section 4.2.6.

4.2.5.2 Personnel

Personnel decontamination is detailed in the HASP (Volume 4 of the RI/FS Work Plan [AECOM, 2005d], as updated for the SSC [AECOM, 2014b]).

4.2.6 Investigation Derived Waste Management

Investigation-derived waste (IDW) for the field investigation program will be managed in accordance with applicable USEPA and IDEM regulations. It is anticipated that IDW materials will be generated during the field investigation. These materials may include:

- Decontamination fluids,
- Used PPE, and
- Used sampling equipment.

These wastes will be handled in the following manner:

- Visibly clear, non-phosphate and non-borate detergent wash water and rinse water decontamination fluids from sampling equipment will be released to the ground, in the immediate vicinity of its point of generation. If warranted, based on its condition or the sample location, the decontamination rinse water will be contained in properly labeled 55-gallon drums or bulk containers and staged at the designated IDW staging area.
- Used PPE, such as sampling gloves, paper towels, or other materials will be bagged and sealed prior to disposal as general refuse.
- Used disposable sampling equipment, such as trowels and empty bottles, will be disposed of with the PPE as general refuse.

4.2.7 Surveying by GPS

Where sufficient accuracy may be achieved by field personnel, a GPS unit may be used to determine the locations of objects of interest (e.g., gamma dose rate sampling locations, CCB sample locations, soil sample locations, etc.). A GPS unit will also be integrated with the instrument used in the gamma walkover survey in order to correlate the gamma measurements with the area within the survey units.

A Trimble GPS Pathfinder Pro XRS® (or similar) unit will be utilized to obtain horizontal measurements with an accuracy of +/-0.5 meters. At the beginning and end of each day, GPS measurements will be collected from a reference point. This reference point will be the same location for each day that the GPS unit is being used. The collection of data from the reference point will allow for comparison in accuracy of the data collected.

GPS positions will be collected in World Geodetic System (WGS), 1984 during data collection. After data has been collected, the data will be downloaded and converted to the project coordinate system. All associated attribute data used for data collection will be downloaded with the coordinate information. The data will then be added to the project database.

4.3 Field Investigation Methodologies

4.3.1 Utility Clearance

Clearance of utilities located in the work area is necessary prior to performing subsurface field activities. Utilities may include municipal water, electricity, cable television, telephone, gas, and storm sewer. At least two full working days, but no more than 20 calendar days prior to the start of intrusive field work, the field staff will contact Indiana811:

Indiana811
1-800-382-5544
www.indiana811.org

The field staff will provide Indiana811 with the county and the township as well as a street address and cross street of the locations necessary for utility clearance. Where possible, the field staff will mark areas where field work may affect any subsurface utilities with white marking paint or white flags (where paint is not applicable) prior to calling Indiana811. Marking areas with white paint/flags will guide Indiana811 on where to concentrate their locating efforts.

Indiana811 underground facility members will mark or otherwise identify facilities according to the following color codes in accordance with Damage to Underground Facilities, Indiana Code 8-1-26-18:

Utility	Marking Color
Electric power distribution and transmission	Safety Red
Municipal electric systems	Safety Red
Gas distribution and transmission	High Visibility Safety Yellow
Oil distribution and transmission	High Visibility Safety Yellow
Dangerous materials, product lines & steam lines	High Visibility Safety Yellow
Telephone and telegraph systems	Safety Alert Orange
Cable television	Safety Alert Orange
Police and fire communications	Safety Alert Orange
Water systems	Safety Precaution Blue
Sewer systems	Safety Green
Proposed construction	White

Additional information on contacting and providing the necessary information can be found on the Indiana811 website at www.indiana811.org.

Where subsurface work takes place on private property, field staff will work with the property owner to supplement the Indiana811 information where possible.

4.3.2 Gamma Surveys

4.3.2.1 Gamma Count Rate Walk-over Survey

Each survey unit will receive a complete gamma walk-over coverage scan of accessible areas with a 2-inch by 2-inch NaI gamma scintillation detector and a digital scaler/ratemeter (i.e., Ludlum Model 44-10 detector and Model 2221 scaler/ratemeter). NaI detectors will be calibrated by the manufacturer (Ludlum) or a rental vendor who specializes in radiation survey equipment to optimize detection efficiency for the gamma energies associated with the decay products of Ra-226, where Pb-214 and Bi-214 are generally regarded as the notable gamma emitters. The response of each NaI detector used in the walk-over surveys will be correlated to a source block set (4 stacked blocks) with known total radium concentration, prior to conducting the field surveys. A 10 pCi/g total radium source block set is located at the former Kerr McGee Rare Earths Facility in West Chicago, Illinois, and is under the control of the West Chicago Environmental Response Trust. This work plan assumes that access to this source block set will be provided. Appendix F provides an alternate calibration method to be used should the block set not be available. The detector will be connected to a data logging GPS receiver that will log gamma radiation count rates (in cpm) and position.

The survey units will be divided into transects spaced 2 feet apart. Where hand-held units are used, survey technicians will walk along transects while moving the detector in a serpentine pattern, walking at a pace less than 1 meter per second (m/s) and keeping the detector close to the ground as possible but not more than 6 inches from the ground. When practical, detectors mounted on a survey cart will be used, with the detector mounted to be within 6 inches of the ground surface. The radiological survey data obtained will be processed and mapped.

The gamma walk-over surveys will be conducted in accordance with AECOM RS-TPG SOP 001 – Portable Detection Equipment, AECOM RS-TPG SOP 007 – Grid Systems and Surveys, and AECOM RS-TPG SOP 011 – Radiation Surveys, provided in Appendix C. Daily instrument operational checks described in these procedures will be performed at the beginning and end of each day the instruments are in use.

4.3.2.2 Gamma Dose Rate Survey

The gamma dose rate survey will consist of recording a dose reading at a pre-determined number of discrete sampling locations within each survey unit. Gamma dose rate surveys will be performed using a tissue-equivalent gamma dose rate meter (e.g., Thermo Scientific™ Micro Rem meter). The dose rate meter will be calibrated by the manufacturer; daily dose response checks (typically done with a Cs-137 button source), will be performed at the beginning and end of each survey day. The dose measurements and GPS location will be recorded at each sample location. In addition, direct gamma count rate measurements will be acquired over a two-minute period of time at each discrete sample location using a 2-inch by 2-inch NaI gamma scintillation detector.

The gamma dose rate surveys will be conducted in accordance with AECOM RS-TPG SOP 001 – Portable Detection Equipment, AECOM RS-TPG SOP 007 – Grid Systems and Surveys, and AECOM RS-TPG SOP 011 – Radiation Surveys, provided in Appendix C.

4.3.3 CCB Visual Inspection Confirmation

Discrete 6-inch surface core samples will be collected from five locations previously logged in each of the three categories: 0-25% CCBs, 26-50% CCBs, 51-75% CCBs, for a total of 15 samples. A GPS unit will be used to navigate to the pre-selected sampling locations, based on coordinates collected during the previous CCB visual inspections. Samples will be collected from the zero to six inch interval.

Samples will be collected using a trowel or hand auger in accordance with AECOM SOP 7110Pines – Surface Soil Sampling. The sample will be visually inspected for the presence of CCBs in the same manner as the previous visual inspections and logged in accordance with Section 7.4 – Sample Logging of AECOM SOP 109Pines – Split Spoon Sampling for Geologic Logging. Consistent with previous visual inspection procedures, the CCB content in the sample will be estimated in the field as 0-25% CCBs, 26-50% CCBs, 51-75% CCBs, or 76-100% CCBs. If the visual inspection performed during the sampling differs significantly than the original, this will be documented in the field notes. Effort will be made to locate a sample that exhibits the target percent range; however, there were very few locations classified within the 50-75% range in the original CCB visual inspections, so it may not be possible to achieve collection of five samples within this range. The AECOM SSC Sampling Task Manager, the AECOM Project Manager, and the USEPA Project Manager will be consulted should this field visual inspection differ from the original CCB visual inspection results.

The sample will then be containerized and packaged in accordance with AECOM SOP 7510Pines – Packaging and Shipment of Environmental Samples and shipped to RJ Lee Group under chain of custody procedures in accordance with AECOM SOP 1007Pines – Chain-of-Custody Procedures.

Non-disposable field equipment will be decontaminated in accordance with AECOM SOP 7600Pines – Decontamination of Field Equipment.

SOPs are provided in Appendix C.

4.3.4 Private Property Soil Sampling

Each property to be sampled will be divided into quadrants as described in Section 3.4.3. Five approximately equally spaced sample locations will be identified in each quadrant. Sample locations within the quadrant will not be biased based on the visual observations of CCBs. Quadrant boundaries and sampling locations will be logged with a GPS unit. Each sampling location will be sampled at three discrete intervals:

- 0 to 6 inches bgs – to be referred to as surface soil
- 6 to 18 inches bgs – to be referred to as near surface soil
- 1.5 ft (18 inches) to 5 ft bgs, or to maximum depth possible if less than 5 ft bgs (e.g., based on hole collapse or refusal with hand tools) – to be referred to as subsurface soil

Samples will be collected and logged in accordance with AECOM SOP 7110Pines – Surface Soil Sampling, using hand tools such as a trowel and/or hand auger.

Samples collected at each of the five locations within a quadrant will be composited over the specific depth intervals, resulting in one composite sample from each sampling depth interval, from each quadrant. At each location, the collected sample will cover the full depth interval, not a portion of the interval. For each depth interval, the five equal volume discrete samples will be placed into a plastic bowl or similar non-metal container and homogenized. A single composite sample will then be withdrawn from the homogenized material and placed into appropriate laboratory-supplied containers. Photographs will be taken of each discrete and composite sample. Photographs will be collected as described in Section 4.2.2.

A 0 to 6 inch bgs composite sample and a 6 to 18 inch composite sample will be submitted for analysis for all quadrants sampled.

The subsurface soil horizon will extend from 1.5 ft until hole collapse or refusal, or to a maximum depth of 5 ft. Where subsurface soils are sandy or peaty, the hand-dug borehole may not stay open such that it is not possible to obtain a sample that originates from the targeted depth. Also, where subsurface soils are compacted CCBs, it may not be possible to penetrate them using hand tools (refusal). If CCBs are not visually observed within the deeper horizon (1.5 to 5 ft bgs) at any of the five sample locations in a quadrant based on visual inspection of that soil interval, then no sample from this horizon will be submitted for analysis. If CCBs are present based on a visual inspection at one or more sample locations within the deeper horizon in a quadrant, then a 5-point composite sample from that horizon will be submitted for analysis. The field logs will note if at any sample location the vertical extent of visual CCBs is not reached.

Discrete grab samples may be collected at specific locations if anomalous gamma readings (i.e., distinct areas of elevated activity) were encountered during the gamma walkover survey. All decisions to collect discrete grab samples will be made in conjunction with USEPA.

Equipment blanks will be collected when non-dedicated sampling equipment is used at a rate of 1 per 10 field samples. Field duplicates and MS/MSDs will be collected at a rate of 1 per 10 field samples.

Samples will be containerized and packaged in accordance with AECOM SOP 7510Pines – Packaging and Shipment of Environmental Samples and shipped to ALS Group (formerly Columbia Analytical Services, Inc.) and GEL Laboratories, LLC under chain of custody procedures in accordance with AECOM SOP 1007Pines – Chain-of-Custody Procedures.

Non-disposable field equipment will be decontaminated in accordance with AECOM SOP 7600Pines – Decontamination of Field Equipment. SOPs are provided in Appendix C.

5 Reporting

Within 90 calendar days after receipt of final radiological data, the Respondents will submit to USEPA a draft SSC Report presenting the data collected under this SSC Work Plan. The SSC Report will present the results of the gamma surveys, CCB visual inspection verification, and the private property soil sampling. This information will be used to update the CSM for the Area of Investigation.

6 Schedule

Following USEPA approval of this SSC Work Plan, the planned schedule for field activities, laboratory analytical services and reporting will begin. The first task, which has already started, will be to obtain access agreements from owners of properties in which field investigations are to be performed. Access must be obtained before field work begins. Every effort will be made to receive access agreements in a timely manner. We have been working cooperatively with USEPA to obtain access agreements. However, based on past experience, it is anticipated that the access agreement process may take several months to complete. All access agreements will be obtained prior to starting field work on private property to avoid multiple mobilizations into the residential areas. Based on the need for access agreements, and the calendar (observational, survey, and sampling tasks cannot be conducted when the ground is frozen or snow-covered), field activities will likely to start in Spring of 2014.

Completion of the field activities is anticipated to take approximately six months. The gamma surveys at background locations will be performed first to provide a reference/background gamma dataset. Once these data are processed, gamma surveys will be completed on additional properties. Based on the results of the gamma surveys, CCB verification sampling, and access, the properties for soil investigations will be selected in consultation with USEPA and the community. It is assumed that the list of properties to be sampled can be finalized within two weeks of initial recommendations.

Once the field activities are complete, compilation of field notes, laboratory analysis and other report preparation tasks continue for another three month period. Within 90 calendar days after receipt of final radiological data, the Respondents will submit to USEPA a draft SSC Report presenting the data collected under this SSC Work Plan.

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Tables

TABLE 1
PROPOSED PRELIMINARY REMEDIATION GOALS AND BACKGROUND THRESHOLD VALUES
FOR CCB-DERIVED CONSTITUENTS IN SOIL
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

AECOM

Constituent	Preliminary Remediation Goals (PRGs)				BTV - Expanded CCB-Free Background Dataset - 95% UTL with 95% Coverage (a)	Published Background Concentration		MWSE Data		Units
	Target Carcinogen Risk = 1E-6	Target Carcinogen Risk = 1E-5	Target Carcinogen Risk = 1E-4	Target Hazard Quotient =1				Maximum Detected Concentration	EPC	
Metals										
Aluminum	NC	NC	NC	108,000	13,800	43,000	(f)	44,600	29,874	mg/kg
Arsenic	0.7	7.3	73	41	30.1	16.9	(f)	97.2	28.6	mg/kg
Chromium	NC	NC	NC	135,142	41	52	(k)	166	95.8	mg/kg
Chromium, Hexavalent	1.8	17.8	178	295	(b)	--		1.95	1.2	mg/kg
Cobalt	541	5,410	54,100	33	23.8	9.2	(k)	19.5	13.35	mg/kg
Iron	NC	NC	NC	76,436	57,700	44,900	(f)	142,000	80,948	mg/kg
Thallium	NC	NC	NC	1.1	1.9	0.3 to 0.7	(g)	5	1.8	mg/kg
Vanadium	NC	NC	NC	498	67.9	66	(k)	89.9	65.85	mg/kg
Radionuclides										
Lead-210+d	0.163	1.63	16.3	(e)	8.84	--		2.17	1.76	pCi/g
Radium-226+d	0.0406	0.406	4.06	(e)	0.975	1.6	(h)	2.91	2.24	pCi/g
Radium-228+d	0.153	1.53	15.3	(e)	1.17	--		2.38	1.85	pCi/g
Sum of Radium-226 and 228	7.15 (c,d)				2.15 (d)	0.4 to 3.6	(i)	5.09	4.07	pCi/g
Thorium-228	24.58	246	2,458	(e)	1.13	--		5.74	4.014	pCi/g
Thorium-230	3.50	35	350	(e)	0.975	--		2.91	2.232	pCi/g
Thorium-232	3.06	31	306	(e)	1.17	--		1.54	1.149	pCi/g
Uranium-234	4.08	41	408	(e)	0.975	0.6 to 3	(j)	3.34	2.477	pCi/g
Uranium-235+d	0.59	6	59	(e)	0.144	0.6 to 3	(j)	ND	ND	pCi/g
Uranium-238+d	1.533	15	153	(e)	3.46	0.6 to 3	(j)	3.53	2.42	pCi/g

See Notes on following page.

TABLE 1
PROPOSED PRELIMINARY REMEDIATION GOALS AND BACKGROUND THRESHOLD VALUES
FOR CCB-DERIVED CONSTITUENTS IN SOIL
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

AECOM

Notes:

ARAR - Applicable or Relevant and Appropriate Requirement.
ATSDR - Agency for Toxic Substances and Disease Registry.
BTV - Background Threshold Value.
CCB - Coal Combustion By-Product.
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act.
EPC - Exposure Point Concentration.
mg/kg - milligrams per kilogram.
MWSE - Municipal Water Service Extension.
NC - Not Calculated. Not a potential carcinogen.
ND - Not Detected.
pCi/g - picoCuries per gram.
PRG - Preliminary Remediation Goal.
UMTRCA - Uranium Mill Tailings Radiation Control Act.
USEPA - United States Environmental Protection Agency.
USGS - United States Geological Survey.
UTL - Upper Threshold Limit.
(a) - See Appendix F2 Table 3 of the Feasibility Study (AECOM, 2014) for BTV details.
(b) - Hexavalent chromium was not detected in the background samples. Detection limits ranged from 0.44 mg/kg to 2.2 mg/kg.
(c) - For the sum of the radiums, the PRG is identified as the chemical-specific ARAR, namely, the Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR §192.12). While these regulations are only applicable to the control of residual radioactive material at designated processing or depository (Title I) sites under Section 108 of UMTRCA, USEPA has provided guidance that these criteria should be considered relevant and appropriate at other CERCLA sites, and, as such are considered so for the Pines Area of Investigation. The regulations identify a standard of 5 pCi/g above background for use of assessing the combined levels of Ra-226 and Ra-228.
(d) - The BTV for the sum of the radiums is 2.15 pCi/g. Therefore, the PRG, as discussed in (c) is 5 pCi/g above background, or 7.15 pCi/g.
(e) - Radionuclides are evaluated for potentially carcinogenic effects only.
(f) - Average for Porter County from USGS, 2013. http://tin.er.usgs.gov/geochem/county.php?place=f18127&el=As&rf=upper-midwestern.
(g) - Range of naturally occuring thallium. ATSDR. 1992. Toxicological Profile for Thallium. Available at: http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=309&tid=49.
(h) - ATSDR reports the mean of naturrally occuring radium-226 in 33 states as 1.6 pCi/g. ATSDR. 2012. Toxicological Profile for Radon. Available at: http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=407&tid=71
(i) - The Health Physics Society reports the range for naturally occuring total radium as 0.4 - 3.6 pCi/g. http://hps.org/publicinformation/ate/uranium.pdf
(j) - Value for total uranium. Health Physics Society. http://hps.org/publicinformation/ate/uranium.pdf
(k) - Shacklette and Boerngen. 1984. Element Concentrations in Soils and other Surficial Materials of the Conterminous United States. USGS Professional Paper 1270.

TABLE 2
PROPOSED BACKGROUND GAMMA SURVEY LOCATIONS
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

Background ID	Location Description	Roadside	Soil Type
SS003	Willow Street; right-of-way	Yes	Native Granular Soil
SS008	West of County Line Road	No	Native Organic Soil
SS011	East of Ardendale	No	Native Granular Soil
SS016	Indiana Dunes National Lakeshore	No	Native Organic Soil
SS023	South of Pine Street	Yes	Native Granular Soil
SS027	Indiana Dunes National Lakeshore	No	Native Organic Soil
SS028	Indiana Dunes National Lakeshore	No	Native Granular Soil
SS030	Indiana Dunes National Lakeshore	No	Native Organic Soil
SS031	County Highway 600 E; right-of-way	Yes	Native Granular Soil
SS038	County Highway 1600 N; right-of-way	Yes	Native Granular Soil

Notes:

Locations were selected to be representative of background soil sampling conditions such as geology, proximity to roads and chemistry.

TABLE 3
PERCENT SUSPECTED CCBS ON PROPERTIES VISUALLY INSPECTED
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

Property Number	Structure	CCBs Indentified?	Used in HHRA?	Used in SERA?	Driveway Composition	Suspected CCBs Adjacent to Structure	Total Number of Locations Surveyed	Number of Locations Surveyed with Suspected CCBs Present (a)					Conservative Maximum Average Percent Suspected CCBs Across the Exposure Area (c)
								Total	Surface (b)	0-25%	26-50%	51-75%	
1	residence	Yes	Yes	Yes	asphalt	Yes	46	26	0	21	5	0	22%
2	residence	Yes	Yes	Yes	gravel	No	71	55	0	47	8	0	27%
3	residence	Yes	Yes	Yes	NA	Yes	73	42	0	18	24	0	26%
4	residence	Yes	Yes	Yes	gravel	Yes	340	59	0	54	4	1	15%
5	residence	Yes	Yes	Yes	gravel	Yes	49	19	5	14	0	0	10%
6	residence	Yes	Yes	No (f)	asphalt/gravel	No	89	14	0	9	2	3	8%
7	residence	Yes	Yes	Yes	gravel	No	48	13	0	9	4	0	8%
8	residence	Yes	Yes	Yes	NA	No	52	7	0	7	0	0	5%
9	residence	Yes	Yes	Yes	asphalt	No	61	8	0	7	1	0	6%
10	residence	Yes	Yes	Yes	concrete/gravel	No	63	6	0	6	0	0	10%
11	residence	Yes	Yes	Yes	asphalt	No	40	3	0	2	1	0	5%
12	residence	Yes	Yes	Yes	concrete	No	56	7	0	3	4	0	5%
13	residence	Yes	Yes	Yes	asphalt	No	27	6	3	3	0	0	3%
14	residence	Yes	Yes	Yes	gravel	No	103	9	0	3	6	0	4%
15	residence	Yes	Yes	Yes	concrete/gravel	No	79	9	1	8	0	0	3%
16	residence	Yes	Yes	Yes	NA	No	29	4	0	4	0	0	2%
17	residence	Yes	Yes	Yes	concrete	No	30	1	0	1	0	0	4%
18	residence	Yes	Yes	Yes	gravel	No	242	32	0	15	14	3	6%
19	residence	Yes	Yes	No (f)	gravel	No	116	32	2	30	0	0	6%
20	residence	Yes	Yes	Yes	asphalt	No	88	8	0	8	0	0	2%
21	residence	Yes	Yes	Yes	asphalt	No	76	2	0	2	0	0	2%
22	residence	Yes	Yes	Yes	gravel/concrete	No	86	5	0	3	0	2	2%
23	residence	Yes	Yes	Yes	asphalt	No	43	1	0	1	0	0	1%
24	residence	Yes	Yes	Yes	asphalt	No	61	4	1	3	0	0	1%
25	residence	Yes	Yes	Yes	asphalt	No	117	10	1	6	2	1	4%
26	residence	Yes	Yes	Yes	asphalt	No	86	4	0	4	0	0	1%
27	residence	Yes	Yes	Yes	concrete	No	49	10	4	6	0	0	3%
28	residence	Yes	Yes	Yes	gravel	No	86	7	0	7	0	0	1%
29	residence	Yes	Yes	Yes	gravel	No	53	3	0	3	0	0	1%
30	residence	Yes	Yes	Yes	concrete	No	31	4	4	0	0	0	2%
31	residence	Yes	Yes	Yes	concrete	No	86	3	0	3	0	0	0% (d)
32	residence	No	No (d)	No (d)	concrete	No	40	0	0	0	0	0	0% (d)
33	town hall	Yes	Yes	Yes	gravel	No	109	77	0	77	0	0	8%
34	vacant store	Yes	Yes	Yes	asphalt	No	88	30	1	29	0	0	10%
35	fire department	Yes	Yes	No (f)	asphalt/gravel	Yes	37	14	3	11	0	0	7%
36	none	Yes	No (e)	Yes	NA	NA	86	86	0	57	11	18	(e)
37	none	Yes	Yes	Yes	gravel	NA	25	9	0	8	1	0	13%
38	none	Yes	Yes	Yes	NA	NA	38	19	2	16	1	0	11%
39	none	Yes	No (e)	Yes	NA	NA	20	20	0	13	4	3	(e)
40	none	No	No (d,e)	No (d)	NA	NA	73	0	0	0	0	0	0% (d)
41	none	Yes	Yes	Yes	NA	NA	40	7	0	7	0	0	8%
42	none	Yes	Yes	Yes	NA	NA	61	19	0	19	0	0	5%
43	none	Yes	Yes	Yes	NA	NA	40	7	0	4	3	0	4%
44	none	Yes	Yes	Yes	NA	NA	157	45	0	44	1	0	5%
45	none	Yes	Yes	Yes	NA	NA	54	2	0	1	1	0	2%
46	none	Yes	Yes	Yes	NA	NA	41	14	0	13	1	0	15%
47	residence	Yes	Yes	Yes	NA	No	14	3	0	1	2	0	7%
Total	**47**	**45**	**43**	**42**	**--**	**5**	**3,399**	**765**	**27**	**607**	**100**	**31**	**Average: 7%**
													Maximum: 27%

GPS - Global Positioning System.
m^2 - square meters.
NA - Not applicable.
HHRA - Human Health Risk Assessment (AECOM, 2012a).
SERA - Screening Level Ecological Risk Assessment (AECOM, 2012b).
(a) - Suspected CCB presence was determined by visually observing a six inch below ground surface core. Each sample was classified as surface, 0-25%, 26-50%, 51-75%, or 76-100% (No samples were classified as 76-100%). Only samples within each property's exposure area were included. More information about the visual inspections is presented in the Remedial Investigation Report (AECOM, 2010).
(b) - Suspected CCBs were observed on the ground surface but were not present at depth; therefore, percentages were not estimated for these locations.
(c) - Weighted average of the percentage of suspected CCBs present in each sample location multiplied by the percent of the exposure area with suspected CCBs (See HHRA, Appendix I). It It was conservatively assumed that samples classified as 0-25% contained 25% suspected CCBs, 0-25% contained 25% suspected CCBs, samples classified as 26-50% contained 50% suspected CCBs, etc. In addition, all surface samples were assumed to contain 25% suspected CCBs.
(d) - CCBs were not identified. Therefore, this property was not included in the calculations of CCB percent for either the human health or ecological risk assessments.
(e) - Not used to derive the CCB percentage for the human health risk assessment; located in a wetland area.
(f) - Not located in an area of potential terrestrial habitat for ecological receptors.

TABLE 4
PROPOSED 2009 GAMMA SURVEY LOCATIONS
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

Location ID[1]	Approximate Location Description
F	Yard 520
G	Ardendale Road
H	Ardendale Road
I	Ardendale Road
J	Illinois Avenue
K	Railroad Avenue
L	Railroad Avenue
M	Railroad Avenue
N	Railroad Avenue
O	East Johns Avenue
P	Connecticut Avenue
Q	Alabama Avenue
R	Carolina Avenue & Calumet Bike Trail

Notes:

1 - Properties selected are from the 2009 Gamma Count Rate Survey of Pines conducted by Larry Jensen. The properties selected are those within the boundary of the Area of Investigation and those that do not already overlap with the 45 properties identified from the CCB visual inspections. Locations shown on Figure 1 are approximate based on report descriptions.

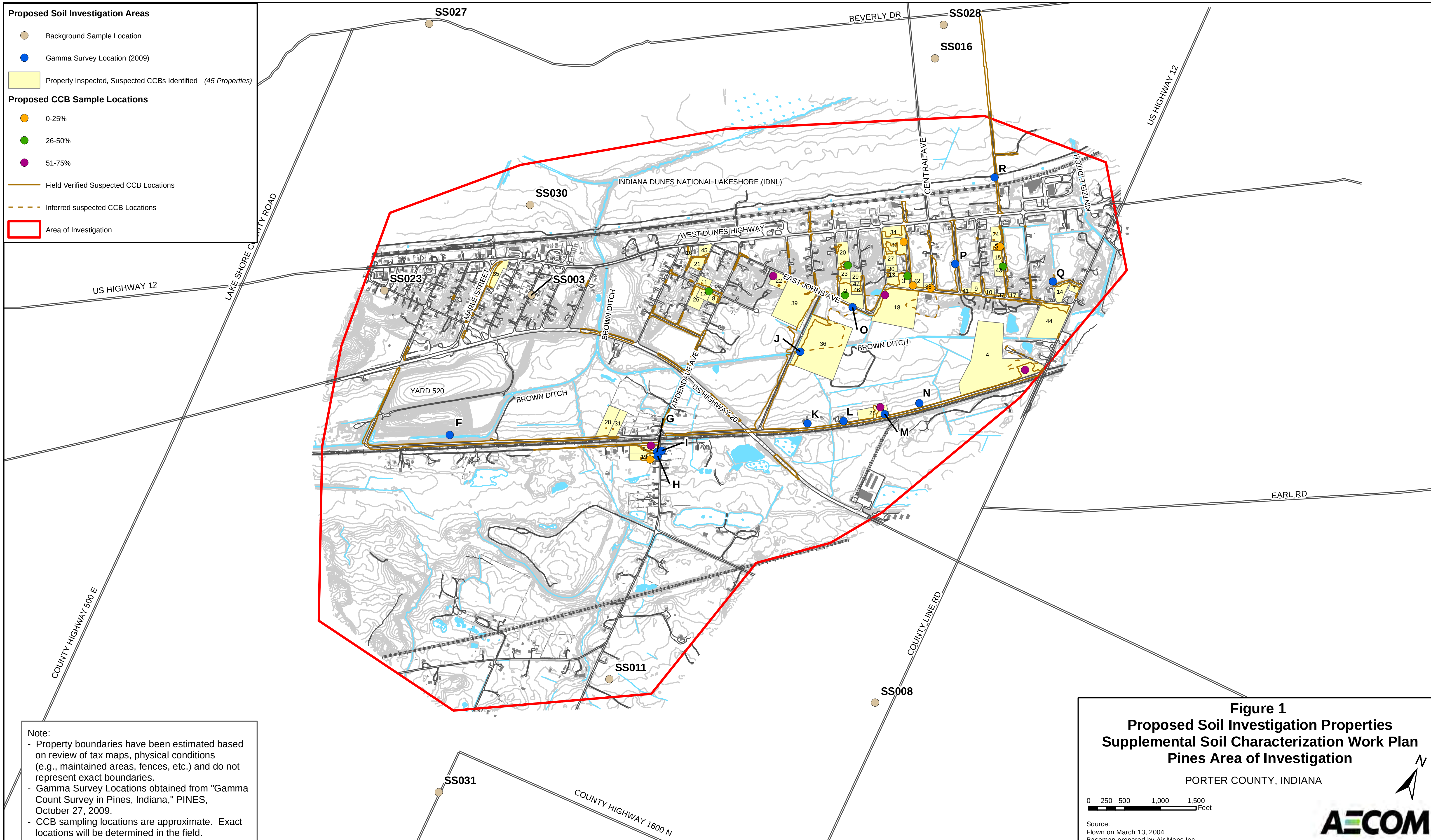
TABLE 5
PROPOSED CCB SAMPLE LOCATIONS
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

	Percent Category Based on CCB Visual Inspections		
Property Number[1]	**0-25%**	**26-50%**	**51-75%**
1		X	
2		X	
3		X	
4			X
5	X		
6			X
12		X	
18			X
19	X		
22			X
25			X
33	X		
38	X		
42	X		
43		X	

Notes:

1 - Property number is the same as the property numbers used for the CCB visual inspections. See Table 3.

Figures



Proposed Soil Investigation Areas

- Background Sample Location
- Gamma Survey Location (2009)
- Property Inspected, Suspected CCBs Identified *(45 Properties)*

Proposed CCB Sample Locations

- 0-25%
- 26-50%
- 51-75%
- Field Verified Suspected CCB Locations
- Inferred suspected CCB Locations
- Area of Investigation

Note:
- Property boundaries have been estimated based on review of tax maps, physical conditions (e.g., maintained areas, fences, etc.) and do not represent exact boundaries.
- Gamma Survey Locations obtained from "Gamma Count Survey in Pines, Indiana," PINES, October 27, 2009.
- CCB sampling locations are approximate. Exact locations will be determined in the field.

Figure 1
Proposed Soil Investigation Properties
Supplemental Soil Characterization Work Plan
Pines Area of Investigation

PORTER COUNTY, INDIANA

0 250 500 1,000 1,500 Feet

Source:
Flown on March 13, 2004
Basemap prepared by Air Maps Inc.

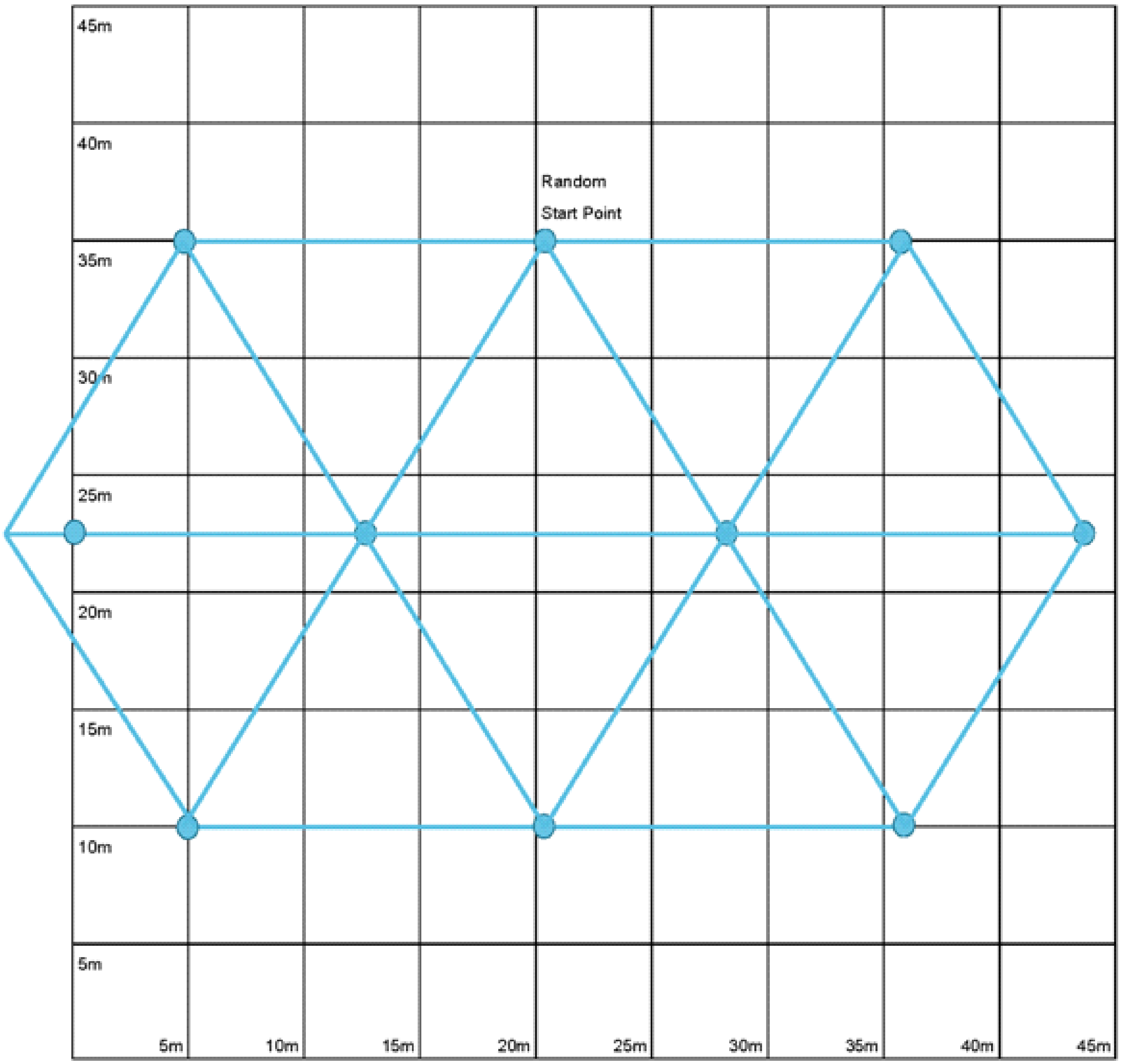


Figure 2
Example Dose Rate Survey Unit
Supplemental Soil Characterization Work Plan
Pines Area of Investigation

PORTER COUNTY, INDIANA

AECOM

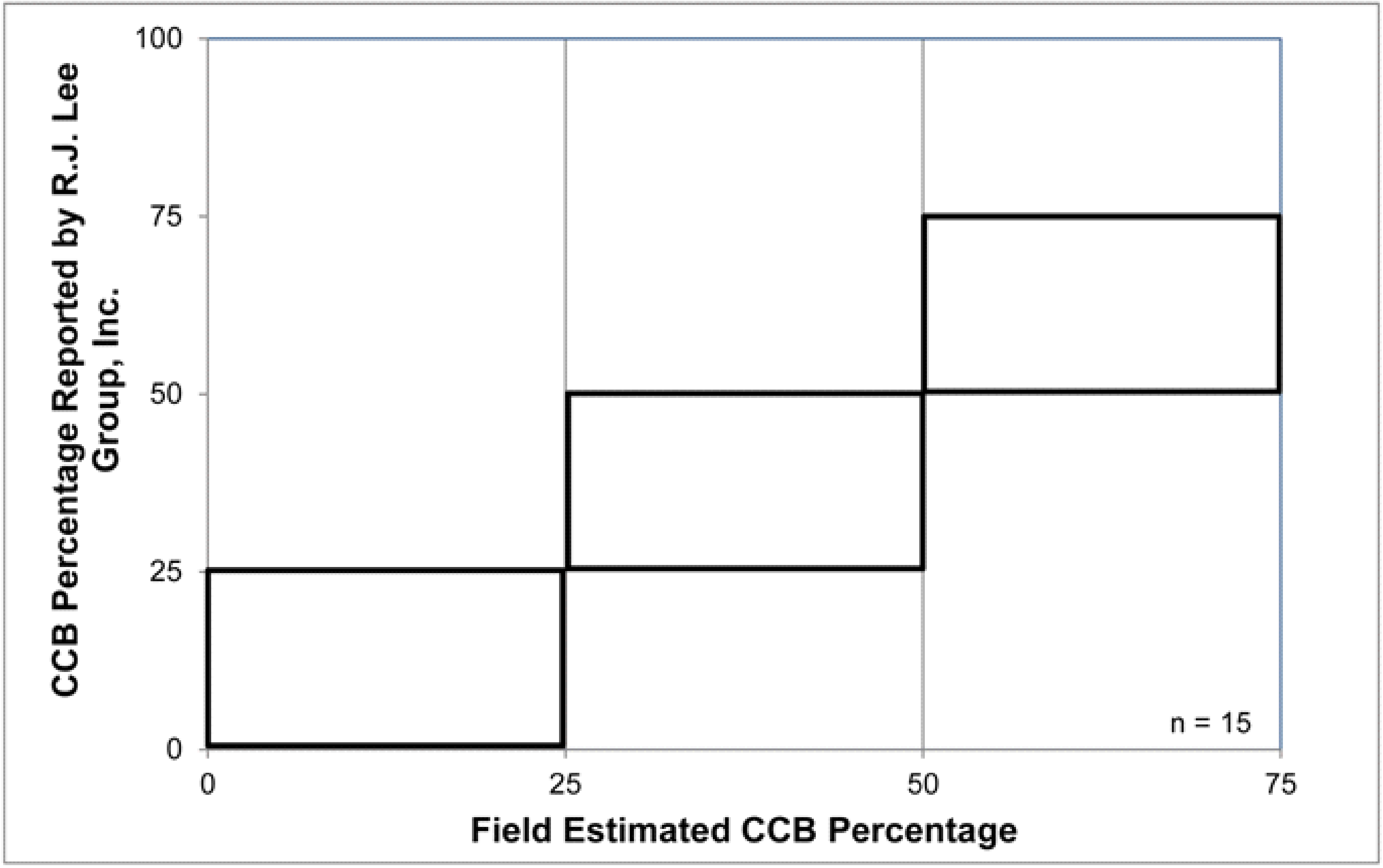


Figure 3
Example Plot of Laboratory Reported CCB Percentage Versus Field Estimated CCB Percentage
Supplemental Soil Characterization Work Plan
Pines Area of Investigation

PORTER COUNTY, INDIANA

AECOM

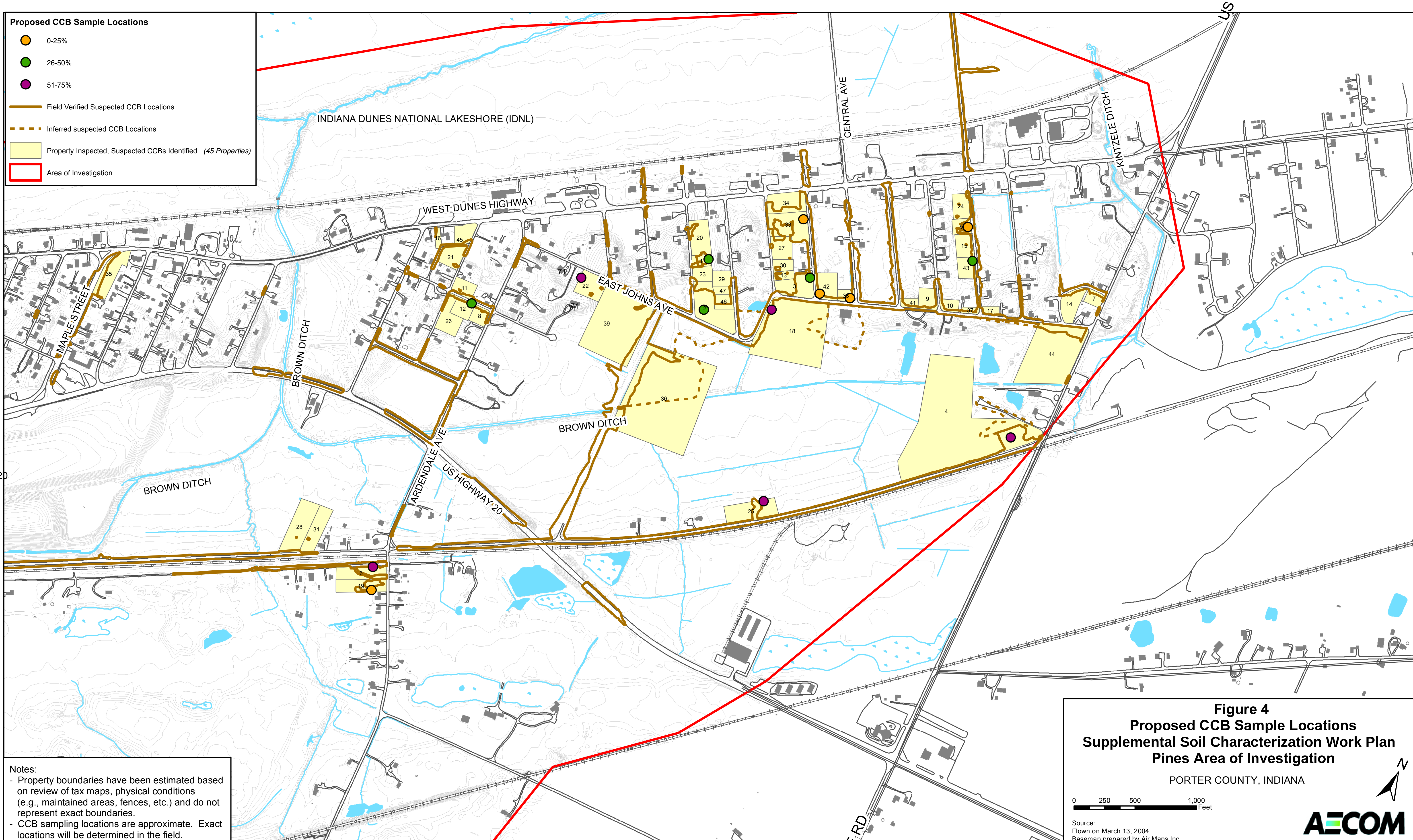
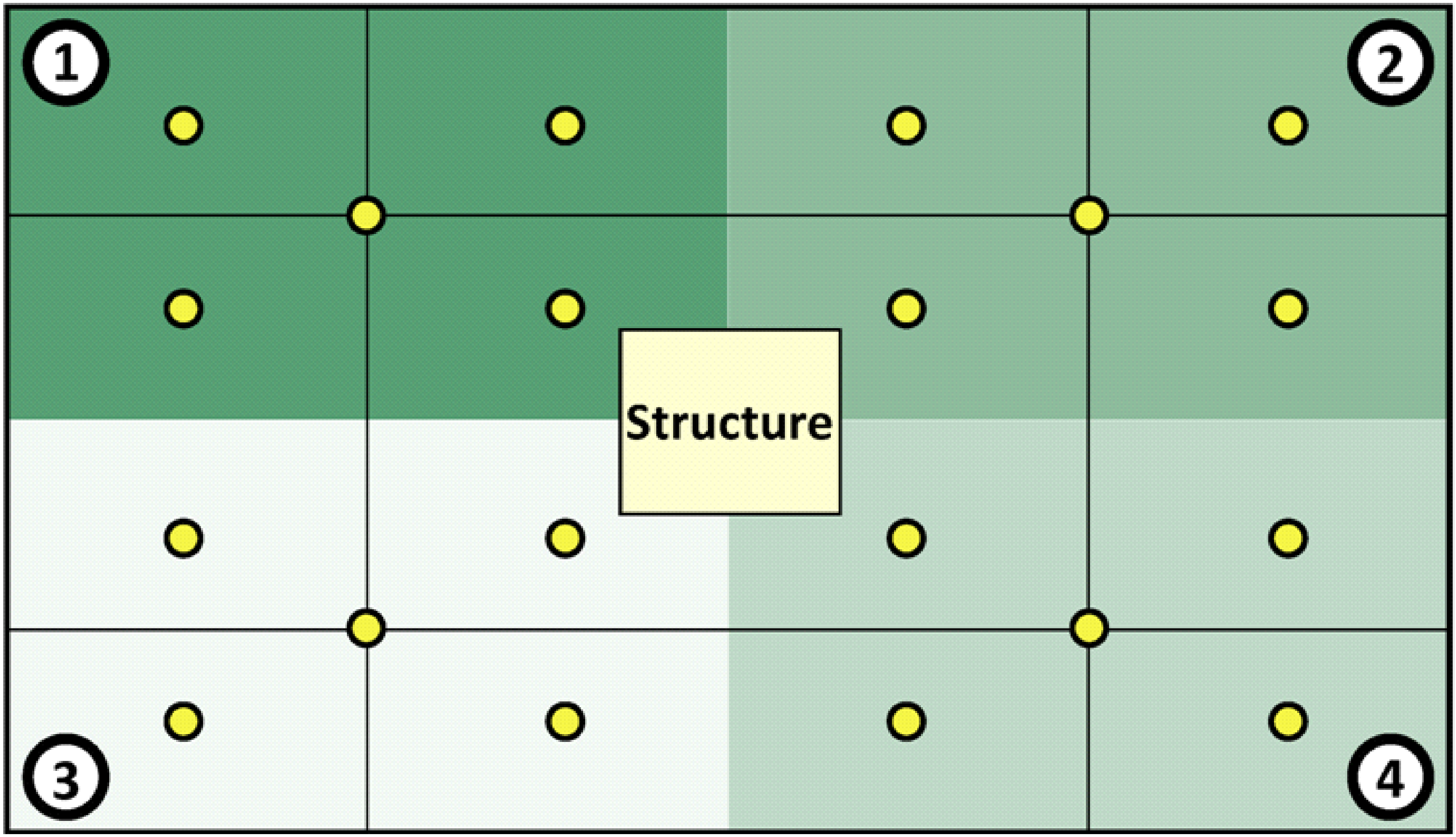


Figure 4
Proposed CCB Sample Locations
Supplemental Soil Characterization Work Plan
Pines Area of Investigation
PORTER COUNTY, INDIANA



Quadrants 1 through 4
- Each quandrant has five sample locations.
- Each sample locations will take samples at 3 depth intervals:
  - 0 to 6 inches
  - 6 to 18 inches
  - 18 inches to 5 feet (or the maximum depth possible, if less than 5 feet)
- Each quadrant will ultimately have one sample per sample depth. The five individual samples within each quadrant will be composited to one representative sample for each depth interval.
- Locations may be adjusted based on field conditions.

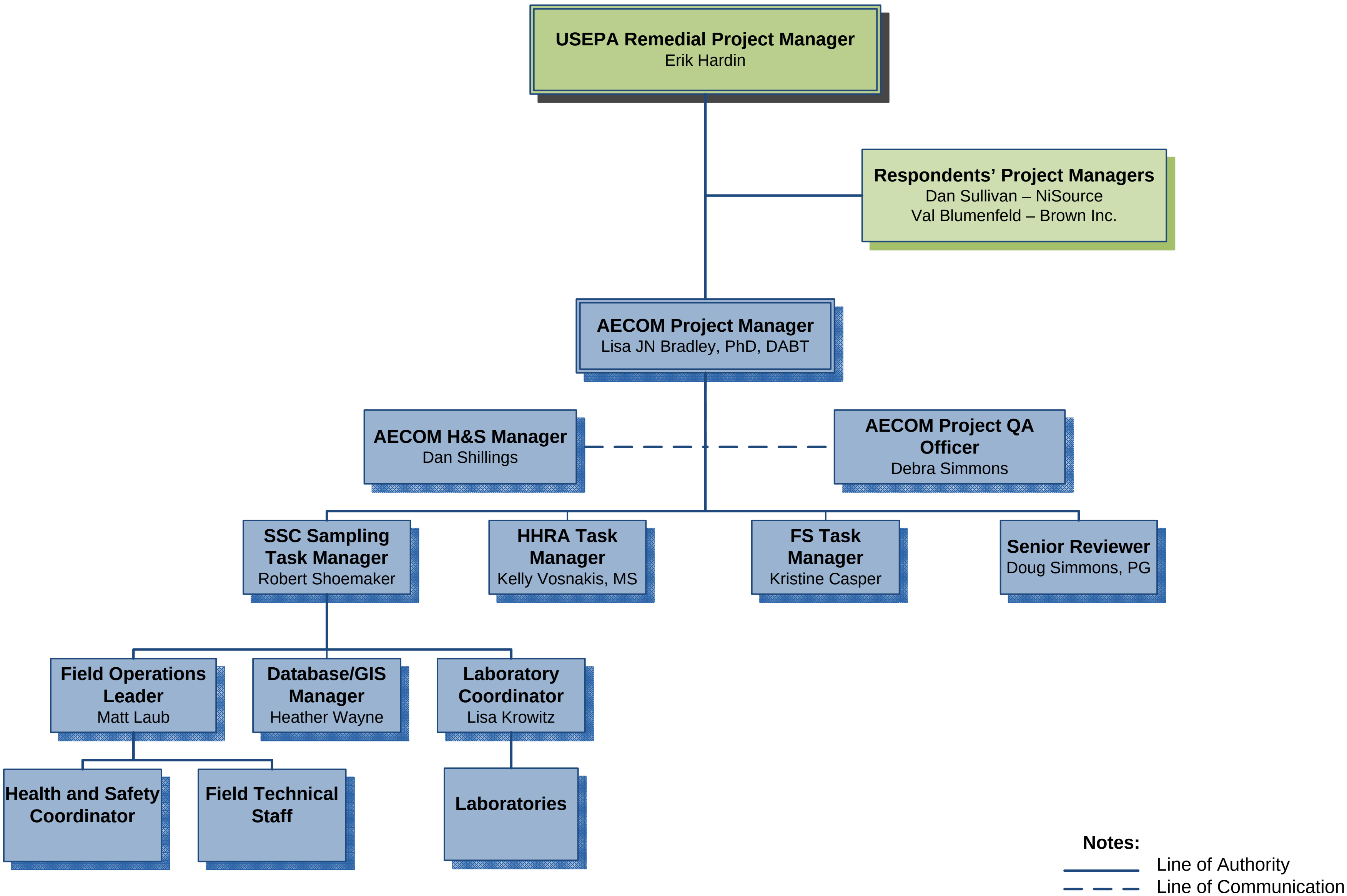
Sample Location

Figure 5
Generalized Property Sampling Plan
Assuming Four Quadrants
Supplemental Soil Characterization Work Plan
Pines Area of Investigation

PORTER COUNTY, INDIANA

AECOM

Figure 6
Project Organization Chart
Supplemental Soil Characterization Work Plan
Pines Area of Investigations



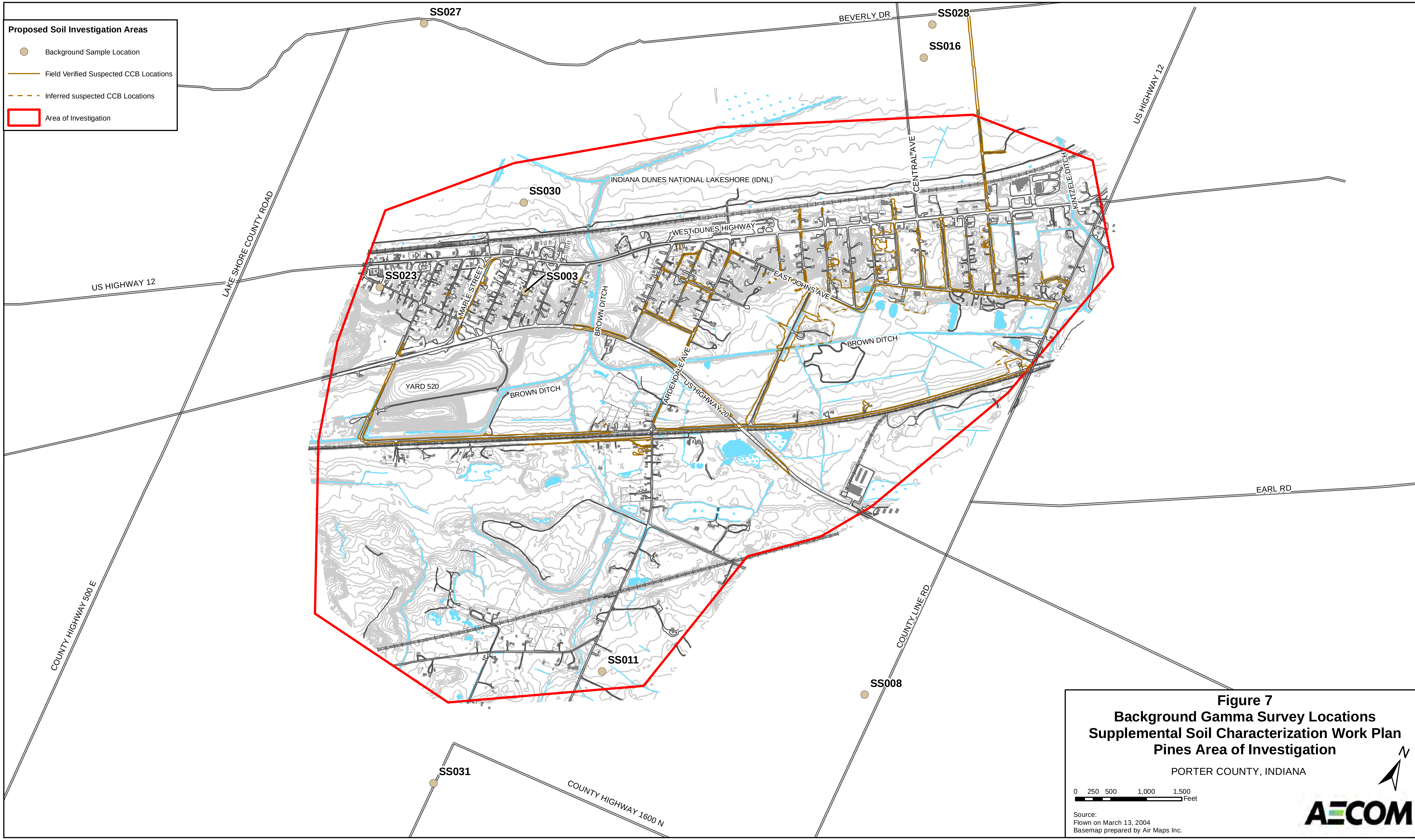


Figure 7
Background Gamma Survey Locations
Supplemental Soil Characterization Work Plan
Pines Area of Investigation

PORTER COUNTY, INDIANA

Source:
Flown on March 13, 2004
Basemap prepared by Air Maps Inc.

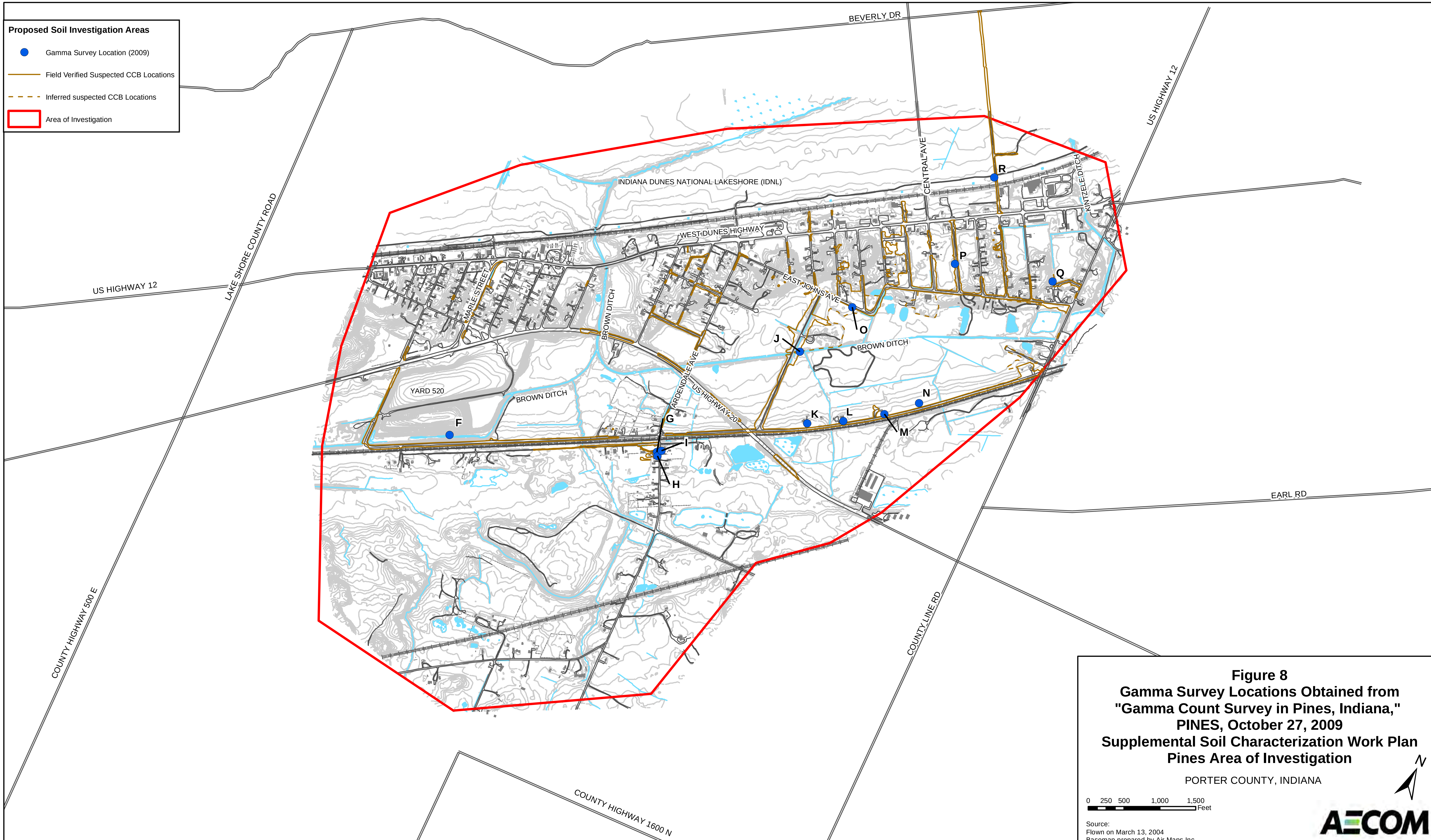


Figure 8
Gamma Survey Locations Obtained from "Gamma Count Survey in Pines, Indiana," PINES, October 27, 2009
Supplemental Soil Characterization Work Plan
Pines Area of Investigation

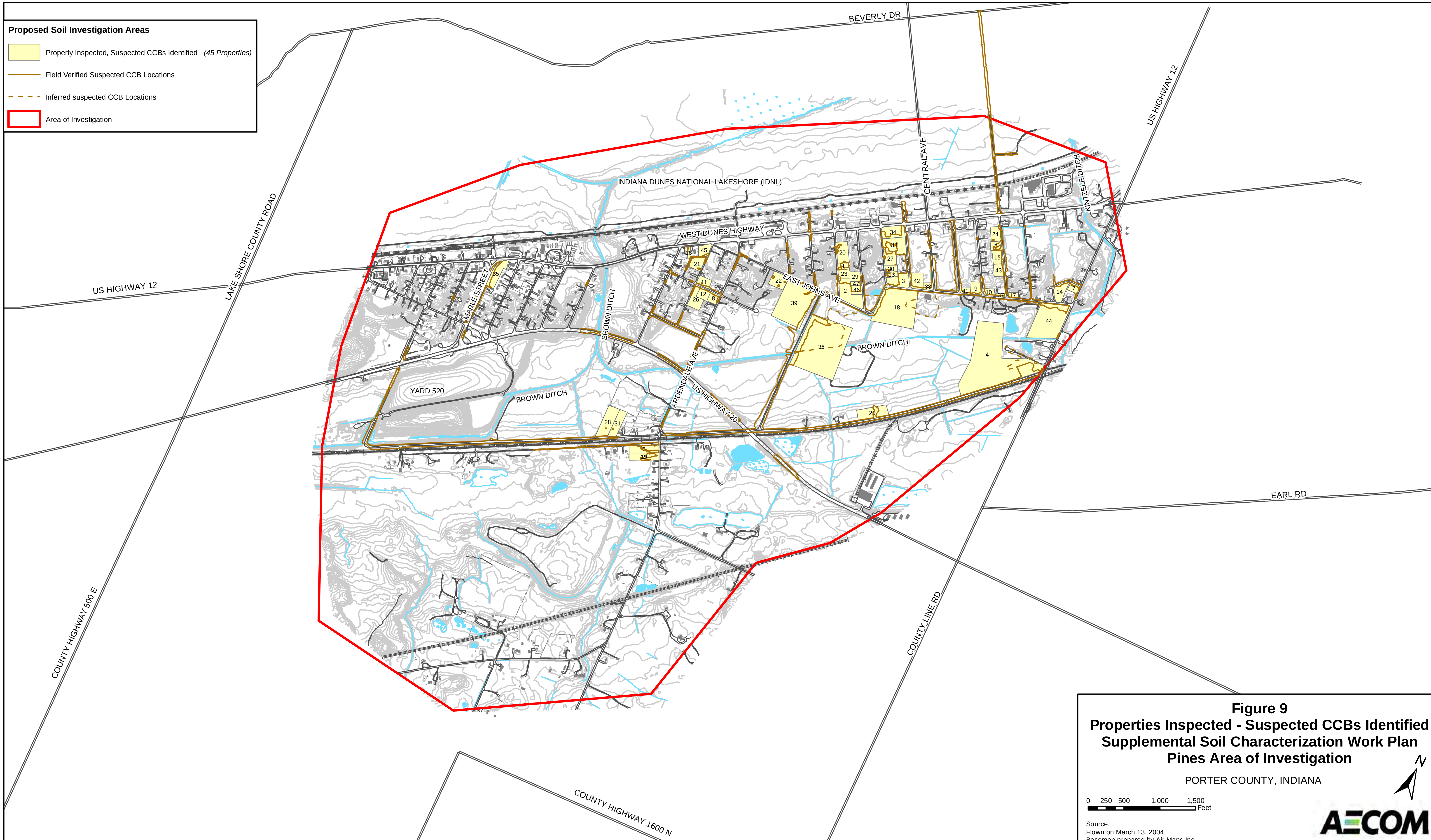


Figure 9
Properties Inspected - Suspected CCBs Identified
Supplemental Soil Characterization Work Plan
Pines Area of Investigation

PORTER COUNTY, INDIANA

Appendix A

Statistical Property Number Determination

Appendix A

Calculations of Representative Number of Properties to Sample

As discussed in Section 1.3.4 of the Supplemental Soil Characterization (SSC) Work Plan, the data from the gamma surveys and the coal combustion by-product (CCB) verification studies will be compiled and evaluated to aid in the identification of appropriate properties for soil sampling. A statistical procedure has been used to determine the number of properties to sample in order to provide a representative subset, as described in this appendix.

<u>Approach</u>

While there are numerous statistical methods available to estimate sample sizes, most are not directly applicable to the circumstances of this plan. For example, most methods assume an infinite number of possible samples rather than being designed to select a subset from a fixed, finite population (the total number of properties in this case). There are also a number of methods that estimate sample size based on cost constraints. The method used here is based on stratified sampling, and was one of the few methods based on a finite population that was identified (U. S. Environmental Protection Agency (USEPA), 2002).

The number of properties based on stratified sampling is dependent on the statistical characteristics (for example mean and standard deviation) of the parameter being measured, in this case, concentrations of constituents of potential concern (COPCs) as identified in the Human Health Risk Assessment (AECOM, 2012). Since the statistical characteristics can be different for different parameters, the calculated number of properties can also be different. The statistical calculations were conducted using those COPCs for which detected results were available, and for which the maximum detected concentration was above the site-specific Preliminary Remediation Goals (PRGs) developed for the project (see Table 1 of the main text of the SSC Work Plan). Therefore, statistical calculations were performed using the following constituents:

- Arsenic
- Iron
- Thallium
- Lead-210
- Radium-226
- Radium-228
- Uranium-238

The following constituents, while identified as COPCs, were not included in the statistical calculations because their concentrations in all the municipal water service extension (MWSE) samples were below site-specific PRGs: aluminum, chromium (total), cobalt, thorium-228, thorium-230, thorium-232, uranium-234, uranium-235, and vanadium. Hexavalent chromium is also a COPC, but it was not included in the statistical calculations because the concentrations in all the MWSE samples were nondetect.

<u>Methodology and Calculations</u>

Equations for estimating sample sizes for stratified sampling designs were taken from USEPA guidance QA/G-5S: Guidance for Choosing a Sampling Design for Environmental Data

Collection (USEPA, 2002). For stratified sampling, the population or area to be sampled is divided into groups (strata) that have different characteristics with the end goal of calculating a mean per group. Examples of strata include land use characteristics (industrial/commercial, urban, agricultural, forest, etc.). Although the sampling program is not designed to calculate an overall mean across properties, the results are still usable as described in the Results section below, and are generally consistent with results based on the only other statistical method that was found to use a finite population: item sampling with judgemental samples.

For the purposes of the SSC Work Plan, there are a total of 94 private properties that were identified as potentially having coal combustion by-products (CCBs) based on visual inspections in rights-of-ways and other historical information. Of these properties, CCBs were confirmed through visual inspections on 45 properties. CCBs were confirmed not present on 27 properties, and access was not granted on 22 properties. Thus, the 94 properties can be divided into two strata: properties where CCBs were confirmed not present (27), and properties where CCBs were confirmed present or may be present but were not inspected (45+22=67).

USEPA guidance (USEPA, 2002) provides equations for calculating the number of samples (in this case, number of properties) in each stratum to provide a representative sampling subset:

$$n = \frac{z^2_{1-\frac{\alpha}{2}}\left(\frac{\sum_{h=1}^{L} W_h s_h^2}{d}\right)}{1+z^2_{1-\frac{\alpha}{2}}\left(\frac{W_h s_h^2}{d^2 N}\right)}$$

Where
$d = margin\ of\ error$
$L = number\ of\ strata$
$n = number\ of\ properties\ to\ be\ sampled$
$N = total\ number\ of\ properties\ across\ all\ strata$
$s_h = prior\ known\ standard\ devation\ in\ concentrations\ in\ strata\ 1\ through\ h$
$Z_{1-\frac{\alpha}{2}} =\ cumulative\ normal\ distribution\ with\ probability\ of\ 1-\frac{\alpha}{2}$
$W_h = \frac{number\ of\ properties\ in\ strata}{number\ of\ properites\ across\ all\ strata}\quad in\ strata\ 1\ through\ h$

For this project, there are a total of 94 properties (N) divided into two strata (L). The first stratum will be called “Group 1” and consists of the 67 properties where CCBs were confirmed or may be present. Group 2 consists of the 27 properties where CCBs were confirmed to not be present. The concentrations of the parameters in Group 1 are based on the concentrations in the MWSE samples (Table A-2), representing the presence of CCBs. Concentrations in Group 2 are based on background soil samples (Table A-3), representing background locations where no CCBs are present. The standard deviations were calculated from the concentrations of these previously-obtained samples. The calculations were performed at the 95% confidence level (α=0.05).

Table A-1 presents the inputs to the calculations for arsenic, iron, thallium, lead-210, radium-226, radium-228, and uranium-238. Standard deviations were calculated on either straight concentrations or log transformed concentrations based on the distribution of concentrations. Non-detect values were included in the calculations using a surrogate value of the reporting limit. Concentration distributions were evaluated using the Shapiro Wilk Test in Stata/IC 11.0 (Stata Corporation, 2009). The probabilities associated with the Shapiro Wilk Tests are show in Table A-4. If the probability associated with the Shapiro Wilk test on log transformed concentrations was greater than 0.05 for both Groups 1 and 2, then both groups were treated as lognormally-distributed, and the standard deviation was calculated using log transformed concentrations for both Groups 1 and 2. This was the case for arsenic, lead-210, radium-226, and radium-228. None of the parameters were normally-distributed for both groups. Of the remaining three parameters, iron concentrations were lognormally-distributed in Group 1 and normally-distributed in Group 2; thallium was neither normally nor lognormally-distributed in both groups; and uranium-238 concentrations were lognormally-distributed in Group 1 and neither normally nor lognormally-distributed in Group 2. Therefore, the standard deviations for these parameters were calculated using both log transformed concentrations and straight concentrations, and the equation for calculating number of samples was run twice. Calculated results (i.e., the number of properties to be sampled) were typically not integers, so the result was rounded up to the nearest integer, representing the number of properties to be sampled (for example, a result of 7.02 for arsenic was rounded up to 8 properties).

Results

The results of the calculations for the number of properties based on concentrations of arsenic, iron, thallium, lead-210, radium-226, radium-228, and uranium-238 are summarized in Table A-5. The appropriate number of properties to sample ranges from 5 to 10. For iron, thallium, and uranium-238 the calculated number of samples based on straight and log transformed concentrations were similar.

The statistical method for stratified sampling used here and outlined in the USEPA guidance (USEPA, 2002), is based on the assumption that calculated number of samples (in this case, properties) would be divided between the two strata, and would be randomly selected within each strata. However, to be conservative, the sampling plan proposes that all properties be selected from Group 1, that is, properties where CCBs are confirmed or may be present, and that the specific properties be selected not randomly, but based on criteria such as the results of the gamma surveys and CCB visual inspections as described in the SSC Work Plan.

Although the statistical method based on stratified sampling is intended to calculate a mean concentration, the sampling to be conducted is judgemental and biased to evaluate likely worst-case situations, that is, properties most likely to have the greatest human health risks posed by CCBs. If the calculated number of properties is sufficient to calculate the means of each group, then the same number of properties selected from only one of the groups is more than sufficient to estimate worst-case conditions for that group.

The number of properties (9) selected for judgemental sampling was also run through the algorithm for item sampling with judgemental samples in the visual sample plan (VSP) from Pacific Northwest National Laboratory (VSP Development Team, 2014). Item sampling with judgemental samples is another method based on a finite population. The number of properties calculated from item sampling with judgemental samples indicates that nine judgemental properties are sufficient to characterize the properties where CCBs have been observed. In fact, using inputs based on best professional judgement, the number of properties based on item sampling with judgemental samples in the VSP indicates that three judgement properties would be sufficient. These results are generally consistent with those from the statistical procedure based on stratified sampling that is used in this appendix.

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References:

AECOM. 2012. Human Health Risk Assessment (HHRA). Pines Area of Investigation. July 2012.

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USEPA. 2002. Guidance on Choosing a Sampling Design for Environmental Data Collection for Use in Developing a Quality Assurance Project Plan. EPA QA/G-5S.

VSP Development Team, 2014. Visual Sample Plan: A Tool for Design and Analysis of Environmental Sampling. Version 6.5. Pacific Northwest National Laboratory. Richland, WA. http://vsp.pnnl.gov

Tables

Table A-1: Inputs Used To Calculate Optimal Number of Properties to Sample

Parameter	Arsenic (Log Transformed)	Iron	Iron (Log Transformed)	Thallium	Thallium (Log Transformed)	Lead-210 (Log Transformed)	Radium-226 (Log Transformed)	Radium-228 (Log Transformed)	Uranium- 238	Uranium-238 (Log Transformed)
N (Number of Properties Across Groups)	94	94	94	94	94	94	94	94	94	94
Number of Properties in Group 1 (Inspections Conducted, CCBs Suspected/ No Access Granted)	67	67	67	67	67	67	67	67	67	67
Number of Properties in Group 2 (Inspections Conducted, CCBs Not Identified)	27	27	27	27	27	27	27	27	27	27
s_1^2 (s_1 = Standard Deviation of Concentrations in Group 1)	0.57	782058552	0.29	1.49	0.69	0.08	0.15	0.15	0.83	0.34
s_2^2 (s_2 = Standard Deviation in Concentrations in Group 2)	1.05	179549286	0.83	0.42	0.30	0.90	0.31	0.320	0.77	0.63
α (statistical significance level)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$Z_{1-\alpha/2}$ (Cumulative Normal Distribution With Probability of 1-α/2)	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98
Preliminary Remediation Goal	30.1	76,436	76,436	1.35	1.35	8.44	0.975	1.17	4.5	4.5
d (Desired Margin of Error)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
$W_h s_h^2$ added for Groups 1 through h	0.71	608997380.20	0.45	1.18	0.58	0.32	0.19	0.20	0.81	0.42

Table A-2: MWSE CCB Samples Used To Calculate Standard Deviation in Group 1

Location	Sample	Date
Metals Samples		
TP001	TP001BCB091004S	9/10/04
TP002	TP002BCB091004S	9/10/04
TP003	TP003BCB091004S	9/10/04
TP004	TP004BCB091304S	9/13/04
TP005	TP005BCB091304S	9/13/04
TP006	TP006BCB091304S	9/13/04
TP008	TP008BCB092204S	9/22/04
TP009	TP009BCB092204S	9/22/04
TP010 *	TP010BCB092204D	9/22/04
TP010	TP010BCB092204S	9/22/04
TP011	TP011BCB092204S	9/22/04
TP012	TP012BCB092204S	9/22/04
TP013	TP013BCB092404S	9/24/04
TP014	TP014BCB092404S	9/24/04
TP015	TP015ECB100104S	10/1/04
TP016	TP016ECB100104S	10/1/04
TP017	TP017BCB100104S	10/1/04
TP018	TP018BCB100104S	10/1/04
TP019	TP019BCB100104S	10/1/04
TP020 *	TP020CCB100604D	10/6/04
TP020	TP020CCB100604S	10/6/04
TP021	TP021CCB100604S	10/6/04
TP022	TP022BCB100604S	10/6/04
TP023	TP023ACB100604S	10/6/04
TP026	TP026CCB112904S	11/29/04
TP027	TP027CCB112904S	11/29/04
TP028	TP028CCB112904S	11/29/04
TP033	TP033CCB032305S	3/23/05
TP034 *	TP034CCB032305D	3/23/05
TP034	TP034CCB032305S	3/23/05
TP035	TP035CCB032305S	3/23/05
TP036	TP036CCB032305S	3/23/05
TP037	TP037ACB032305S	3/23/05
TP039	TP039CCB082405S	8/24/05
TP040	TP040ACB082405S	8/24/05
TP041	TP041ACB082405S	8/24/05
TP042	TP042BCB082405S	8/24/05

Location	Sample	Date
Radionuclide Samples		
TP002	TP002XCB040908S	9/10/04
TP004	TP004XCB040908S	9/13/04
TP011	TP011XCB040908S	9/22/04
TP012	TP012XCB040908S	9/22/04
TP014	TP014XCB040908S	9/24/04
TP018	TP018XCB040908S	10/1/04
TP020	TP020XCB040908S	10/6/04
TP026	TP026XCB040908S	11/29/04
TP035	TP035XCB040908S	3/23/05
TP041 *	TP041XCB040908D	8/24/05
TP041	TP041XCB040908S	8/24/05

*Duplicate sample. Results were averaged with parent sample and treated as one sample for calculation of standard deviation. All samples were not necessarily analyzed for all parameters.

Table A-3: CCB-Free Background Samples Used To Calculate Standard Deviation in Group 2

Location	Sample*	Sample Date
SS003	SS003ASS111512S	11/15/2012
SS005	SS005ASS110212S	11/2/2012
SS008	SS008ASS111512S	11/15/2012
SS011	SS011ASS111512S	11/15/2012
SS012	SS012ASS111512S	11/15/2012
SS014	SS014ASS050107S	5/1/2007
SS015	SS015ASS111512S	11/15/2012
SS016	SS016ASS043007S	4/30/2007
SS017	SS017ASS050107S	5/1/2007
SS018	SS018ASS050107S	5/1/2007
SS023	SS023ASS110212S	11/2/2012
SS026	SS026ASS110212S	11/2/2012
SS027	SS027ASS110212S	11/2/2012
SS028	SS028ASS110212S	11/2/2012
SS029	SS029ASS110212S	11/2/2012
SS030	SS030ASS110212S	11/2/2012
SS030*	SS030ASS110212D	11/2/2012
SS031	SS031ASS110212S	11/2/2012
SS033	SS033ASS110212S	11/2/2012
SS034	SS034ASS110212S	11/2/2012
SS034*	SS034ASS110212D	11/2/2012
SS035	SS035ASS110212S	11/2/2012
SS038	SS038ASS111512S	11/15/2012
SS040	SS040ASS111512S	11/15/2012

*Duplicate sample. Results were averaged with parent sample and treated as one sample for calculation of standard deviation.

Table A-4: Probabilities Associated with Shapiro Wilk Test For Normality on Concentrations Used for Calculations of Known Standard Deviation in Groups 1 and 2

Parameter	Shapiro Wilk Test Probability for Group 1	Shapiro Wilk Test Probability for Group 2
Arsenic	0.00002	0.00002
Log Transformed Arsenic	0.99276	0.36363
Iron	0.588827	0.00024
Log Transformed Iron	0.00001	0.08677
Thallium	0.00003	0.00005
Log Transformed Thallium	0.0309	0.00133
Pb 210	0.23059	0.00891
Log Transformed Pb 210	0.30244	0.49842
Ra-226	0.41005	0.00472
Log Transformed Ra-226	0.18498	0.29016
Ra-228	0.14234	0.00059
Log Transformed Ra-228	0.07371	0.18821
U-238	0.84429	0.00004
Log Transformed U-238	0.41313	0.02514

Note: A probability >0.05 suggests there is not enough evidence to reject the hypothesis that a dataset is normal.

Table A-5: Results of Optimal Number of Property Calculations

Parameter	Number of Properties To Be Sampled
Arsenic (Log Transformed)	8
Iron	10
Iron (Log Transformed)	7
Thallium	8
Thallium (Log Transformed)	7
Lead-210 (Log Transformed)	6
Radium-226 (Log Transformed)	5
Radium-228 (Log Transformed)	5
Uranium-238	8
Uranium-238 (Log Transformed)	6

Appendix C

Field Standard Operating Procedures

Radiological Service Technical Practice Group Standard Operating Procedure	PROCEDURE NO. RS-TPG, SOP 001 DATE: March 20, 2014 APPROVED:
Portable Detection Equipment	Radiological Service TPG Leader

Standard Operating Procedure

PORTABLE DETECTION EQUIPMENT

AECOM's Radiological Service Technical Practice Group (RS-TPG) is responsible for the issuance, revision, and maintenance of this policy. This procedure has also been provided to the South Carolina Department of Health and Environmental Control (SC DHEC) as part of AECOM's "decommissioning license" application. Therefore, any deviations from the procedures set forth in this document require approval of the RS-TPG Leader and the SC DHEC license Radiation Safety Officer (RSO). This SOP supersedes all previous SOPs on this topic.

SC DHEC License RSO Approval: ______________________ March 20, 2014

1 PURPOSE

The purpose of this procedure is to provide instruction for operating portable radiation detection instrumentation. For aspects of instrumentation operation not covered in this procedure, refer to the instrument technical manual.

2 SCOPE

This procedure provides guidance for the response and source checks of portable instrumentation and area radiation monitors. Response and source checks are the periodic checks to verify that the instrument is properly functioning within the manufacturer's specifications. Guidance is also provided for removing from service, shipping and receipt of instruments returned from repair and calibration.

3 ALARA POLICY

It is AECOM's policy to plan and conduct its radiological activities safely and in such a fashion as to protect the health and safety of its employees, subcontractors, members of the public, and the environment. To achieve this, AECOM shall confirm that efforts are taken to reduce radiological exposures and releases to the environment as low as is reasonably achievable (ALARA), taking into account social, technical, economic, practical and public policy considerations. AECOM's RS-TPG is committed to implementing this procedure and maintain radiation detection equipment in a manner to reflect this policy.

4 PRECAUTIONS

4.1 When operating a battery powered instrument, the batteries shall be checked each time the instrument is used and batteries changed when required.

4.2 Handle instruments with care. Do not drop or allow them to bang against hard surfaces. Use only instruments possessing a current calibration.

4.3 Care should be taken when using thin window detectors (pancake and scintillation detectors) near sharp objects so that the window and detector shall not damaged.

4.4 Slowly enter areas of unknown radiation with instruments on the high scale to avoid off-scale readings and subsequent prolonged recovery time.

4.5 Minimize contact with the surface being surveyed. If lose/removable contamination is present, avoid contact with the surface and check instruments for contamination if contact occurs.

4.6 Occasionally verify instrument is responding properly if background appears outside the expected range.

4.7 When checking instruments, place the source in its holder or center it on the probe as required.

4.8 Carefully pack for shipment any instrument being sent to a facility to be calibrated or repaired to avoid damage in transit.

4.9 Radiation survey instruments and count rate instruments shall be calibrated at least every twelve months, after the instrument is repaired and at the start of each project.

5 PROCEDURE

5.1 Steps Prior to Using Instruments

5.1.1 Calibration Verification

5.1.1.1 All portable radiological instruments shall have a current calibration label.

5.1.1.2 The calibration date will be check daily prior to use of the instrument.

5.1.2 Physical Check

5.1.2.1 Inspect the general physical condition of the instrument and detector prior to each use.

5.1.2.2 Inspect for loose, damaged knobs, buttons, cables, connectors, broken/damaged meter movements/ displays, dented or corroded instrument cases, punctured/deformed probe/probe window(s), cables, etc., and any other physical impairments that may affect the proper operation of the instrument or detector.

5.1.2.3 Any instrument or detector having a questionable physical condition shall not be used until corrected.

5.1.3 Battery Check

5.1.3.1 Check that there is sufficient power being supplied to the detector and instrument circuitry for proper operation.

5.1.3.2 Document the battery check in the daily log or on the Radiological Instrument Daily Source Check Record, Attachment 1.

5.1.3.3 Perform this check in accordance with the instrument's technical manual; although, it is generally performed as follows:

5.1.3.3.1 Position the appropriate selector switch to the "Batt" position or depress the "Batt Check" button with the instrument on.

5.1.3.3.2 Observe the indication for the current battery condition. Typically, the current battery condition will be indicated by a meter deflection into the "Batt OK" region or "Batt OK" on the display, etc.

5.1.3.3.3 If unsatisfactory results are obtained, refer to the technical manual for replacement of the batteries and repeat the check. The instrument shall display a satisfactory battery check prior to use.

5.1.4 High Voltage (HV) Check

5.1.4.1 HV is adjusted appropriately during instrument calibration and does not require adjustment for normal operation.

5.1.4.2 A HV check is required for instruments with an “HV” check button prior to each use as applicable in accordance with the instrument technical manual.

5.1.4.3 Record the HV setting on the Radiological Instrument Daily Source Check Record, Attachment 1.

5.1.4.4 An instrument with suspected HV problems shall be reported to the Project Manager and RSO.

5.1.5 Instrument Source Check (Contamination Detectors)

This check is performed periodically to verify that the instrument will respond accurately to a known source of radiation. Locate the source for the instrument/detector being used and perform the response source check as described in the following.

5.1.5.1 Check the battery condition. If batteries are not in the allowed range, replace the batteries or clean contacts as necessary. If battery check is not satisfactory after corrective actions, then place instrument out of service and send to an authorized calibration facility for repair and calibration.

5.1.5.2 Determine the background radiation level. It must be low enough to allow a measurable response to the check source being used. Careful monitoring of changing background levels is necessary to obtain accurate instrument readings.

5.1.5.3 Perform source checks with appropriate sources. For on-contact readings, verify that the source to probe geometry is reproducible, in direct contact, and facing the probe.

5.1.5.4 Record the source check results on the Radiological Instrument Daily Source Check Record, Attachment 1.

5.1.5.5 Compare the source check counts against the response range calculated in accordance with Section 5.3.7. Instruments with source check responses that responded outside the acceptable range two out of three times will be removed from service and the Project Lead notified.

5.1.6 Daily Response Checks (Dose Rate/Exposure Rate Detectors)

This instrument check is performed to see if the instrument responds to a source of radiation. This is a qualitative check only.

5.1.6.1 Daily response checks of dose/exposure rate survey instruments shall be performed every day when in use. Documentation of these response checks is required.

5.1.6.2 Begin with the instrument on the highest range/scale and enable the audible device, if applicable.

5.1.6.3 Slowly move the detector towards the check source and observe for an increase in audible and/or visual response.

5.1.6.4 Change the range/scale of the instrument as appropriate to obtain a readable indication and to check each of the meter ranges/scales possible. If an appreciable response can not be obtained, even in the lowest range, evaluate instrument performance by comparison to previous source check data for the instrument.

5.1.7 Should the battery, source or response check be unsatisfactory, the instrument shall be removed from service. Record this on the instrument check form, Attachment 1. Send the instrument to an authorized calibration facility for repair and calibration.

5.1.8 When an instrument has reached its calibration due date, the instrument shall be sent to an authorized calibration facility.

5.2 Background Measurement for Scaler Instruments (Initial Setup)

5.2.1 Verify that the background area is free of radioactive sources. The detector geometry should be set up in the same configuration as that to be used when counting samples to produce the most accurate results.

5.2.2 Perform the background measurement for one minute and record the total counts measured (C_b) on the Scaler Instrumentation Background Setup Sheet, Attachment 2.

5.2.3 Repeat the background measurement 9 times, for a total of ten measurements. Record the total counts observed (C_b) for each measurement on the Scaler Instrumentation Background Setup Sheet, Attachment 2.

5.2.4 Calculate the average background counts ($\overline{C}_b$), the standard deviation (SD_b) and average background count rate ($\dot{C}$):

$$\overline{C}_b = \frac{\sum_i^n C_i}{N}$$

$$SD_b = \sqrt{\frac{\sum_i^n \left(C_i - \overline{C}_b\right)^2}{N-1}}$$

$$\dot{C}_b = \frac{\overline{C}_b}{t_b}$$

where:

$\overline{C}_b$ = average background count

SD_b = standard deviation of the average background

N = number of measurements

Σ = summation

C_i = C_1 through C_n (C_{10} if 10 measurements are made)

$\dot{C}_b$ = average net background count rate

t_b = time in minutes of a background count

5.2.5 Record the average background counts ($\overline{C}_b$), the standard deviation (SD_b), and the average background count rate ($\dot{C}_b$) on the Scaler Instrumentation Background Setup Sheet, Attachment 2.

5.2.6 Calculate the limits for background and record on Attachment 3, Scaler Instrumentation Efficiency Sheet.

High limit $\dot{C}_b + 2SD_b$

Low limit $\dot{C}_b - 2\ SD_b$ (if less than 0, record 0)

5.3 Instrument Efficiency for Scaler Instruments (E)

Efficiency is a quantitative measure of detector performance for a particular radioisotope. It provides the necessary relationship between counts per minute (cpm) as seen by the detector and disintegrations per minute (dpm) from source decay. Determine detector efficiency with a source of known activity of the nuclide (or of a nuclide with similar energy decay products) being monitored for as follows:

5.3.1 Correct source activity for decay as follows: (if necessary)

$$A = A_o e^{-\lambda T}$$

$$Where:\ \lambda = \frac{0.693}{t_{1/2}}$$

where: A = present source activity.

A_o = source activity at initial assay.

λ = decay constant for the source isotope.

T = time elapsed since initial source assay*

$t_{1/2}$ = source isotope half-life

*Time units must be consistent (days, hrs., or min., etc.)

5.3.2 Correct source activity for backscatter: (if necessary)

$$A_c = A(1+B_s)$$

where: A_c = corrected activity (dpm)

A = present source activity.

B_s = percent backscatter (expressed as a decimal, i.e., 50% = 0.50 taken from source calibration sheet); $(1+B_s)$ can be found on page 127 of the Radiological Health Handbook.

5.3.3 Determine expiration date of source check limits by adding to the current date the value derived from dividing the $t_{1/2}$ of the source by 15. The limits will need to be recalculated in accordance with this section (5.4) after the expiration date.

Current date + ($t_{1/2}$)/15 (of source) = Expiration date

If this date is later than the calibration due date record calibration due date as expiration date.

5.3.4 Count the source ten times (one minute each) and calculate the standard deviation (SD_n). Record the total counts measured (C_i) on the Instrument Efficiency Determination form, Attachment 3:

$$SD_g = \frac{\sqrt{\sum_i^{10} \left(C_i - \overline{C}_g\right)^2}}{N-1} = \sqrt{\frac{SS}{N-1}}$$

where: SS = sum of squares

$$SD_n = \sqrt{\left(SD_g\right)^2 + \left(SD_b\right)^2}$$

C_i = gross counts (source counts including background for a single count)
Σ = summation
N = number of measurements
SD_n = standard deviation of the average net counts.
SD_g = standard deviation of the average gross counts
SD_b = standard deviation of the average background counts (obtained from section 5.2)

Record the ten gross counts (C_g) and the standard deviations (SD_n and SD_g) on the Scaler Instrumentation Efficiency Sheet, Attachment 3.

5.3.5 Calculate the net count rate ($\dot{C}_n$):

$$\dot{C}_g = \frac{\overline{C}}{t_g}$$

$$\dot{C}_n = \dot{C}_g - \dot{C}_b$$

where: $\dot{C}_g$ = average gross count rate
$\overline{C}_g$ = average gross counts
t_g = time in minutes of a source count

C_b = average background count rate (obtain from Section 5.2)

Record on Attachment 3.

5.3.6 Calculate the detector efficiency (E) for the radioactive standard which equals of best approximates the potential contamination source as follows:

$$E = \frac{\dot{C}_n}{A_c} = \frac{cpm}{dpm}$$

where: $\dot{C}_n$ = average net cpm

A_c = corrected activity (dpm).

Record on Attachment 3.

5.3.7 Calculate the limits for source checks and record on Attachment 3.

High limit $\dot{C}_n$ + 2 SD_n

Low limit $\dot{C}_n$ - 2 SD_n

5.4 Estimated Minimum Detectable Concentration (MDC) for Scaler Instruments

5.4.1 The estimated minimum detectable activity is determined to verify that the detector being used will detect the presence of activity at or above the allowable limit under a given set of counting conditions. MDC is based on the estimated detection limit in counts (L_D) and detector efficiency. Determine the estimated L_D and MDC as follows:

$$L_D = k^2 + 2k\sqrt{B}$$

$$L_D = 3 + 4.65\sqrt{B}$$

Where:

k = Poisson probability sum for α and β (assuming a and b are equal) = 1.645 for α and β both equal to 0.05 (95% confidence level)

B = number of background counts expect while performing the measurement (background rate x sample count time)

5.4.2 Record the calculated L_D on the Minimum Detectable Concentration Calculation form, Attachment 4.

5.4.3 Calculate the estimated MDC (in dpm/100 cm^2). For instances when the background and sample count time are the same:

$$MDC = \frac{L_D}{E \times A/100 \times t_b}$$

For instances when the background count time and the sample count time are different:

$$MDC = \frac{3 + 3.29\sqrt{C_b t_s \left(1 + \frac{t_s}{t_b}\right)}}{E \times t_s x \frac{A}{100}}$$

Where:

E = total detector 2-pi efficiency (in cpm/dpm) (from Section 5.3.6)

A = detector probe area (in cm^2)

t_s = sample count time

t_b = background count time

5.4.4 Record the calculated MDC in on Attachment 4.

5.5 Control Charts

5.5.1 Control charts should be used by the health physics technician to monitor for shifts, trends, or increases in variability. They are used as guides to indicate the need for investigative action, rather than for evaluating precise values.

5.5.1.1 The cpm for each background check should be plotted on a control chart with high and low limits.

5.5.1.2 The net cpm for each source check should be plotted on a control chart with high and low limits.

5.6 Calibration

Instruments used for monitoring and contamination control shall be:

- Periodically maintained and calibrated on an established frequency of at least once per year;
- Appropriate for the type(s), levels, and energies of the radiation(s) encountered;
- Appropriate for existing environmental conditions; and
- Routinely tested for operability.

5.6.1 Radiological instruments shall be used only to measure the radiation for which their calibrations are valid.

5.6.2 The ANSI N323 method for radiological instrumentation calibration will be adhered to.

5.6.3 Calibrations shall use National Institute of Standards and Technology (NIST) traceable sources.

5.6.4 Calibration records shall be maintained on-site and in an electronic project file.

5.6.5 Pocket and electronic dosimeters and area radiation monitors should be calibrated at least annually.

5.6.6 The effects of environmental conditions, including interfering radiation has on an instrument shall be known prior to use.

5.6.7 Functional tests should be used to assess instrumentation designs that include alarms or that involve a process control.

5.6.8 A functional test should be developed to test all components involved in an alarm or trip function and performed at least annually.

5.6.9 Special calibrations should be performed for use of instrumentation outside manufacturer's specifications.

5.6.10 The instrument should be adjusted, calibrated and labeled to identify the special conditions and used only under the special conditions for which it was calibrated.

5.6.11 Instruments should bear a label or tag with the date of calibration and date calibration expires.

5.6.12 For AECOM-owned instruments, the calibration will be performed by a vendor appropriately licensed by the NRC or an Agreement State. Calibrations will be performed at least once annually while the instrument is in service. Rented instruments will also have a valid calibration from a vendor appropriately licensed by the NRC or an Agreement State.

5.7 Receipt of Repaired/Calibrated Instrument

5.7.1 This section applies to instruments sent from a project site out for calibration and returned to the project site. It does not apply to rented equipment received on the project site for the first time.

5.7.2 Verify instrument has the correct calibration due date on the calibration sticker

5.7.3 Place the date the instrument was returned to service in the Out of Service Tracking Log, Attachment 5.

5.7.4 Perform a reference source check of the instrument using the appropriate source.

5.7.4.1 Repeat the procedure provided in Section 5.2 through 5.4 if the instrument's response is outside the original response range.

5.7.4.2 The new background, efficiency, and MDA obtained shall be used as the base line value for that instrument.

5.8 Instruments requiring calibration or repair at an off-site facility, as determined in Section 5.1, are treated as follows.

5.8.1 Remove the instrument from service and record information on instrument check form. In addition, fill out the appropriate information in the Out of Service Tracking Log, Attachment 5.

5.8.2 Instruments with delicate probe windows should have a probe cover secured to prevent damage. Any special instructions should be included with the instrument.

5.8.3 Carefully package the instrument and ship to the calibration facility.

The following procedures (5.8 – 5.11) are for general guidance only. Project-specific work plans will fully describe survey requirements.

5.9 Using Exposure and Dose Rate Instruments

5.9.1 General Area Surveys

Hold the detector at waist level with the most sensitive areas of the detector facing the item or areas being surveyed. Unless the radiation level on the item being surveyed is known, start on the high scale and work down scale until the instrument reading is between 1/4 and 3/4 (mid-scale) scale, if possible.

5.9.2 Direct Measurements

Hold the detector at about one inch from the surface of the item being surveyed.

5.9.3 Recording a Measurement

Allow the detector to stabilize 15-30 seconds before recording the measurement. If the analog or digital display is sporadic and it difficult to obtain an average response, record 10 instantaneous readings and calculate the average.

5.10 Using Gamma Scintillation Detectors

5.10.1 Direct Measurements

With the detector as close to the surface as possible or some other pre-determined position, collect a measurement for a length of time sufficient to provide an acceptable minimum detectable count rate. Record the measurement on the appropriate field survey form.

5.10.2 Walk-Over Surveys

With the detector as close to the ground as possible, move the detector in a serpentine pattern while advancing along a predetermined survey area transect at a rate of not more than 1 meter per second. For instruments mounted on carts, ensure that the detector height allows sufficient field of view considering the coverage requirements and the spacing of the survey area transect. Record the average and maximum count rates observed for a predetermined survey area or log the data using appropriate survey and position logging instruments.

5.11 Using Beta-Gamma Survey Meters

5.11.1 Counting Smears, Air Sample Filters, and Direct Measurements

Hold the detector no further than 1/2 inch from the smear, filter, or surface. Count smears/filters for a length of time such that the MDA is less than the removable contamination release criterion. Count surfaces for a length of time such that the MDA is less than the total contamination release criterion.

5.11.2 Frisking/scanning

Hold the detector within 1/2 inch of the surface being frisked/scanned. Move the detector no faster than two inches per second. Stop when positive indication is noted from audio response, allow meter indication to stabilize and record that value.

5.12 Using Alpha Survey Meters

5.12.1 Direct Measurements

Hold the detector no further than 1/4 inch from the surface. Count surfaces for a length of time such that the MDA is less than the total contamination release criterion.

5.12.2 Frisking/scanning

Hold the detector within 1/4 inch of the surface being surveyed. Move the detector no faster than two inches per second. Stop when positive indication is noted and allow meter indication to stabilize and record that value.

6 RECORDS

6.1 Radiological Instrument Daily Instrument Check Record, Attachment 1

6.2 Background Setup Record, Attachment 2

6.3 Instrument Efficiency Determination, Attachment 3

6.4 Minimum Detectable Concentration Calculation, Attachment 4

6.5 Out of Service Tracking Log, Attachment 5

ATTACHMENT 1

RADIOLOGICAL INSTRUMENT DAILY SOURCE CHECK RECORD

INSTRUMENT:______________________________ **SERIAL NO.:**_________________________
CALIBRATION DUE DATE:____________________

DETECTOR:_________________________________ **SERIAL NO.:**_________________________

SOURCE CHECK MATERIAL:___________________ **SERIAL NO.:**_________________________
ACTIVITY:_________________________________ **COUNT TIME:**________________________

DATE	TIME	BATTERY CHECK	HV SETTING	SOURCE CPM	IN RANGE (Y/N)	TECHNICIAN INITIALS

Reviewed By:____

BACKGROUND SETUP RECORD

Technician:		**Date:**	
Location:		**Project:**	
Meter Model	**Meter S/N**	**Detector Model**	**Detector S/N**

Count Time (t_b):	minutes
Measurement #	**Counts (C_i)**
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Average: $\overline{C}_b = \frac{\Sigma_1^{10} C_i}{N}$	
Standard Deviation: $SD_b = \sqrt{\frac{\Sigma_i^n (C_i - \overline{C}_b)^2}{N-1}}$	
$\dot{C}_b = \frac{\overline{C}_b}{t_b}$	cpm
High Limit : $\dot{C}_b$ + 2SD_b	cpm
Low limit: $\dot{C}_b$ - 2 SD_b (if less than 0, record 0)	cpm

Reviewed By:_______________________________________

$\overline{C}_b$ = average background count

SD_b = standard deviation of the average background

N = number of measurements (10)

Σ = summation

C_i = C_1 through C_n (C_{10} if 10 measurements are made)

$\dot{C}_b$ = average net background count rate

t_b = time in minutes of a background count

INSTRUMENT EFFICIENCY DETERMINATION

Technician:		Date:	
Location:		Project:	
Source/Activity:		Source S/N:	
Meter Model	**Meter S/N**	**Detector Model**	**Detector S/N**

Count Time (t):	minutes	**Corrected Source 2-pi Activity (A_c):**	dpm
Measurement #	**Counts Gross**	**Counts Net**	**Equations**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Average			$\overline{C} = \frac{\Sigma_1^{10} C_i}{N}$
Average Count Rate ($\dot{C}_n$)			$\dot{C}_n = \frac{\overline{C}}{t}$
2-pi Efficiency (E)			$E = \frac{\dot{C}_n}{A_c} = \frac{cpm}{dpm}$
SD_g (gross)			See Attachment 2
SD_b (background)			See Attachment 2
SD_n (net)			$SD_n = \sqrt{(SD_g)^2 + (SD_b)^2}$
Upper Source Check Limit			$\dot{C}_n + 2SD_b$
Lower Source Check Limit			$\dot{C}_n - 2SD_b$

Reviewed By:_______________________________________

ATTACHMENT 4

MINIMUM DETECTABLE CONCENTRATION CALCULATION

Technician:		**Date:**	
Location:		**Project:**	
Meter Model	**Meter S/N**	**Detector Model**	**Detector S/N**

C_b = Background count rate (from Attachment 2)	cpm
t_b = background measurement count time	minutes
t_s = Sample/direct measurement count time	minutes
B = background counts expected during sample count (C_b x t_s)	counts
Minimum Detectable Count Rate (L_D)	cpm
E = 2-pi Efficiency (see Instrument Efficiency Determination, Attachment 3)	cpm/dpm
Detector Probe Area (A)	cm^2
Minimum Detectable Concentration (MDC)	dpm/100 cm^2

$$L_D = 3^* + 4.65^* \sqrt{B}$$

$$MDC = \frac{L_D}{E \times A/100 \times t_b}$$

* - derived constant based on the 95% confidence (α and β = 0.05)

$$MDC = \frac{3 + 3.29\sqrt{C_b t_s \left(1 + \frac{t_s}{t_b}\right)}}{E \times t_s x \frac{A}{100}}$$

Reviewed By:____

ATTACHMENT 5

OUT OF SERVICE TRACKING LOG

Instrument [1]	Serial # [2]	Calibration Due Date [3]	Out of Service Date [4]	Remarks [5]	Returned to Service Date [6]

1. Instrument type
2. Instrument serial number
3. Calibration due date
4. Date removed from service
5. Reason instrument removed from service
6. Date instrument returned from service

Reviewed By:___________________________________

AECOM **Radiological Service Technical Practice Group Standard Operating Procedure**	PROCEDURE NO. RS-TPG, SOP 007 DATE: January 24, 2014 APPROVED: Radiological Service TPG Leader
Grid Systems and Surveys	

AECOM's Radiological Service Technical Practice Group (RS-TPG) is responsible for the issuance, revision, and maintenance of this policy. Any deviations from the procedures set forth in this policy require approval of the RS-TPG Leader. This SOP supersedes all previous SOPs on this topic.

1 PURPOSE

The purpose of this procedure provides instruction for establishing a reference grid system and performing radiological surveys for the established grids.

2 EQUIPMENT

Instrumentation shall be selected to accomplish the type of survey to be performed. All instrumentation shall be approved for use by a RS-TPG Certified Health Physicist (CHP) or Radiation Safety Officer (RSO). The following are examples of the instruments that can be used.

2.1 Gamma exposure rate and/or dose rate instruments such as the Ludlum Model 19 or Bicron MicroRem meters respectively.

2.2 Survey meters with gamma scintillation detectors for walk-over surveys, direct measurements, or down-hole gamma measurements.

2.3 Survey meters with Gieger-Mueller (GM), gas proportional, or scintillation detectors for alpha, beta, alpha/beta, or beta/gamma contamination.

2.4 Removable contamination sample counters such as a Ludlum Model 2929 with a thin window Zinc Sulfide Scintillator.

2.5 Crayons, permanent marker, or other markings devices depending on the type of surface to be marked.

2.6 The Ludlum Model 2224 Scaler with/239-1F detector or equivalent will be utilized to characterize flooring. The Model 2224 is battery capable and shall be mounted on a cart with a P-10 gas supply for easy handling and overall equipment protection.

3 PRECAUTIONS

Pre-operational checks shall be performed on all instruments prior to use to verify the following requirements per RS-TGP, SOP 001:

3.1 The instrument has been pre/post source checked for the day.

3.2 The instrument has been calibrated within the past 12 months.

3.3 The battery check is satisfactory (for portable instrumentation).

3.4 Overall physical condition of the instrument is satisfactory.

3.5 The instrument manufacturer's specific operational checks have been accomplished.

4 PROCEDURE

4.1 Establishing Exterior Grids

4.1.1 Each exterior area shall be gridded prior to starting a walk-over or vehicle-assisted survey.

4.1.2 Each grid area with a size approved by the CHP/RSO shall be based on an alphanumeric numbering system.

4.1.3 Each gridded area shall begin in the northwest corner. The northwest grid corner shall be labeled as A1. Each subsequent grid to the east of that grid shall be labeled A2, A3, A4, etc. Each subsequent grid to the south of that grid shall be labeled B1, C1, D1, etc.

4.1.4 A variety of materials may be used to mark grids, including stakes, pin flags, marking paint, etc.

4.2 Surveying Exterior Grids

4.2.1 Grids will be surveyed based on their expected level of coverage. For 100% coverage, surveyors will walk grid transects spaced 1-meter apart at a pace typically not to exceed 1 meter per second. The detector will be swung side to side in a serpentine pattern across the straight-line transect. The transect spacing can be increased as the required coverage decreases.

4.2.2 When using carts (either manually operated or automated), the detector will be placed at a height that provides a sufficient field of view to provide the appropriate coverage of the survey area. Cart-mounted detectors will be pushed/pulled along straight lines if practical. The transect spacing is based on the required level of coverage and can be increased as the required coverage decreases.

4.2.3 When manually recording data, record the approximate average and maximum measurement for a pre-determined sub-section of the survey unit. This may be an individual grid square or a collection grid squares (depending on the size of the gird squares). Use Radiological Survey Report, Attachment 1 to RS-TPG SOP-011, to document the survey readings.

4.2.4 When recording survey data using a data logging instrument, download data at least daily.

4.3 Establishing Interior Grids

4.3.1 Each interior building, (rooms, walls and hallways) shall be gridded prior to starting the instrument survey.

4.3.2 Each interior 3m x 3m grid area or 1m x 1m grid area, dependent on the CHP/RSO, shall be based on an alphanumeric numbering system.

4.3.3 Each gridded area shall begin in the northwest corner. The northwest grid corner shall be labeled as A1. Each subsequent grid to the east of that grid shall be labeled A2, A3, A4, etc. Each subsequent grid to the south of that grid shall be labeled B1, C1, D1, etc.

4.3.4 A variety of materials may be used to mark grids, including chalk lines, paint, labels, tags, etc. Uniformity and reproducibility of results shall drive material selection.

4.4 Surveying Interior Floor Grids

4.4.1 All Interior grids classed as potentially contaminated shall be surveyed.

4.4.2 Interior grids classed as potentially uncontaminated shall have at least 10% of grids surveyed. Survey grids shall be selected based on areas of high probability for contamination.

4.4.3 When manually recording data, record the approximate average and maximum measurement for a pre-determined sub-section of the survey unit. This may be an individual grid square or a collection grid squares (depending on the size of the gird squares). Use Radiological Survey Report, Attachment 1 to RS-TPG SOP-011, to document the survey readings.

Note: There is an area for comments on the survey form. Surveying personnel are encouraged to check and comment on suspicious areas within the survey grid. Mark the areas on grid to correspond with comments.

4.5 Establishing Interior Wall Grids

4.5.1 Walls shall be identified as North, South, East, and West.

4.5.2 Walls shall be drawn on miscellaneous survey maps. Wall dimensions and descriptive material or equipment shall be indicated on map, to the extent it would aid in survey reproducibility

4.5.3 Potentially contaminated walls shall be marked with survey locations at one meter points, vertically corresponding to floor grids.

4.5.4 Survey locations shall be marked with paint, labels, tags or other methods to provide reproducibility.

4.5.5 Survey locations shall be marked numerically beginning from the northwest corner.

4.5.6 Potentially uncontaminated interior walls shall be marked in the same manner as above, but at a frequency of at least one survey location per 10 floor grids.

4.6 Establishing Survey Locations, Ceilings/Overhead

4.6.1 Ceilings shall not be gridded in the manner previously described for floors, walls, etc. Rather a prescribed number of survey locations shall be identified and marked on a per square meter basis determined by building classification.

4.6.2 Potentially contaminated rooms and/or buildings shall have at least one disk smear taken above each floor grid.

4.6.3 Potentially uncontaminated rooms and/or buildings shall have at least one disk smear taken above each 4 floor grids.

4.6.4 Survey locations shall be marked by paint, label, tag or other material.

4.6.5 Ceiling surveys shall be identified on miscellaneous survey maps

4.6.6 Survey locations shall be identified numerically, beginning in the northwest corner.

4.7 Surveying Ceilings/Overhead

4.7.1 Follow the gridding procedures listed in 4.4.1.

4.7.2 Obtain a miscellaneous survey form and draw the **ceiling as viewed from below.**

4.7.3 Add equipment, lights, vent ducts, etc., to the extent it would aid in survey reproducibility.

4.7.4 Establish survey locations pursuant to Section 4.4.6. Monitoring personnel shall select locations where contamination would be most probable.

4.7.5 Disk smears shall be taken at the frequency required by Sections 4.4.2 and 4.4.3.

4.7.6 Disk smears shall be counted for one minute on the Ludlum Model 2929 Alpha/Beta counting system or pancake probe if approved by the CHP or RSO.

4.7.7 Disk smears shall be taken when contamination is suspected, consideration will be given to the use of large area swipes. This shall be dependent on surface medium, access, and building use. This shall be determined on a building-by-building basis by the CHP or RSO.

4.7.8 When manually recording data, record the approximate average and maximum measurement for a pre-determined sub-section of the survey unit. This may be an individual grid square or a collection grid squares (depending on the size of the gird squares). All survey results shall be recorded on the Radiological Survey Report Form, Attachment 1 to RS-TPG SOP-011.

4.6 Final Status Survey

4.7.9 Survey grid for the final status survey will be established using the protocols in MARSSIM.

4.7.10 The number of direct measurements required for the final status survey will be established using the protocols in MARSSIM.

4.7.11 Distance between samples for final status survey will be established using the protocols in MARSSIM.

4.7.12 Other associated operations will be done in accordance with MARSSIM protocols.

5 REFERENCES

5.1 *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM),* Revision 1, August 2000.

AECOM **Radiological Service Technical Practice Group Standard Operating Procedure**	PROCEDURE NO. RS-TPG, SOP 011 DATE: March 20, 2014 APPROVED: Radiological Service TPG Leader
Radiological Surveys	

Standard Operating Procedure

RADIOLOGICAL SURVEYS

AECOM's Radiological Service Technical Practice Group (RS-TPG) is responsible for the issuance, revision, and maintenance of this policy. This procedure has also been provided to the South Carolina Department of Health and Environmental Control (SC DHEC) as part of AECOM's "decommissioning license" application. Therefore, any deviations from the procedures set forth in this document require approval of the RS-TPG Leader and the SC DHEC license Radiation Safety Officer (RSO). This SOP supersedes all previous SOPs on this topic.

SC DHEC License RSO Approval: ______________________ March 20, 2014

1 PURPOSE

This document establishes the guidelines to be used for measuring radiation and contamination. It also provides guidelines for maintaining control of radioactive materials and areas that need to be surveyed.

2 SCOPE

This procedure provides guidance on properly performing radiological surveys conducted on temporary project sites where AECOM has either implemented its SC DHEC license or where RS-TPG leadership is involved with project implementation.

3 ALARA POLICY

It is AECOM's policy to plan and conduct its radiological activities safely and in such a fashion as to protect the health and safety of its employees, subcontractors, members of the public, and the environment. To achieve this, AECOM shall confirm that efforts are taken to reduce radiological exposures and releases to the environment as low as is reasonably achievable, taking into account social, technical, economic, practical and public policy considerations. AECOM's RS-TPG is committed to implementing this radiological survey procedure to reflect this policy.

4 EQUIPMENT

The following are examples of instrumentation that might be used to perform surveys.

- Beta-gamma contamination surveys are performed using a Ludlum model 2224 with a thin window Geiger-Mueller (GM) probe, a Ludlum Model 44-9, or equivalent.
- Alpha surveys are performed with a thin window gas flow proportional probe, a Ludlum model 2224 with 43-93 probe, or equivalent.
- Disk smears from equipment or buildings may be counted in the Ludlum Model 2929 attached to a zinc sulfide thin window scintillator, or equivalent
- The Ludlum Model 2224 Scaler with/239-1F detector or equivalent will be utilized to characterize flooring, during the characterization phase. The Model 2224 is battery-capable and will be mounted on a cart with a P-10 gas supply for easy handling and overall equipment protection.
- The Ludlum Model 19 or equivalent Micro-R meter will be used to document gamma exposure levels. The Model 19 is portable, battery powered and durable.
- The Bicron Micro-Rem Survey Meter or equivalent dose rate meter will be used to document tissue-equivalent gamma dose rates.

5 INSTRUMENT OPERATIONAL CHECKS

5.1 A pre-operational check will be performed on all instruments prior to use to verify the following requirements in accordance with RS-TPG SOP-001, *Portable Detection Equipment*, and RS-TPG SOP-002, *Swipe Counter*. In general:

5.1.1 The instrument must be source checked every day before use and at the end of each shift;

5.1.2 The instrument has been calibrated within the last year;

5.1.3 The battery check is satisfactory, and spare batteries are available (for portable instrumentation);

5.1.4 Overall physical condition of the instrument is satisfactory; and

5.1.5 A consistent low-background counting area must be selected for daily checks of the instruments.

6 PROCEDURES

The following procedures are for general guidance only. Project-specific work plans will fully describe survey requirements.

6.1 Exposure/Dose Rate Surveys

6.1.1 General Requirements

- Exposure/dose rate surveys are performed, using any of the exposure rate instruments approved for use, to provide an indication of the amount and type (e.g., beta or gamma) of external radiation exposure the workers will receive while performing routine work operations;
- A reasonable amount of care should be taken when performing exposure/dose rate surveys to identify items that are contributing to the general area exposure rates (i.e., barrels, equipment, etc.);
- Exposure/dose rates measurements should be observed continually while approaching a radiation source from a background area;
- All exposure/dose rates shall be recorded on a Radiological Survey Report Form, Attachment SOP011-1, or equivalent;
- Exposure/dose rates that are taken "on contact" shall be noted on the Radiological Survey Report Form, Attachment SOP011-1, or equivalent; and
- Items identified with exposure/dose rates greater than five times the general work area shall be recorded with an asterisk indicating "hot spot". As these items are identified, the surveyor should shield the item, or remove it from the area, if possible.

6.1.2 Gamma Surveys

- Gamma dose rates:
  - Allow instruments to stabilize for 15 to 30 seconds
  - Record measurements as mrem/hr or μrem/h
  - If the analog or digital display is sporadic and it difficult to obtain an average response, record 10 instantaneous readings and calculate the average.
- Gamma exposure rates:
  - Allow instruments to stabilize for 15 to 30 seconds
  - Use the detector slow response/integrating mode
  - Recorded measurements as mR/hr or μR/h

- If the analog or digital display is sporadic and it difficult to obtain an average response, record 10 instantaneous readings and calculate the average.

6.1.3 Beta Dose Rate Surveys

- Beta dose rates are recorded as mRad/hr (µGy/hr) or µRad/h;
- Beta dose rates are derived by the following formula:

mRad/hr = (OW - CW) x CF

OW = Open window exposure rate
CW = Closed window exposure rate
CF = Correction factor*

- The beta correction factor used for each instrument shall be determined by the calibration facility
- If the analog or digital display is sporadic and it difficult to obtain an average response, record 10 instantaneous readings and calculate the average.

6.2 Contamination Surveys

6.2.1 Contamination surveys are used as a tool to maintain control of work areas, verify clean areas, and establish protective clothing and requirements;

6.2.2 Removable contamination surveys are performed by using either disk smears or large area swipes (masslin cloth or similar). Disk smear surveys are performed by wiping a surface area approximately 100 cm^2.

6.2.3 Scan surveys may be performed with any approved count rate instrument. Consideration should be given to using the audible setting on the instrument, if so equipped, since audible response is quicker to respond to than the visual provided by the meter.

- When using the beta-gamma instrument, the detector should be held within 1/2 inch of the surface being frisked and moved no faster than 2 inches per second.

- When using the alpha instrument, the detector should be held within 1/4 inch of the surface being monitored and the probe moved no faster than 2 inches per second. Increased counts are an indication of alpha activity, when counts increase either by audible or visual, stop all detector motion until a stable count rate is determined.

6.2.4 Personnel contamination surveys ("frisking") shall be performed on individuals, materials, and equipment (M&E) exiting a radiologically controlled area by a qualified radiation professional or technician. Surveys are performed in accordance with Section 4.2.3. When surveying personnel, at a minimum, the bottoms of the shoes and hands should be scanned. During more detailed scans, detector movement should be paused at locations of potential contamination such as knees, elbows, and mouth.

6.2.5 General Requirements

- Count rate instruments approved for use shall be used for evaluating contamination levels of disk smears or wipes;
- Smears are counted in an area where the background is less than 100 cpm;
- Smears are placed 1/2" from the surface of the detector for 15 to 20 seconds to allow the count rate meter's indication to stabilize;
- Smear results are recorded on the Radiological Survey Report Form, Attachment 2-1, in disintegrations per minute.
- Disintegrations per minute per 100 square centimeters (dpm/100cm^2) shall be calculated from gross counts per minute (cpm) by the following formula. For smears, the area of the surface smeared (e.g., 100 cm^2) is substituted for the probe area.

$$dpm/100cm^2 = \frac{gross\ cpm - background\ cpm}{detector\ efficiency \times {}^{probe\ area}/_{100}}$$

Example:

$$dpm/100cm^2 = \frac{1200\ cpm - 100\ cpm}{20\% \times {}^{15cm^2}/_{100cm^2}}$$

6.3 Gamma Count Rate Surveys

6.3.1 With the detector as close to the surface as possible or some other pre-determined position, collect a measurement for a length of time sufficient to provide an acceptable minimum detectable count rate (MDCR). Record the measurement on the appropriate field survey form.

6.3.2 With the detector as close to the ground as possible, move the detector in a serpentine pattern while advancing along a predetermined survey area transect at a rate of not more than 1 meter per second. For instruments mounted on carts, ensure that the detector height allows sufficient field of view considering the coverage requirements and the spacing of the survey area transect. Record the average and maximum count rates observed for a predetermined survey area or log the data using appropriate survey and position logging instruments. When using data-logging instruments which also log position using GPS, follow additional instructions/procedure and download data at a frequency no less than once per day.

6.4 Survey Frequency

The frequency of routine surveys shall be determined at the start of the project by the Project Health Physicist based on the likelihood for contamination in the area. Survey coverage is generally described in a Survey Plan. Survey Plans will often be prepared according to the guidance in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) but other guidance may be applicable under specific conditions. MARSSIM provides specific methods for determining the number of direct survey/sample locations.

6.5 Survey Documentation

Field surveys shall be documented on a Radiological Survey Report Form, Attachment 2-1, or equivalent. Final survey records documentation should include:

- Survey type
- The meter and probe model numbers and serial numbers
- Detector calibration dates
- Detector efficiencies
- Net measurement results (reported in dpm/100cm^2 or exposure/dose rate units)
- Minimum detectable concentrations (MDC)
- Date of the survey
- Name of individual performing the survey
- Maps, diagrams, or pictures.

6.6 Surveying Materials and Equipment (M&E).

- The surveying M&E (e.g., pipe, valves, tools, heavy equipment, vehicles, etc.) shall be performed and documented as in Sections 4.2 and 4.4.
- M&E surveys shall include a drawing, photograph, or description on the survey form and in the final survey record, to the extent it could be relocated and resurveyed. Measurement locations shall be identified.
- For projects involving a significant amount of surveys for the release of M&E, the Project Health Physicist should develop a separate Survey Plan in

accordance with the protocols described in the Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME) Manual.

6.7 Posting Radiation and Contamination Areas.

- Posting of Radiation and Contamination Areas identified during radiological surveys will be done in accordance with RS-TPG, SOP 20, *License/Site Radiation Protection Program*.

7 RECORDS

7.1 Calibration Records and Daily Instrument Check Records (according to RS-TPG SOP-001, *Portable Detection Equipment.*

7.2 Radiological Survey Record, Attachment 1.

7.3 An electronic version of Attachment 1 can be obtained from the RS-TPG Leader.

ATTACHMENT 1
RADIOLOGICAL SURVEY RECORD

AECOM

Project Name
Project No.

Survey No.: _____

Surveyor: ______________________________ ________

Reviewer: ______________________________ ________

Date

Survey Meters

Total (Direct) β γ	Removable β γ	Removable α	Dose γ
Instrument #	Instrument #	Instrument #	Instrument #
Meter Model #	Meter Model #	Meter Model #	Meter Model #
Meter Serial #	Meter Serial #	Meter Serial #	Meter Serial #
Detector Model #	Detector Model #	Detector Model #	Detector Model #
Detector Serial #	Detector Serial #	Detector Serial #	Detector Serial #
Cal Due	Cal Due	Cal Due	Cal Due
Detector Efficiency (ε_i)	Detector Efficiency (ε_i)	Detector Efficiency (ε_i)	Detector Efficiency (ε_i)
Surface Efficiency (ε_s)	Surface Efficiency (ε_s)	Surface Efficiency (ε_s)	(Approximate)
Sample Time (T_s) (min)	Sample Time (T_s) (min)	Sample Time (T_s) (min)	Sample Time (T_s) (min)
Background Time (T_b) (min)	Background Time (T_b) (min)	Background Time (T_b) (min)	Background Time (T_b) (min)
BKG (R_b) (cpm)	BKG (R_b) (cpm)	BKG (R_b) (cpm)	BKG (R_b) (cpm)
Probe Area (A) (cm)	Swipe Area (A) (cm)	Swipe Area (A) (cm)	Probe Area (A) (cm)
MDC (dpm/100cm2)	MDC (dpm/100cm2)	MDC (dpm/100cm2)	MDC (dpm/100cm2)

LOCATION:	Location	dpm/100cm^2 α/β/γ - Total	dpm/100cm^2 β/γ - Remov.	dpm/100cm^2 α - Remov.	uR/hr γ - Dose
PURPOSE:	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				

Field Change Order Procedures

SOP Number 100Pines

Revision Number: 3.0

September 2013

AECOM Project Manager
September 24, 2013

AECOM Project QA Officer
September 24, 2013

AECOM
September 2013
Pines Area of Investigation

CONTENTS

LIST OF ACRONYMS

FCO	Field Change Order
FSP	Field Sampling Plan
HASP	Health and Safety Plan
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
RI	Remedial Investigation
SOP	Standard Operating Procedure

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes field change order (FCO) procedures applicable to AECOM sampling and analysis programs.

2.0 SUMMARY OF METHOD

Procedural changes in the field can be needed when the sample network is changed (i.e., fewer or more samples, adjustments to locations) or when field procedures require modification due to unexpected conditions. Changes made in the field will be documented on an FCO form (see Figure 1).

3.0 HEALTH AND SAFETY WARNINGS

Not applicable.

4.0 INTERFERENCES

Not applicable.

5.0 PERSONNEL QUALIFICATIONS

Individuals responsible for completing FCO documentation must be personnel working on the specific field program for which the change is necessary, have read this SOP, and have worked under the oversight of experienced personnel.

6.0 EQUIPMENT AND SUPPLIES

General field supplies include the following items:

- FCO Form (Figure 1)
- Field project logbook/pen
- Approved plans (e.g., FSP, QAPP, HASP)

7.0 METHODS

7.1 Field Change Order

7.1.1 The field personnel and/or the Field Operations Leader will recommend a change in consultation with the AECOM Project Manager, the AECOM Remedial Investigation (RI) Task Manager, and/or the AECOM Project Quality Assurance (QA) Officer. The AECOM Project Manager, RI Task Manager, or QA Officer will approve the change, which will be implemented by the field personnel. Approval may initially be received verbally or electronically, but will be documented on the FCO, as detailed below.

7.1.2 The following information shall be completed on the FCO form (Figure 1):

- Date
- Project name
- Project number
- Description of change and reason and justification for change, including reference to section(s) of Work Plan(s) affected
- Field personnel or Field Operations Leader signature and date
- Project Manager, RI Task Manager, or QA Officer signature and date

7.1.3 Field changes will be implemented and documented in the field logbook. No field personnel will initiate field changes without prior communication of findings through the proper channels. Thus, communication will be documented in the field logbook and FCO form.

8.0 DATA AND RECORDS MANAGEMENT

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Quality control will consist of implementing the field change process as described above, including the appropriate approval process.

10.0 REFERENCES

Not applicable.

FIGURE 1 - Example Field Change Order Form

Field Change Order (FCO)
DATE: **PROJECT NAME:** **PROJECT NUMBER:**
DESCRIPTION OF CHANGE AND RATIONALE
SIGNATURE APPROVALS IN THE FIELD: ______________________ DATE: ____________ MANAGEMENT: ______________________ DATE: ____________

Management may include RI Task Manager, Project Manager and/or QA Officer.

Split Spoon Sampling for Geologic Logging

SOP Number 109Pines

Revision Number: 3.0

September 2013

AECOM Project Manager
September 24, 2013

AECOM Project QA Officer
September 24, 2013

AECOM
September 2013
Pines Area of Investigation

CONTENTS

LIST OF ACRONYMS

ASTM	American Society for Testing and Materials
FSP	Field Sampling Plan
HASP	Health and Safety Plan
IDEM	Indiana Department of Environmental Management
OSHA	Occupational Safety and Health Adminstration
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedure
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the methods used to obtain subsurface soil samples for geologic logging and physical characterization. Subsurface soil samples are obtained in conjunction with soil boring programs, and provide information on the physical and/or chemical makeup of the subsurface environment.

The purpose of this SOP is to provide a description of a specific method or procedure to be used in the collection of subsurface soil samples. Subsurface soil is defined as unconsolidated material that may consist of one or a mixture of the following materials: sand, gravel, silt, clay, peat (or other organic soils), and/or fill material. Subsurface soil sampling conducted in accordance with this SOP will promote consistency in sampling and provide a basis for sample representativeness.

This SOP covers subsurface soil sampling by split-spoon only.

2.0 SUMMARY OF METHOD

Split-spoon subsurface soil sampling generally requires use of a drilling rig and, typically, the hollow-stem auger or other common drilling method to generate a borehole in which to use the split-spoon sampler. The split-spoon sampler is inserted through the augers (or other type of drill casing) and then driven into the subsurface soil with a weighted hammer. The sampler is then retrieved and opened to reveal the recovered soil sample. Soil samples may be collected at continuous intervals or at pre-selected vertically spaced intervals within the borehole.

3.0 HEALTH AND SAFETY WARNINGS

Subsurface soil sampling may involve chemical hazards associated with exposure to the constituents potentially present in the subsurface and physical hazards associated with use of drilling equipment. When subsurface soil sampling is performed, adequate health and safety measures must be taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

4.0 INTERFERENCES

Potential interferences could result from cross-contamination between samples or sample locations. Minimization of the cross-contamination will occur through the use of clean sampling tools at each location, which will require decontamination of sampling equipment as per AECOM SOP No. 7600Pines – Decontamination of Field Equipment.

5.0 PERSONNEL QUALIFICATIONS

Soil sampling by split-spoon requires a moderate degree of training and experience as numerous drilling situations may occur that will require field decisions to be made. It is recommended that inexperienced personnel be supervised for several drilling locations before working on their own. Geologists or personnel with geologic experience should supervise drilling activities. The geologic work performed under this SOP will be conducted under the direction of a professional geologist licensed to practice in Indiana.

Field and subcontract personnel will be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

It will be the responsibility of field personnel to ensure that subsurface soil sampling is conducted in a manner that is consistent with this SOP. Field personnel will observe all activities pertaining to subsurface soil sampling to ensure that the SOP is followed, and to record all pertinent data onto a boring log and/or field logbook. It is also the field personnel's responsibility to indicate the specific targeted sampling depth or sampling interval to the drilling subcontractor. Field personnel are also responsible for preparing a geologic description of the soils once the sampling device has been retrieved and opened. Field personnel are responsible for compiling a detailed log of the geologic materials encountered.

It will be the responsibility of the drilling subcontractor to provide a trained operator and the necessary materials for obtaining subsurface soil samples. This generally includes one or more split-spoon samplers in good, operating condition. It is the drilling subcontractor's responsibility to provide and maintain their own boring logs if desired.

6.0 EQUIPMENT AND SUPPLIES

In addition to those materials provided by the subcontractor, other field supplies include:

- Boring Log Forms (Figure 1)
- Plastic sheeting
- Trash bags
- Folding rule or tape measure
- Utility knife
- Equipment decontamination materials (as required by AECOM SOP No. 7600Pines – Decontamination of Field Equipment)
- Health and safety supplies (as required by HASP)
- Approved plans (e.g., HASP, FSP, QAPP)
- Field project logbook/pen

7.0 METHODS

7.1 General Method Description

Split-spoon sampling devices are typically constructed of steel and are most commonly available in lengths of 18 and 24 inches and diameters of 1.5 to 3 inches. The split-spoon consists of a tubular body with two halves that split apart lengthwise, a drive head on the upper end with a ball-check valve for venting, and a hardened steel cutting shoe at the bottom. The soil sample enters the split-spoon through the cutting shoe as the device is driven into the ground. A replaceable plastic or metal basket is often inserted into the shoe to assist with retaining samples. Once the sampler is retrieved, the drive head and cutting shoes are removed and the split-spoon halves are then separated, revealing the sample.

Sample depth intervals are defined in the Field Sampling Plan (FSP). For this project, continuous split-spoon samples will be collected to enable development of detailed geologic boring logs.

7.2 General Procedures – Borehole Preparation

7.2.1 Advancing Casing/Augers

Soil borings that are completed for soil sampling purposes are typically advanced using hollow-stem augers and sometimes drive-and-wash or other casing methods, operated by a qualified subcontractor. The casing/augers must be of sufficient diameter to allow for soil sampling at a minimum. If hollow-stem augers are used, a temporary plug shall be used in the lead auger to prevent the auger from becoming filled with drill cuttings while drilling is in progress.

7.2.2 Obstructions

For those borings that encounter obstructions, the casing/augers will be advanced past or through the obstruction if possible. Caution should be exercised when obstructions are encountered and an effort made to identify the obstruction before drilling is continued. If the obstruction is not easily drilled through or removed, the boring should be relocated to an adjacent location, in consultation with the AECOM Remedial Investigation (RI) Task Manager. Such changes will be documented in accordance with AECOM SOP No. 100Pines – Field Change Order Procedures.

7.2.3 Use of Added Water

The use of added or recirculated water during drilling is permitted when necessary, for example, to control running sands. Based on previous experience at Yard 520, running sands, when encountered, are typically controlled by maintaining a head of water in the augers. Use of extraneous water should be minimized or avoided if possible because it may impact sample quality. Only potable water will be used, and water usage should be documented in the field logbook. Sampling and analysis of added or recirculated water may be required for quality assurance purposes. If a well is installed within the completed borehole, removal of the added water through well development is required (refer to AECOM SOP No. 7221Pines – Monitoring Well Development).

7.3 Split Spoon Sampling Procedure

7.3.1 Standard Penetration Test

The drilling subcontractor will lower the split-spoon into the borehole. Samples are generally obtained using the Standard Penetration Test (SPT) in accordance with American Society for Testing and Materials (ASTM) standards (ASTM D 1586-84). Following this method, the sampler will be driven using the 140-pound hammer with a vertical free drop of 30 inches using two turns of the rope on the cathead (or equivalent). The number of hammer blows required for every 6 inches of penetration will be recorded on the boring log by the field personnel. Blowcount information is used as an indicator of soil density for geotechnical as well as stratigraphic logging purposes. Once the split-spoon has been driven to its fullest extent, or to refusal, it will be removed from the borehole.

7.3.2 Sample Recovery

Sample recovery will be determined by field personnel who will examine the soil core once the sampler is opened. The length of sample shall then be measured with a folding rule or tape measure and recorded in the field logbook or boring log. Any portion of the split-spoon contents that are not considered part of the true sample (e.g., heaved soils) will be discarded.

7.4 Sample Logging

Geologic materials recovered from boreholes will be logged in accordance with the Unified Soil Classification System (USCS) protocols (see, for example, USEPA, 1991). Geologic descriptions will be entered on a boring log (see Figure 1). Specific information to be recorded on the log may include:

- Location identification and/or description
- Drilling subcontractor
- Geologist/field personnel name
- Drilling date
- Drilling equipment
- Split-spoon sample interval
- Blow counts
- Total depth of boring

Additional geologic description information to be recorded may include:

- Moisture content
- Color
- Grain-size
- Sorting
- Density
- Plasticity
- Other relevant observations

In accordance with Indiana Department of Environmental Management (IDEM) guidance (IDEM, 1988), additional information may also be recorded, such as U.S. Department of Agriculture (USDA) soil classification, rounding, effervescence, mineralogy, and bedding. Additional information concerning geologic logging protocols is attached to this SOP.

7.5 Equipment Decontamination

All equipment that comes into contact with soil and/or groundwater (e.g., drill rig, split-spoon) will be decontaminated in accordance with AECOM SOP No. 7600Pines – Decontamination of Field Equipment before moving to the next location.

8.0 DATA AND RECORDS MANAGEMENT

Specific information regarding the split spoon sample collection should be documented in the boring log and field logbook. Additional information regarding each form of documentation is presented in the following paragraphs:

8.1 Boring Log

This form (Figure 1) will be used to record the geologic description of the split spoon samples collected. Logging protocols are attached to this SOP. Geologic logs will be reviewed by a geologist licensed to practice in Indiana.

8.2 Field Logbook

This logbook should be dedicated to the project and should be used by field personnel to maintain a general log of activities throughout the sampling program. This logbook should be used in support of, and in combination with, the sample collection record. Documentation within the logbook should be thorough and sufficiently detailed to present a concise, descriptive history of the sample collection process.

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Field personnel should follow specific quality assurance guidelines as outlined in the QAPP and/or FSP.

The geologic work performed under this SOP will be conducted under the direction of a professional geologist licensed to practice in Indiana. Boring logs will be reviewed by the licensed Indiana geologist.

10.0 REFERENCES

ASTM D 1586-84. 1992. “Test Method for Penetration Test and Split-Barrel Sampling of Soils”.

AECOM SOP No. 100Pines – Field Change Order Procedures. Revision 3.0.

AECOM SOP No. 7221Pines – Monitoring Well Development.

AECOM SOP No. 7600Pines – Decontamination of Field Equipment. Revision 4.0.

IDEM. 1988. Technical Guidance Document, Volume 1 – Requirements for Describing Unconsolidated Deposits. Indiana Department of Environmental Management. Draft, Revised November 18, 1988.

USEPA. 1991. Description and Sampling of Contaminated Soils: A Field Pocket Guide. EPA/625/12-91/002. November 1991.

FIGURE 1 – EXAMPLE SUBSURFACE SOIL BORING LOG

AECOM

Client:
Project Number:
Boring Location:
Drilling Method:
Weather:
Logged By:
Drilled By:

BORING ID:
Sheet: 1 of 1
Date/Time Started:
Date/Time Finished:

Depth (ft)	Sample Number	Sample Type	Recovery (ft)	Density (SPT)	U.S.C.S	Lithologic Description	Remarks	Well Construction Details
_1								
_2								
_3								
_4								
_5								
_6								
_7								
_8								
_9								
_0								
_1								
_2								
_3								
_4								
_5								
_6								
_7								
_8								
_9								
_0								

END OF BORING @ ' below ground surface (bgs)

NOTES:

Checked by:____________ Date:______________

Chain-of-Custody Procedures

SOP Number 1007Pines

Revision Number: 5.0

September 2013

AECOM Project Manager
September 24, 2013

AECOM Project QA Officer
September 24, 2013

AECOM
September 2013
Pines Area of Investigation

Chain-of-Custody Procedures

CONTENTS

LIST OF ACRONYMS

COC	Chain-of-Custody
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedure
USEPA	United States Environmental Protection Agency

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes chain-of-custody (COC) procedures applicable to AECOM sampling and analysis programs.

2.0 SUMMARY OF METHOD

The National Enforcement Investigations Center of the U.S. Environmental Protection Agency (USEPA) defines custody of evidence in the following manner:

- It is in your actual possession;
- It is in your view, after being in your physical possession;
- It was in your possession and then you locked or sealed it up to prevent tampering; or
- It is in a secure area.

Samples are physical evidence and should be handled according to certain procedural safeguards described in of this SOP.

3.0 HEALTH AND SAFETY WARNINGS

Not applicable.

4.0 INTERFERENCES

Not applicable.

5.0 PERSONNEL QUALIFICATIONS

Individuals responsible for completing COC documentation must be personnel working on the specific field program, have read this SOP, and have worked under the oversight of experienced personnel.

6.0 EQUIPMENT AND SUPPLIES

General field supplies include the following items:

- Sample Labels

- COC Form (Figure 1)
- COC Tape (Figure 2)
- Field project logbook/pen

7.0 METHODS

7.1 Field Custody

7.1.1 The field personnel is required to complete the following information on the COC form (Figure 1):

- Project Number (not project name)
- Project Location
- Field Sample Identification Number
- Date and Time of Sample Collection
- Sample Matrix
- Preservative
- Analysis Requested
- Sampler's Signature
- Signature of Person Relinquishing Sample Custody
- Date and Time Relinquished
- Sampler Remarks
- COC Tape Number

7.1.2 The COC must be filled out completely and legibly in ink. Corrections will be made, if necessary, by drawing a single line through and initialing and dating the error. The correct information is then recorded with indelible ink. All transfers from field personnel to laboratory personnel are recorded on the COC form in the "Relinquished By" and "Received By" sections.

7.1.3 If samples are to be shipped by overnight commercial courier (e.g., Federal Express), the field personnel must complete a COC form for each package (e.g., cooler) of samples and place a copy of each completed form inside the associated package before the package is sealed. Each completed COC form must accurately list the sample identification numbers of the samples with which it is packaged, and must contain the identification number of the COC tape on the package. It is not necessary for the shipping company to sign the COC.

Sample packaging will be conducted in accordance with AECOM SOP No. 7510Pines – Packaging and Shipment of Environmental Samples.

7.1.4 If samples are hand carried to a laboratory, the person hand carrying the samples is the sample custodian. If the carrier is a different person than the one who filled out the COC form and packaged the samples, then that person must transfer custody to the carrier by signing and dating each form in the "Relinquished By" section. The carrier must then sign and date each form in the adjacent "Received By" section. When the carrier transfers the samples to the laboratory, he or she must sign and date each form in the next "Relinquished By" section, and the laboratory sample custodian must sign and date each form in the adjacent "Received By" section.

7.2 Laboratory Sample Receipt and Inspection

7.2.1 Upon sample receipt, the coolers or packages are inspected for general condition and the condition of the COC tape. The coolers or boxes are then opened and each sample is inspected for damage.

7.2.2 Sample containers are removed from packing material and sample label field identification numbers are verified against the COC form.

7.2.3 The following information is recorded in the laboratory's records:

- Airbill Number
- Presence/absence of COC forms and COC tape
- Condition of samples
- Discrepancies noted
- Holding time and preservatives
- Sample storage location

7.2.4 The COC form is completed by signing and recording the date and time of receipt.

7.2.5 The AECOM Project Manager or designate must be notified of any breakage, temperature exceedances, or discrepancies between the COC paperwork and the samples.

8.0 DATA AND RECORDS MANAGEMENT

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion, and in the files of the laboratories that have performed the sample analyses.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

The records generated in this procedure are subject to review during data validation, in accordance with the Quality Assurance Project Plan (QAPP).

10.0 REFERENCES

AECOM SOP No. 7510Pines - Packaging and Shipment of Environmental Samples.

FIGURE 1 EXAMPLE CHAIN OF CUSTODY FORM

AECOM **CHAIN OF CUSTODY RECORD**

Page _1_ of _1_

Client/Project Name:	Project Location:		Analysis Requested
Project Number:	Field Logbook No.:		
Sampler (Print Name)/(Affiliation):	Chain of Custody Tape Nos.:		
Signature:	Send Report to:	TAT: Standard	

Container Type
P – Plastic
A – Amber Glass
G – Clear Glass
V – VOA Vial
O – Other
E – Encore

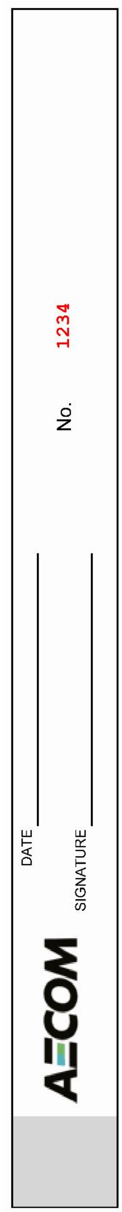
Preservation
1 – HCl, 4°
2 – H2SO4, 4°
3 – HNO3, 4°
4 – NaOH, 4°
5 – NaOH/ZnAc, 4°
6 – Na2S2O3, 4°
7 – 4°

Matrix Codes:
DW – Drinking Water
WW – Wastewater
GW – Groundwater
SW – Surface Water
ST – Storm Water
W – Water
S – Soil
SL – Sludge
SD – Sediment
SO – Solid
A – Air
L – Liquid
P – Product

Field Sample No./Identification	Date	Time	COMP	GRAB	Sample Container (Size/Mat'l)	Matrix	Preserv.	Field Filtered	Boron										Lab I.D.	Remarks

Relinquished by: (Print Name)/(Affiliation) Signature:	Date: Time:	Received by: (Print Name)/(Affiliation) Signature:	Date: Time:	Analytical Laboratory (Destination):
Relinquished by: (Print Name)/(Affiliation) Signature:	Date: Time:	Received by: (Print Name)/(Affiliation) Signature:	Date: Time:	
Relinquished by: (Print Name)/(Affiliation) Signature:	Date: Time:	Received by: (Print Name)/(Affiliation) Signature:	Date: Time:	Sample Shipped Via: UPS FedEx Courier Other Temp blank Yes No

FIGURE 2 EXAMPLE CHAIN OF CUSTODY TAPE



Packaging and Shipment of Environmental Samples

SOP Number 7510Pines

Revision Number: 5.0

September 2013

AECOM Project Manager
September 24, 2013

AECOM Project QA Officer
September 24, 2013

AECOM
September 2013
Pines Area of Investigation

CONTENTS

LIST OF ACRONYMS

COC	Chain-of-Custody
DOT	Department of Transportation
HASP	Health and Safety Plan
OSHA	Occupational Safety and Health Adminstration
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
RCRA	Resource Conversation and Recovery Act
RI	Remedial Investigation
SOP	Standard Operating Procedure
USEPA	United States Environmental Protection Agency

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the procedures associated with the packaging and shipment of environmental samples consisting of water, soil, and sediment submitted for routine environmental testing. Environmental samples are not considered a Resource Conservation and Recovery Act (RCRA) classified hazardous waste by definition; therefore, more stringent RCRA and Department of Transportation (DOT) regulations regarding sample transportation do not apply. Environmental samples do, however, require fairly stringent packaging and shipping measures to ensure sample integrity as well as safety for those individuals handling and transporting the samples.

This SOP is designed to provide a high degree of certainty that environmental samples will arrive at their destination intact. This SOP assumes that samples will often require shipping overnight by a commercial carrier service; therefore, the procedures are more stringent than may be necessary if a laboratory courier is used or if samples are transported directly to their destination by a field personnel. Should either of the latter occur, the procedures may be modified to reflect a lesser degree of packaging requirements.

2.0 SUMMARY OF METHOD

Sample packaging and shipment involves the placement of individual sample containers into a cooler or other similar shipping container and placement of packing materials and coolant in such a manner as to isolate the samples, maintain the required temperature, and to limit the potential for damage to sample containers when the cooler is transported.

3.0 HEALTH AND SAFETY WARNINGS

Sampling personnel should be aware that packaging and shipment of samples involves potential exposure and physical hazards primarily associated with handling of occasional broken sample containers and lifting of heavy objects. Adequate health and safety measures must be taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

4.0 INTERFERENCES

Sample containers with presumed high constituent concentrations should be isolated within their own cooler with each sample container placed into a zipper-lock bag.

5.0 PERSONNEL QUALIFICATIONS

Sample packaging and shipment is a relatively simple procedure requiring minimal training and a minimal amount of equipment. It is recommended that initial attempts be supervised by more experienced personnel.

Field personnel should be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials may be present.

It is the responsibility of the field personnel to be familiar with the procedures outlined within this SOP, quality assurance, and health and safety requirements outlined within the FSP, Quality Assurance Project Plan (QAPP), and HASP. Field personnel are also responsible for proper documentation in the field logbook.

6.0 EQUIPMENT AND SUPPLIES

General field supplies include the following items:

- Sample coolers
- Sample containers
- Shipping labels
- Chain-of-custody (COC) form (Figure 1)
- Custody tape (Figure 2)
- Bubble wrap
- Vermiculite (granular), or styrofoam pellets
- Ice
- Temperature blank
- Transparent tape, or rubber bands
- Fiber tape
- Duct tape

- Utility knife
- Zipper-lock plastic bags
- Trash bags
- Health and safety supplies (as required by the HASP)
- Field project logbook/pen

7.0 METHODS

7.1 Preparation

The extent and nature of sample containerization will be governed by the type of sample, and the most reasonable projection of the sample's hazardous nature and constituents. U.S. Environmental Protection Agency (USEPA) regulations (40 CFR Section 261.4(d)) specify that samples of solid waste, water, soil or air, collected for the sole purpose of testing, are exempt from regulation under RCRA when any of the following conditions are applicable:

- Samples are being transported to a laboratory for analysis;
- Samples are being transported to the collector from the laboratory after analysis;
- Samples are being stored (1) by the collector prior to shipment for analyses, (2) by the analytical laboratory prior to analyses, or (3) by the analytical laboratory after testing but prior to return of sample to the collector or pending the conclusion of a court case.

7.1.1 Laboratory Notifications

Prior to sample collection, the AECOM Remedial Investigation (RI)/Feasibility Study (FS) Task Manager or designee must notify the laboratory project manager of the number, type, and approximate collection and shipment dates for the samples. If the number, type, or date of sample shipment changes due to program changes that may occur in the field, the AECOM RI/FS Task Manager or alternate must notify the laboratory of the changes. Additional notification from the field is often necessary when shipments are scheduled for weekend delivery.

7.1.2 Cooler Inspection and Decontamination

Laboratories will often re-use coolers. Every cooler received at a project location should be inspected for condition and cleanliness. Any coolers that exhibit cracked interiors or exterior linings/panels or hinges should be discarded because the insulating properties of the coolers would be considered compromised. Any coolers missing one or both handles should also be discarded if replacement handles (i.e., knotted rope handles) can not be fashioned in the field.

The interior and exterior of each cooler should be inspected for cleanliness before using it. Excess strapping tape and old shipping labels should be removed. If the cooler interior exhibits visible contamination or odors it should not be used. Drain plugs should be sealed on the inside with duct tape.

7.2 Sample Packaging

7.2.1 Place plastic bubble wrap matting over the base of each cooler or shipping container as needed. A 2- to 3-inch thick layer of vermiculite may be used as a substitute base material.

7.2.2 Insert a clean trash bag into the cooler to serve as a liner.

7.2.3 Check that each sample container is sealed, labeled legibly, and is externally clean. Re-label and/or wipe bottles clean if necessary. Clear tape should be placed over the labels to protect them and keep them from falling off the container. Wrap each sample bottle individually with bubble wrap secured with tape or rubber bands. For aqueous samples in glass containers, each sample should be sealed in a zipper-lock bag to prevent leakage and cross-contamination in the case of breakage. Place bottles into the cooler in an upright single layer with approximately one inch of space between each bottle. Do not stack bottles or place them in the cooler lying on their side. If plastic and glass sample containers are used, alternate the placement of each type of container within the cooler so that glass bottles are not placed side by side.

7.2.4 Insert the cooler temperature blank supplied by the laboratory into each cooler (if any).

7.2.5 Place additional vermiculite, bubble wrap, and/or styrofoam pellet packing material throughout the voids between sample containers within each cooler to a level that meets the approximate top of the sample containers. Packing material may require tamping by hand to reduce the potential for settling.

7.2.6 Cubed ice in heavy duty zipper-lock plastic bags or loose ice may be used. Cold packs should be used only if the samples are chilled before being placed in the cooler.

7.2.7 Add additional bubble wrap/styrofoam pellets or other packing materials to fill the balance of the cooler or container.

7.2.8 Obtain two pieces of COC tape as shown in Figure 2 and enter the custody tape numbers in the appropriate place on the COC form (Figure 1). Sign and date the COC tape.

7.2.9 Complete the COC form per AECOM SOP No. 1007Pines – Chain-of-Custody Procedures. If shipping the samples involves use of a third party commercial carrier service, sign the COC record thereby relinquishing custody of the samples. Shippers should not be asked to sign COC records. If a laboratory courier is used, or if samples are transported to the laboratory by field personnel, the receiving party should accept custody and sign the COC records. Remove the last copy from the multi-form COC and retain it with other field notes. Place the original (with remaining copies) in a zipper-lock plastic bag and tape the bag to the inside lid of the cooler or shipping container.

7.2.10 Close the lid of the cooler or the top of the shipping container.

7.2.11 Place the COC tape at two different locations (i.e., one tape on each side) on the cooler or container lid and overlap with transparent packaging tape.

7.2.12 Packaging tape should be placed entirely around the sample shipment containers. A minimum of two full wraps of packaging tape will be placed at least two places on the cooler/container.

7.2.13 Repeat the above steps for each cooler or shipping container.

7.3 Sample Shipping

Transport the cooler/container to the package delivery service office or arrange for package pick-up at the site. Fill out the appropriate shipping form or airbill and affix it to the cooler/container. Some courier services may use multi-package shipping forms where only one form needs to be filled out for all packages going to the same destination. If not, a separate shipping form should be used for each cooler/container. The receipt for package tracking purposes should be kept in the project files, in the event a package becomes lost.

Each cooler/container also requires a shipping label that indicates point of origin and destination. This will aid in recovery of a lost cooler/container if a shipping form gets misplaced.

Never leave coolers/containers unattended while waiting for package pick-up.

Airbills or waybills will be maintained as part of the custody documentation in the project files.

7.4 Sample Receipt

Upon receipt of the samples, the analytical laboratory will open the cooler or shipping container and will sign "received by laboratory" on each COC form. The laboratory will verify that the COC tape has not been broken previously and that the tape number corresponds with the number on the COC record. The laboratory will note the condition of the samples upon receipt and will identify any discrepancies between the contents of the cooler/container and COC. The analytical laboratory will then forward the back copy of the COC record to the project Quality Assurance (QA) Officer to indicate that sample transmittal is complete.

8.0 DATA AND RECORDS MANAGEMENT

Documentation supporting sample packaging and shipment consists of COC records and shipping records. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

The potential for samples to break during transport increases greatly if individual containers are not snugly packed into the cooler. Packed coolers may be lightly shake-tested to check for any loose bottles. The cooler should be repacked if loose bottles are detected.

Environmental samples are generally shipped so that the samples are maintained at a temperature of approximately 4°C. Temperature blanks may be required for some projects as a quality assurance check on shipping temperature conditions. These blanks usually are supplied by the laboratory and consist of a 40-ml vial or plastic bottle filled with tap water. Temperature blanks should be placed near the center of the cooler.

10.0 REFERENCES

AECOM SOP No. 1007Pines – Chain-of-Custody Procedures. Revision 5.0.

FIGURE 1 - Example Chain of Custody Form

AECOM **CHAIN OF CUSTODY RECORD**

Page _1_ of _1_

Client/Project Name:	Project Location:		Analysis Requested
Project Number:	Field Logbook No.:		
Sampler (Print Name)/(Affiliation):	Chain of Custody Tape Nos.:		
Signature:	Send Report to:	TAT: Standard	

<u>Container Type</u>
P – Plastic
A – Amber Glass
G – Clear Glass
V – VOA Vial
O – Other
E – Encore

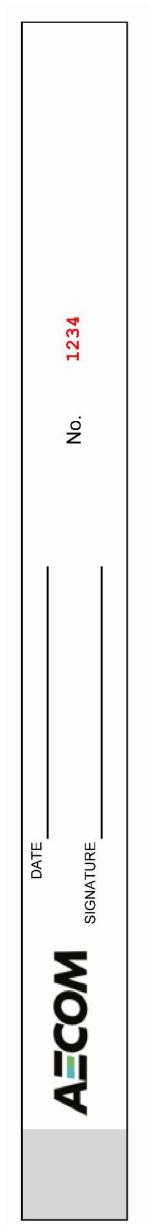
<u>Preservation</u>
1 – HCl, 4°
2 – H2SO4, 4°
3 – HNO3, 4°
4 – NaOH, 4°
5 – NaOH/ZnAc, 4°
6 – Na2S2O3, 4°
7 – 4°

<u>Matrix Codes:</u>
DW – Drinking Water
WW – Wastewater
GW – Groundwater
SW – Surface Water
ST – Storm Water
W – Water
S – Soil
SL – Sludge
SD – Sediment
SO – Solid
A – Air
L – Liquid
P – Product

Field Sample No./Identification	Date	Time	COMP	GRAB	Sample Container (Size/Mat'l)	Matrix	Preserv.	Field Filtered	Boron										Lab I.D.	Remarks

Relinquished by: (Print Name)/(Affiliation) Signature:	Date: Time:	Received by: (Print Name)/(Affiliation) Signature:	Date: Time:	Analytical Laboratory (Destination):
Relinquished by: (Print Name)/(Affiliation) Signature:	Date: Time:	Received by: (Print Name)/(Affiliation) Signature:	Date: Time:	
Relinquished by: (Print Name)/(Affiliation) Signature:	Date: Time:	Received by: (Print Name)/(Affiliation) Signature:	Date: Time:	Sample Shipped Via: UPS FedEx Courier Other Temp blank: Yes No

FIGURE 2 - Example Chain of Custody Tape



Decontamination of Field Equipment

SOP Number 7600Pines

Revision Number: 4.0

September 2013

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AECOM Project Manager
September 24, 2013

____
AECOM Project QA Officer
September 24, 2013

AECOM
September 2013
Pines Area of Investigation

CONTENTS

LIST OF ACRONYMS

FSP	Field Sampling Plan
HASP	Health and Safety Plan
IDW	Investigation Derived Waste
OSHA	Occupational Safety and Health Administration
QC	Quality Control
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
QAPP	Quality Assurance Project Plan

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the methods to be used for the decontamination of field equipment used in the collection of environmental samples. Field equipment for decontamination may include a variety of items used in the field for monitoring or for collection of soil, sediment, and/or water samples, such as water level meters, water quality monitoring meters (turbidity meter, multi-parameter meter), split-spoon samplers, trowels, scoops, spoons, and pumps. Heavy equipment such as drill rigs also requires decontamination, usually in a specially constructed temporary decontamination area.

Decontamination is performed as a quality assurance measure and a safety precaution. Improperly decontaminated sampling equipment can lead to misinterpretation of environmental data due to interference caused by cross-contamination between samples or sample locations through use of contaminated equipment. Decontamination also protects field personnel from potential exposure to hazardous materials on equipment.

This SOP emphasizes decontamination procedures to be used for decontamination of reusable field equipment. Dedicated or disposable equipment will not need to be decontaminated.

2.0 SUMMARY OF METHOD

Decontamination is accomplished by manually scrubbing, washing, or spraying equipment with detergent solutions, tap water, distilled/deionized water, and/or solvents.

Generally, decontamination of equipment is accomplished at each sampling site between collection points. Waste decontamination materials such as spent liquids and solids will be collected and managed as investigation derived waste (IDW) for later management and/or disposal (refer to procedures outlined in the Field Sampling Plan (FSP) or Sampling and Analysis Plan (SAP)). All decontamination materials, including wastes, should be stored in a central location so as to maintain control over the materials used or produced throughout the investigation program.

3.0 HEALTH AND SAFETY WARNINGS

Decontamination procedures may involve chemical exposure hazards associated with exposure to soil, water, or sediment and may involve physical hazards associated with decontamination materials. When decontamination is performed, adequate health and safety measures must be taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

4.0 INTERFERENCES

Equipment decontamination should be performed a safe distance away from the sampling area so as not to interfere with sampling activities, but close enough to the sampling area to maintain an efficient working environment.

5.0 PERSONNEL QUALIFICATIONS

Decontamination of field equipment is a relatively simple procedure requiring minimal training. It is recommended that the initial decontamination of field equipment be supervised by more experienced personnel. Field personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

It is the responsibility of field personnel to be familiar with the decontamination procedures outlined within this SOP, quality assurance, and health and safety requirements outlined within FSP, Quality Assurance Project Plan (QAPP), and HASP. Field personnel are responsible for decontamination of field equipment and for proper documentation in the field logbook.

6.0 EQUIPMENT AND SUPPLIES

General field supplies include the following items:

- Decontamination agents (which are specified in the FSP):
  - DETERGENT8®, or other non-phosphate and non-borate biodegradable detergent;
  - Tap water;
  - Distilled/deionized water; and/or
  - 10% nitric acid solution.
- Health and safety supplies (as required by the HASP)
- Chemical-free paper towels
- Waste storage containers: drums, 5-gallon buckets with covers, plastic bags
- Cleaning containers: plastic buckets or tubs
- Cleaning brushes

- Pressure sprayers
- Squeeze bottles
- Plastic sheeting
- Aluminum foil
- Zipper-lock bags
- Approved plans (e.g., HASP, QAPP, FSP)
- Field project logbook/pen

7.0 METHODS

7.1 General Preparation

7.1.1 New materials, such as well materials, are generally assumed to be clean and decontamination is not anticipated. However, they should be inspected and if they appear to be dirty, should be decontaminated.

Field equipment that is not frequently used should be wrapped in aluminum foil, shiny side out, and stored in a designated "clean" area. Small field equipment can also be stored in zipper-lock plastic bags to eliminate the potential for contamination. Field equipment should be inspected and decontaminated prior to use if the equipment appears dirty.

7.1.2 Heavy equipment (drill rigs, Geoprobes®, excavators) should be decontaminated upon arrival at the Area of Investigation, prior to beginning any work.

7.1.2 A decontamination station will be established within an area that is convenient to each sampling location. If single samples will be collected from multiple locations, then a centralized decontamination station or a portable decontamination station may be established.

7.1.3 One or more IDW containment stations should be established at this time also. In general, decontamination solutions are discarded as IDW between sampling locations.

7.2 Decontamination for Inorganic (Metals) Analyses

7.2.1 This procedure applies to equipment used in the collection of environmental samples submitted for inorganic constituent analysis. Examples of relevant items of equipment include split-spoons, trowels, scoops/spoons, and other small items. Submersible pump decontamination procedures are outlined in Section 7.4.

7.2.2 Decontamination is to be performed before sampling events and between sampling points, unless otherwise noted in the FSP or SAP.

7.2.3 After a sample has been collected, remove all gross contamination from the equipment or material by brushing and then rinsing with available tap water. This initial step may be completed using a 5-gallon bucket filled with tap water. A water pressure sprayer may also be used to remove solids and/or other contamination.

7.2.4 Wash the equipment with a non-phosphate and non-borate detergent and tap water solution. This solution should be kept in a 5-gallon bucket with its own brush.

7.2.5 Rinse with tap water or distilled/deionized water until all detergent and other residue is washed away. This step can be performed over an empty bucket using a squeeze bottle or pressure sprayer.

7.2.6 Rinse with 10% nitric acid.

7.2.7 Rinse with distilled/deionized water to remove any residual acid.

7.2.8 Allow the equipment to air-dry in a clean area or blot with chemical-free paper towels before reuse. Wrap the equipment in aluminum foil with the shiny side out and/or seal it in a zipper-lock plastic bag if it will not be reused immediately.

7.2.9 Dispose of soiled materials and spent solutions in the designated IDW disposal containers.

7.3 Decontamination of Submersible Pumps

7.3.1 This procedure will be used to decontaminate submersible pumps before and between groundwater sample collection points. This procedure applies to both electric submersible and bladder pumps. This procedure does not apply to discharge tubing if it will be reused between sampling points (see section 7.3.8 below).

7.3.2 Prepare the decontamination area if pump decontamination will be conducted next to the sampling point. If decontamination will occur at another location, the pump may be removed from the well and placed into a clean trash bag for transport to the decontamination area. Pump decontamination is easier with the use of 3-foot tall pump cleaning cylinders (i.e., Nalgene cylinder) for the various cleaning solutions, although the standard bucket rinse equipment may be used.

7.3.3 Once the decontamination station is established, the pump should be removed from the well and the discharge tubing and power cord coiled by hand as the equipment is removed. If any of the equipment needs to be put down temporarily, place it on a plastic sheet (around well) or in a clean trash bag. If a disposable discharge line is used it should be removed and discarded at this time.

7.3.4 As a first step in the decontamination procedure, use a pressure sprayer with tap water to rinse the exterior of the pump and power cord as necessary. Collect the rinsate and handle as IDW.

7.3.5 Place the pump into a pump cleaning cylinder or bucket containing a detergent solution (phosphate-free, borate-free detergent in tap water). Holding the power cord, pump solution through the pump system. A minimum of one gallon of detergent solution should be pumped through the system. Collect the rinsate and handle as IDW.

7.3.6 Remove the pump from the cylinder/bucket and if the pump is reversible, place the pump in the reverse mode to discharge all removable water from the system. If the pump is not reversible the pump and discharge line should be drained by hand as much as possible. Collect the rinsate and handle as IDW.

7.3.7 Using a pressure sprayer with distilled/deionized water, rinse the exterior of the pump and power cord thoroughly, shake all excess water, then place the pump system into a clean trash bag for storage. If the pump system will not be used immediately, the pump itself should be wrapped with aluminum foil before placing it into the bag.

7.3.8 If tubing will be reused between locations, the tubing will also need to be decontaminated. The tubing will remain attached to the pump and the decontamination steps (7.3.4 through 7.3.7) above will be followed. Additional volume of rinsate and distilled/deionized water will be used to compensate for the volume within the tubing. At a minimum, the volume of rinsate should be three times the capacity of the tubing.

7.4 Decontamination of Large Equipment

7.4.1 A temporary decontamination pad may be established for decontamination of heavy equipment. This pad may include a membrane-lined and bermed area large enough to drive heavy equipment (e.g., drill rig, backhoe) onto with enough space to spread other equipment and to contain overspray. Usually a small sump is necessary to collect and contain rinsate (a pump is used to remove these wastes from the sump). A water supply and power source is also necessary to run steam cleaning and/or pressure washing equipment.

7.4.2 Upon arrival at the Area of Investigation, all heavy equipment (such as drill rigs) should be thoroughly cleaned. This can be accomplished by steam cleaning or high pressure water wash and manual scrubbing.

Between each sample location (i.e., between boreholes), heavy equipment that has been in the ground must be cleaned by steam cleaning or high pressure water wash and manual scrubbing. This may be performed at the decontamination pad or in the vicinity of the drilling location.

8.0 DATA AND RECORDS MANAGEMENT

Specific information regarding decontamination procedures should be documented in the project-specific field logbook. Documentation within the logbook should thoroughly describe the construction of any decontamination facility and the decontamination steps implemented in order to show compliance with the FSP or SAP. Decontamination events should be logged when they occur with the following information documented:

- Date, time, and location of each decontamination event
- Equipment decontaminated
- Method
- Solvents and/or acids used
- Notable circumstances
- Identification of equipment rinsate blanks
- Management of decontamination fluids
- Method, date, and time of equipment blank collection
- Disposition of IDW

Repetitive decontamination of small items of equipment does not need to be logged each time the item is cleaned.

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

General guidelines for quality control check of field equipment decontamination usually require the collection of quality control (QC) samples such as equipment rinsate blanks. These requirements should be outlined in the QAPP and FSP or SAP.

Equipment rinsate blanks are generally made by pouring laboratory-supplied deionized water into, over, or through the freshly decontaminated sampling equipment and then transferring this water into a sample container. Equipment rinsate blanks should then be labeled as a sample (as per the QAPP and FSP) and submitted to the laboratory to be analyzed for the same parameters as the associated sample, or an appropriate subset thereof. Equipment rinsate blank sample numbers, as well as collection method, time and location should be recorded in the field logbook.

10.0 REFERENCES

Not applicable.

Surface Soil Sampling

SOP Number 7110Pines

Revision Number: 2.0

September 2013

AECOM Project Manager
September 24, 2013

AECOM Project QA Officer
September 24, 2013

AECOM
September 2013
Pines Area of Investigation

Surface Soil Sampling

CONTENTS

LIST OF ACRONYMS

HASP	Health and Safety Plan
IDW	Investigation-derived Waste
MS/MSDs	Matrix spike/matrix spike duplicates
OSHA	Occupational Safety and Health Adminstration
QAPP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure

Surface Soil Sampling

1.0 SCOPE AND APPLICABILITY

This standard operating procedure (SOP) describes the method used for obtaining surface soil samples at the Pines Site for analysis of inorganic parameters. The purpose of this SOP is to provide a specific method and/or procedure to be used in the collection of surface soil samples which, if followed properly, will promote consistency in sampling and provide a basis for sample representativeness.

This SOP is generally applicable to surface and shallow depth soils which are unconsolidated and are of low to moderate density. Higher density or compacted soils may require use of drill rigs or other powered equipment to effectively obtain representative samples.

2.0 SUMMARY OF METHOD

Surface soil sampling generally involves use of hand-operated equipment to obtain representative soil samples from the ground surface and or from shallow depths below the ground surface exposed by excavating equipment. If soil conditions are appropriate, surface soil sampling, following the procedures described in this SOP, can provide representative soil samples in an efficient manner.

3.0 HEALTH AND SAFETY WARNINGS

Surface soil sampling may involve chemical exposure hazards associated with the type of contaminants present in surface soil. When surface soil sampling is performed, adequate Health and Safety measures must be taken to protect sampling personnel. These measures must be addressed in the project Health and Safety Plan (HASP). This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing sampling, and must be adhered to as field activities are performed.

4.0 INTERFERENCES

Potential interferences could result from cross contamination. Minimization of the cross contamination will occur through the following:

- The use of clean, disposable plastic sampling tools at each location.

- Avoidance of material that is not representative of the media to be sampled. Material that has been in contact with the excavator bucket will not be sampled.

5.0 PERSONNEL QUALIFICATIONS

Surface soil sampling is a relatively simple procedure requiring minimal training and a relatively small amount of equipment. It is, however, recommended that initial attempts be supervised by more experienced personnel. Sampling personnel should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

6.0 EQUIPMENT AND SUPPLIES

6.1 Spoons, Scoops and/or Hand Auger

Commercially purchased plastic spoons or scoops may be utilized to collect the samples to be analyzed for inorganic parameters. These tools will be dedicated to each sampling location and will be discarded after use. A hand auger may be used to sample depths greater than one foot in depth and in areas requiring additional sampling volume. Non-disposable equipment shall be decontaminated after use in accordance with AECOM SOP 7600Pines – Decontamination of Field Equipment.

6.2 Collection Bowl

A plastic bowl will be used as the intermediate sample container between removal of the sample from the ground and containerization of the sample. Plastic bowls may be purchased new and dedicated to each sample location. Non-disposable equipment shall be decontaminated after use in accordance with AECOM SOP 7600Pines – Decontamination of Field Equipment.

6.3 Supporting Materials

- Sample kit (i.e., bottles, labels, custody records, cooler, etc.)
- Sample logs/boring logs
- Six-foot folding rule or tape measure for depth measurement
- Personal protective equipment (as required by the HASP)
- Field project notebook/pen

7.0 METHODS

7.1 Equipment Decontamination

Non-disposable sampling equipment (e.g., hand auger) will be decontaminated in accordance with AECOM SOP No. 7600Pines – Decontamination of Field Equipment prior to sampling and between sampling locations. When possible, clean, plastic equipment (trowels or spatulas and bowls) will be dedicated to each sample location and will be disposed of after each use.

7.2 Geologic Logging

Geologic materials recovered may be logged (if applicable) in accordance with the Unified Soil Classification System (USCS) protocols (see, for example, USEPA, 1991). Geologic descriptions will be entered on a surface soil sampling log (see Figure 1). Specific information to be recorded on the log may include:

- Location identification and/or description
- Geologist/field personnel name
- Date
- Equipment
- Total depth of sample

Additional geologic description information to be recorded may include:

- Moisture content
- Color
- Grain-size
- Sorting
- Density
- Plasticity
- Other relevant observations

In accordance with Indiana Department of Environmental Management (IDEM) guidance (IDEM, 1988), additional information may also be recorded, such as U.S. Department of Agriculture (USDA) soil classification, rounding, effervescence, mineralogy, and bedding. Additional information concerning geologic logging protocols is attached to this SOP.

7.3 Discrete Sampling Procedure

7.3.1 Insert the sampling tool into the soil and rotate the tool so that a representative "column" of soil is removed from the ground. One or more scoops of material may be needed until the desired sample volume is achieved.

7.3.2 Place each scoop into an intermediate sample container (plastic bowl) until sufficient sample volume is collected.

7.3.3 Once sufficient material has been collected, thoroughly homogenize the sample within the collection pan prior to bottling. Sample homogenizing is accomplished by manually mixing the entire sample in the collection pan with the sampling tool until a uniform mixture is achieved.

7.3.4 Fill the sample containers with material from the plastic bowl. The sampling tool may be used to fill the sample bottles. Use of fingers/hands to fill or pack sample containers is not allowed.

7.4 Composite Sampling Procedure

7.4.1 Insert the sampling tool into the soil and rotate the tool so that a representative "column" of soil is removed from the ground.

7.4.2 Place scoop into an intermediate sample container.

7.4.3 Move to additional composite sampling location(s) as needed and repeat the above two steps until the sufficient number of composite samples and volume have been reached.

7.4.4 Once sufficient material has been collected, thoroughly homogenize the sample within the collection pan prior to bottling. Sample homogenizing is accomplished by manually mixing the entire sample in the collection pan with the sampling tool until a uniform mixture is achieved.

7.4.5 Fill the sample containers with material from the plastic bowl. The sampling tool may be used to fill the sample bottles. Use of fingers/hands to fill or pack sample containers is not allowed.

7.5 Sample Handling and Preservation

7.5.1 Once each sample container is filled, clean the rim and threads of the sample container by wiping with a paper towel.

7.5.2 Cap and label the container with the sample identifier, sampling date and time, preservation information, and analytical tests.

7.5.3 Place the sample containers into a cooler and maintain on ice.

7.5.4 Complete sample chain-of-custody and other documentation per SOP 1007Pines.

7.5.5 Package the samples for shipment to the laboratory per SOP 7510Pines.

7.5.6 Handle any investigation-derived waste (IDW) per the SAP.

8.0 DATA AND RECORDS MANAGEMENT

Various forms are required to ensure that adequate documentation is made of the sample collection activities. These forms include:

- Field log books
- Sample collection records
- Chain-of-custody forms
- Shipping labels

The field book will be maintained as an overall log of all samples collected throughout the study. Sample collection records are generated for each sample collected and include specific information about the sample (Figure 1). Chain-of-custody forms are transmitted with the samples to the laboratory for sample tracking purposes. Shipping labels are required if sample coolers are to be transported to the laboratory by a third party (courier service). Original and/or copies of these documents will be retained in the appropriate project files.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

- Collection of representative samples will be ensure through adherence to the procedures in this SOP and the sampling strategy outlined in the Sampling and Analysis Plan (SAP).
- The field quality control samples identified in the SAP must be collected. These samples include field duplicates and matrix spike/matrix spike duplicates (MS/MSDs)

10.0 REFERENCES

SOP 1007Pines. Chain-of-Custody Procedures.

SOP 7510Pines. Packaging and Shipment of Environmental Samples.

SOP No. 7600Pines. Decontamination of Field Equipment

AECOM Health and Safety Policy and Procedures Manual.

FIGURE 1 Surface Soil Sample Log

Surface Soil Sampling Log

AECOM

PROJECT:	SURFACE SOIL ID:
	LOCATION OF SAMPLE:
	DATE: GPS:

ELEV.	Depth (feet)	U.S.C.S.	Description of Materials (color, grain size, sorting, etc.)	Remarks (sample time, sample depth, etc.)
0.0	0		Ground Surface	Time: Sample Depth:
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			

Staff:

Appendix D

Response to Comments

Appendix D

Responses to USEPA Comments Dated January 15, 2014

GENERAL COMMENTS

1. The Draft Supplemental Soil Characterization (SSC) Work Plan does not clearly indicate how many samples / surveys of what type will be collected. A table and text clearly providing this information would enhance the understanding of the intended sampling.

   Response: A table indicating the numbers and sampling/investigation types has been added to Section 3.1.

2. The Draft SSC Work Plan does not discuss circumstances under which the proposed activities (particularly the gamma survey) may need to be postponed.

   Response: AECOM has prepared a new subsection, 4.1.3, Work Restrictions, that addresses the field conditions under which gamma surveys would be postponed. These include weather events such as rain and snow.

   Section 1.3.1 also indicates that field work will not commence until all access agreements are in place.

3. Any changes/corrections made to address the specific comments (SCs) below should also be made to the appropriate sections of the Quality Assurance Project Plan (QAPP) in Appendix B of the Draft SSC Work Plan as well as any relevant Appendices.

   Response: Agreed, included with this response to comments is a Revision 1 version of the QAPP with the changes incorporated.

SPECIFIC COMMENTS

1. **Page 1-3, Section 1.3, second paragraph:** The intent of the phrase “specific sampling for radionuclides” should be explained.

   The Draft SSC Work Plan states: “Gamma surveys are typically used as screening tools to determine whether or not specific sampling for radionuclides is needed.” This should be revised to “Gamma surveys can be designed to collect gamma dose and gamma count rate information to support decisions regarding the collection of radionuclide samples.”

   The Draft SSC Work Plan states: “The purpose of including the gamma surveys here is to provide a comparison to gamma surveys conducted by the community; the results of the SSC surveys will be used to guide the selection of some of the soil sampling described in this work plan.” The gamma surveys, with sodium iodide (NaI) count rate and gamma dose rate measurements collected at background locations and investigation areas, should also help allay public concerns regarding risk due to naturally occurring radioactive materials (NORM) in coal combustion byproduct (CCB) materials.

   The Draft SSC Work Plan states: “The analytical results from these samples will be used to evaluate potential risks at these locations.” The receptors evaluated should be those considered in the HHRA, including a recreational user (such as a child at a park) and a construction worker performing excavation work in 100% CCB materials (both surface and subsurface activities).

Response: The requested changes have been made. Note that the second part of the comment provides the clarification requested in the first.

2. **Page 1-4, Section 1.3.1, first paragraph:** Section 1.3.1 discusses access agreements. The third full sentence states: "Where feasible, sample locations will be selected within public rights-of-way." As stated elsewhere in the Draft SSC Work Plan (for example, Sections 1.3.2 through 1.3.4), gamma surveys, coal combustion by-product (CCB) verification, and private property soil sampling will be conducted across all of each residential property. Sample locations cannot be restricted to the public rights-of-way for residential properties. Section 1.3.1 should be revised to clarify any discussion of substitution of other suitable properties (with EPA's approval) or the potential limiting of sample locations. Every effort should be made to gain access to the individual properties. The intent of the access agreement should explain that this supplemental soil characterization is a one-time event and if a property owner declines/refuses access for characterization, there will not be an opportunity to have the property characterized at a later time.

   Response: The preference for sample locations in rights-of-way applies to CCB visual inspection verification samples only. However, due to the confusion and the fact that the visual inspection verification sample locations have already been identified, this text has been removed from the document.

3. **Page 1-4, Section 1.3.2:** The stated objective of conducting gamma surveys is to establish a distribution of responses for the background areas and then to compare the background responses to the property specific distribution of responses to identify if there are any significant differences between the property specific and background surveys. Please explain how distributions of responses will be used if a background value and a numerical standard for total radium concentration above background are used.

   Response: As agreed with USEPA, data collected in the field will be recorded and documented, but to keep the data collection process objective, the data will not be reviewed in the field. Thus, no actions will be taken in the field based on subject property surveys (e.g., sampling, marking areas, communicating with the public, etc.). Therefore, there will be no numerical "decision levels" applied in the field based on measurements above background or total radium concentrations. At the completion of the gamma surveys, the data will be reviewed in conjunction with USEPA to determine whether additional actions, such as sampling, may be warranted.

   A paragraph was added to the end of Section 1.3.2 clarifying this.

4. **Page 1-4, Section 1.3.2:** This section does not indicate the number of gamma surveys planned. To be consistent with Sections 1.3.3 and 1.3.4.2, the number of gamma surveys planned should be clearly indicated.

   Response: Text was added to the first paragraph of Section 1.3.2 providing estimated numbers of surveys and noting that gamma surveys will be performed on each of the properties where access is provided.

5. **Page 1-4, Section 1.3.4, fourth paragraph:** The Draft SSC Work Plan discusses the collection of 5-point composite samples. The Incremental Sampling Methodology (ISM) should be considered. ISM is a structured composite sampling and processing protocol that reduces data variability and provides a reasonable estimate of a chemical's mean concentration for the volume of soil being sampled. More information can be found at the following Interstate Technology & Regulatory Council (ITRC) web links:

   - http://www.itrcweb.org/Team/Public?teamID=11

- http://www.itrcweb.org/Documents/ISM-InformationSheet_All_audiences.pdf

Response: In developing the original sampling plan, ISM was considered as one possible approach. However, the proposed quadrant approach was selected because it had been used by USEPA on a similar project in Region 5, and because ISM has the potential to be extremely intrusive on a residential property, depending on the numbers of depth of increments. Moreover, the ISM approach does not accommodate the judgmental sampling at play areas, gardens, and driveways where CCBs have been used. Text has been added to Section 3.4.2 to indicate this. These factors were discussed with USEPA during a meeting on January 31, 2014, and it was decided to retain the proposed sampling approach in the SSC Work Plan.

6. **Page 1-4, Section 1.3.4, fifth paragraph:** Section 1.3.4 discusses the proposed private property soil sampling. In the first sentence of Paragraph 5, the phrase "gamma radiological assessment results" is used. This phrase is not previously been defined. As discussed in Section 1.3.2, two types of gamma surveys will be conducted at each residence: a sodium iodide (NaI) gamma walk-over survey and a gamma dose rate survey. It is not clear if the phrase "gamma radiological assessment results" is meant to be the results from the two types of gamma surveys or something else. Section 1.3.4 should be revised to clearly define the phrase "gamma radiological assessment results."

   Response: The text has been deleted from this section.

7. **Page 1-5, Section 1.3.4.1, second paragraph:** Section 1.3.4.1 discusses the identification of analytical constituents. The second paragraph describes the step-wise process for identifying constituents of concern (COC) as "very conservative." The qualifier "very" is subjective; while some may consider the process "very conservative," others may consider the process conservative in a reasonably health-protective manner. Therefore, the qualifier "very" should be removed from the subject sentence.

   Response: "Very conservative" has been revised to "conservative."

8. **Page 1-6, Section 1.3.4.1, first full paragraph:** When samples are sent to a laboratory for analysis, specific reporting of the following radionuclides should be requested:

   - Gamma-emitting NORM radionuclides associated with CCBs: Uranium-238 series, Thorium-232 series, Uranium-235 series, and Potassium-40.
   - Man-made and longer lived radionuclides not associated with coal that, if present, could contribute to elevated gamma dose rate and count rate: Cs-137 and Cobalt-60.

   Count times should be sufficient to provide minimum detectable activities equal to 10% to 50% of normal background values for each of the individual radionuclides. Analysis and reporting by the lab for each sample should be sufficient to declare whether the above-mentioned radionuclides are present or absent at levels above typical background values, with sufficient measurement durations so that the reported measurement uncertainties for each radionuclide are reasonable and less than their respective reported activities.

   Also, this section requires editing to eliminate the use of terms for which acronyms have previously been supplied. Acronyms are also supplied again for the terms and then not subsequently used.

   Response: Select gamma emitting NORM radionuclides associated with the U-238 series, Th-232 series, and U-235 series, plus some additional non-NORM (e.g., Potassium-40 (K-40) will be reported by the laboratory. Details are provided in Appendix B, the QAPP. The EPA approved gamma spectroscopy library supplied by the laboratory (GEL) is provided in the QAPP (Attachment B of Appendix B).

The second part of the comment concerning count times and MDCs has been addressed in the updated QAPP (Appendix B).

9. **<u>Page 1-6, Section 1.3.4.1:</u>** In the first full paragraph, Table 1 is referenced as providing the preliminary remediation goals (PRGs) and background threshold values (BTVs) for the constituents of potential concern (COPCs). The BTV for the sum of Radium-226 and 228 is not presented in the table, but instead is provided in the footnote to the table. The BTV should be presented in the table. Additionally, footnote (e) referenced footnote (c); however, it should reference footnote (d).

   Response: Table 1 has been revised; note that the radionuclide PRGs were slightly updated in the FS, and those are presented here.

10. **<u>Page 1-6, Section 1.3.4.2:</u>** Section 1.3.4.2 discusses the identification of soil sampling locations. This section must be revised per the revisions identified for Appendix A of the Draft SSC Work Plan.

    This section is confusing as it lists the COPC then the number of residents to sample. This section implies that each property will be analyzed for different COPCs. For example, only nine properties will be analyzed for Arsenic, and only five properties will be analyzed for Radium 228. This is not the intent of the sampling program, and this section should be revised to more clearly explain and justify the number of properties to be sampled for chemical and radionuclide analyses.

    In addition to the identified locations, soil should be sampled wherever the gamma survey indicates radium concentrations are likely in excess of a value agreed upon with the EPA. In a previous section, the plan states that a complete library of gamma emitting naturally-occurring radioisotopes plus Cs-137 will be used. In this paragraph, it appears that the plan is saying that small and different numbers of samples will be analyzed for each radionuclide. Each sample should be analyzed for all the radionuclides in the complete library of gamma emitting naturally-occurring radioisotopes plus Cs-137.

    Response: See response to Comment 41. In addition, there was no intention to collect a different number of samples for different parameters. The language has been clarified in the revised plan.

    As previously discussed and agreed with USEPA, the criteria and need for additional discrete samples to be analyzed for radiological parameters will be determined in consultation with USEPA based on the results of the gamma surveys. This approach was discussed and confirmed with USEPA during a meeting on January 31, 2014.

11. **<u>Page 3-1, Section 3.1:</u>** This section describes the sampling / investigation locations. The associated Figure 1 does not clearly show all of the locations, primarily due to labels overlapping and scale issues. The use of call-out boxes for areas where points are overlapping should be considered. Figure 1 should be revised so that it clearly shows where the proposed sampling locations are. Additionally, it may be beneficial to provide a separate map of the proposed gamma survey locations, as was done for the proposed CCB sample locations, to provide a clear distinction between the two types of sampling.

    The plan should commit to collecting soil samples at the specified locations and at locations where the count rates indicate concentrations of radium in soil exceeding an agreed-upon value.

    Response: Figure 1 has been revised as recommended. Figure 1 shows all investigation locations. The existing Figure 4 shows the CCB visual inspection verification sample locations. A new Figure 7 shows the background gamma survey locations. A new Figure 8 shows the gamma survey locations based on the third-party gamma survey report. A new Figure 9 shows the properties were CCBs were identified in the RI CCB visual inspection program.

As previously discussed and agreed with USEPA, the criteria and need for specific samples to be analyzed for all COPCs will be determined in consultation with USEPA based on the results of the gamma surveys. This approach was discussed and confirmed with USEPA during a meeting on January 31, 2014.

12. **Page 3-1, Section 3.2.1:** As stated previously, if a specific standard is agreed upon, the objective of the gamma survey shall include identifying properties where gamma surveys indicate that the standard may potentially be exceeded.

    Response: As previously discussed and agreed with USEPA, the criteria and need for discrete samples to be analyzed for radiological parameters will be determined in consultation with USEPA based on the results of the gamma surveys. This approach was discussed and confirmed with USEPA during a meeting on January 31, 2014.

13. **Page 3-2, Section 3.2.2, second paragraph:** The Draft SSC Work Plan refers to "short-lived *decay daughters* of Ra-226 and Ra-228…" – please use the terminology "decay products" instead of "decay daughters.

    Response: "Decay products" has been used in place of "decay daughters."

14. **Page 3-2, Section 3.2.2, third paragraph:** The Draft SSC Work Plan discusses using a survey meter and detector "calibrated to optimize detector efficiency for the gamma energies associated with Ra-226 and its decay progeny." This phrase should be revised to read "calibrated to optimize detector efficiency for the gamma energies associated with the decay progeny of Ra-226, where Pb-214 and Bi-214 are generally regarded as the notable gamma emitters."

    Response: The last three paragraphs of Section 3.2.2 were significantly revised. The revised text incorporates the recommended edits.

15. **Page 3-2, Section 3.2.2:** The third paragraph indicates that each survey unit will receive 100% gamma walk-over coverage with a 2-inch by 2-inch NaI detector. This statement implies that every square inch of the survey unit will be covered during the gamma survey. This statement appears to be contradicted by the statement in the fifth paragraph, which indicates that the survey will be divided into 1-meter transects. This discrepancy should be resolved.

    Response: The last three paragraphs of Section 3.2.2 were significantly revised. The walk-over survey method described is consistent with the survey methods described in MARSSIM that provide 100% coverage of outside areas. However, to provide additional assurance of complete coverage, the transect width was reduced to 2 feet. Also, "100%" has been replaced with "complete."

16. **Page 3-2, Section 3.2.2:** The second sentence in the third paragraph states that the "minimum detectable activity goal is 2.5 pCi/g Ra-226 above background concentrations." Please define which background concentrations will be used (e.g., gamma-surveyed background concentrations or BTVs).

    Response: The revised Section 3.2.2 describes how the ambient background rate for each detector will be used to determine the minimum detectable count rate (MDCR) and the MDCR will be correlated to the approximate Ra-226 concentration in soil based on the measurements that will be made at the former Kerr McGee site in West Chicago.

17. **Page 3-2, Section 3.2.2, third paragraph:** This paragraph in this section references NuReg-1507. Draft NuReg-1507 describes minimum detectable concentrations that could be measured with typical survey instruments. The NuReg, never issued in a final form, describes using a different size detector, a Victoreen Model 489-55 3.2 cm x 3.8 cm detector and a survey meter that did not exist, a

Ludlum Model 12 ratemeter-scaler, for gamma surveys. The NuReg was based upon subjective interpretations of data by surveyors. It may be appropriate to establish a meter/detector-specific counts per minute (cpm) equivalent to an agreed upon number (e.g. 5 pCi/g) above background for total radium, and use that cpm equivalent as an indicator for the potential of exceedance of the total radium PRG.

Measurement depends upon many factors including the dimensions of the detector, whether or not it is shielded, the instrument background, the ambient background, and the detector and instrument resolving times. This requires interpretation of meter readings by a user to determine whether or not a value is exceeded. Using the audible output as the surveyor is frequently the most reliable survey technique particularly when investigating off-transect areas. Most human ears are far more sensitive to changes in count rate than the statistical methods suggest. Using audible output as an indicator of elevated concentrations can produce a lower MDC, less than 1 pCi per gram above background.

Response: According to the cover page of NUREG-1507 and the reference for NUREG-1507 in MARSSIM, the document was finalized by the NRC in 1997. However, the reference was changed to MARSSIM as the same methods are described in both guidance documents.

To maintain an unbiased collection of data and to reduce the impact of non-independent measurements, survey technicians will turn off the audible response of the detector during the surveys. Therefore, only processed data will be used to identify potentially elevated areas of radioactivity. Survey technicians will make detailed sketches of each subject property and identify the location of different types of groundcovers (e.g., grass, concrete, gravel, pavers, mulch, etc.). This is noted in the revised text of Section 3.2.2

18. **Page 3-2, Section 3.2.2, fourth paragraph:** The Draft SSC Work Plan states that, "NaI detectors will be calibrated by the manufacturer or a rental vendor who specializes in radiation survey equipment to optimize detector efficiency for the gamma energies associated with Ra-226 and its decay progeny." This phrase should on one hand be revised for technical accuracy to "NaI detectors will be calibrated by the manufacturer or a rental vendor who specializes in radiation survey equipment to optimize detection efficiency for the gamma energies associated with the decay progeny of Ra-226, where Pb-214 and Bi-214 are generally regarded as the notable gamma emitters." However, if such a calibration is expected to be performed, please specify the company that will be performing this calibration and provide the calibration procedure the company will follow.

    Response: The text has been revised as recommended in the first part of the comment. AECOM will rent survey equipment from ERG in Albuquerque, NM. ERG will send their instruments to Ludlum for calibration. The purchase order with ERG is in place, and the instruments have been sent to Ludlum for calibration. AECOM has requested Ludlum's calibration procedures for USEPA to review.

19. **Page 3-2, Section 3.2.2:** The fifth paragraph indicates that, when the gamma survey is made while walking, the survey will be done in a serpentine pattern. Clarify whether or not a serpentine pattern will be used if survey buggies are used to conduct the survey and how 100% coverage of the property will be conducted with the use of a buggy.

    Response: The last three paragraphs of Section 3.2.2 were significantly revised. The revised text describes the differences in the survey types (buggy/cart or no buggy/cart).

20. **Page 3-2, Section 3.2.2, fifth paragraph:** The Draft SSC Work Plan states that a surveyor will be "walking at a pace of about 1 meter per second (m/s)" – the pace should be 0.5 to 1 m/s to accommodate the minimum detectable concentration (MDC) required.

The stated minimum detection goal should be expressed as a minimum detectable concentration (MDC) rather than as the minimum detectable activity in this section. The MDC goal should be for total radium rather than for Ra-226. Ra-226 appears throughout this section and should be corrected to read total radium.

The gamma survey walk-over surveys are unlikely to be capable of detecting radium-226 and radium-228 at concentrations expected to be relevant to these surveys. The surveys will quantify concentrations of those radionuclides through the use of surrogates (gamma emitting decay products of Ra-226 and Ra-228).

The described Ludlum Measurements, Inc. (Ludlum) Model 44-10 detector moved at 1 meter per second (m/s) may not be able to meet what should be the stated detection goal, 2.5 pCi/g total radium above the background concentration. The Ludlum web site has a link to a calculator, http://www.radprocalculator.com/ScanMDC.aspx, that provides the MDC for count rate survey meters. The MDC using the calculator could be in excess of 5 pCi/g total radium above background for the instrumentation described in the plan. A gamma survey may be more effective when it depends upon subjective evaluation of the instrument's audible output. Surveyors can be much more sensitive to changes in audible output than to analog or digital count rates.

Response: The last three paragraphs of Section 3.2.2 were significantly revised. The revised text directs technicians to use a slower pace during the walkover surveys if necessary to meet the MDC goal. Also, as previously stated, survey technicians will not listen to the audible detector response so that the surveys produce data points that are as independent as possible. All data will be analyzed both visually and statistically after the data are transmitted to the data analyst.

21. **Page 3-3, Section 3.2.3:** This section describes the Gamma Dose Rate Survey and defines a survey unit area as 2,000 square meters (m^2). However, there is no explanation of why the survey unit was chosen to be 2,000 m^2, even though the much-cited 40 *Code of Federal Regulations* (CFR) 192 standard uses 100 m^2. The use of 2,000 m^2 should be supported.

Response: AECOM used MARSSIM as a guide for determining the maximum size of the "survey unit." The text has been edited to clarify this. MARSSIM allows Class 1 land areas to be up to 2000 m^2. Considering the basis of the survey is to document site conditions and not demonstrate a successful cleanup, the MARSSIM guidance is considered sufficient. Also, see the response to SC #24 below. From MARSSIM (emphasis added):

"Survey units should be limited in size based on classification, exposure pathway modeling assumptions, and site-specific conditions. The suggested areas for survey units are as follows:

Classification	Suggested Area
Class 1 Structures	up to 100 m^2 floor area
Land areas	up to 2,000 m^2"

22. **Page 3-3, Section 3.2.3:** The use of a tissue equivalent gamma dose rate meter is appropriate. However, the attached SOP 007 describes measuring dose rate with an instrument, the Ludlum Model 19, which is not a dose rate instrument and is known to be highly energy dependent. Also, there is nothing in the SOP regarding the following:

- At a given survey location, allowing the meter to stabilize for approximately 15 to 30 seconds before collecting instrument readings.
- The Thermo Scientific™ Micro Rem meter has a mechanical dial (analog needle rather than a digital display), so the proper way to measure for data recording purposes is to determine the

average meter reading by collecting 10 instantaneous readings and calculating the average; then recording this average reading on the relevant data collection form. The 10 reading method will provide a more accurate meter reading that having the operator "eyeball" an average meter reading.

This section states that a daily dose response check, typically with the Cs-137 source, will be performed. The plan should describe how Department of Transportation regulations will be satisfied when the source is transported.

This section states: *"Given a probability factor assumed to be 0.92 (based on an assumed standard deviation of survey data), and acceptable Alpha/Beta decision factors chosen to be 1.645, the number of survey locations per survey unit is preliminarily estimated to be 10. The actual number of survey point locations (N) will be calculated during field activities based on the actual standard deviation of the data measured in the field."*

So what this implies is that you'll start with N=10, use that to determine "L" (the distance between survey locations on a triangular grid), collect a survey unit worth of data at 10 locations, then use the actual standard deviation of the data measured to calculate an "actual number of survey point locations." Please elaborate.

Response: It should be noted that the reviewer was not provided the most current revisions of SOP 001 and SOP 011 and these SOPs are not intended to be project-specific. Not all discussions in the SOPs are applicable to the Pines project. However, SOP 007 has been revised to include a tissue equivalent gamma dose rate meter and SOP 011 was revised to include the reviewer's comments in the bullets.

AECOM will only use exempt radioactive sources in the field. These will be transported in accordance with DOT regulations. The applicable shipping information will be provided.

AECOM will collect a set of at least 10 dose rate measurements on the first subject property and calculate a standard deviation ("actual standard deviation"). The number of measurements will be adjusted as necessary based on revised calculations. This information was added to the text for clarity.

23. **Page 3-6, Section 3.4.2:** This section discusses the identification of soil sampling locations. This section must be revised per the revisions identified for Appendix A of the Draft SSC Work Plan (see below).

    Response: See responses to Specific Comment 5 above, and to Specific Comment 41 below.

24. **Page 3-7, Section 3.4.3:** This section presents the depths of the quadrant composite samples. As presented in EPA comments on the revised FS Report, dated December 3, 2013, in the 40 CFR 192 standard, the concentration of radium in soil is to be averaged over 15-centimeter increments in depth. The use of different increments should be supported.

    Response: The objective of the proposed private property soil sampling is to provide data to evaluate the potential human health risk associated with CCB-derived constituents at properties within the Area of Investigation in the context of the methods used in the HHRA (AECOM, 2012c). The proposed soil depths are consistent with the HHRA evaluation.

    40 CFR 192 addresses remediation standards and states the following:

"**192.12 Standards.**

Remedial actions shall be conducted so as to provide reasonable assurance that, *as a result of residual radioactive materials from any designated processing site:*

(a) The concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than—

(1) 5 pCi/g, averaged over the first 15 cm of soil below the surface, and

(2) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface."

The sampling described in the Work Plan is for site investigation purposes and is not designed to demonstrate compliance with a remediation standard.

Therefore, no changes to the text are recommended.

25. **Page 3-9, Section 3.4.4:** Consistent with a previous comment, the radionuclide analyte list should include the complete library of gamma-emitting naturally occurring radioisotopes (U-238 series, U-235 series, Th-232 series, K-40) plus Cs-137 and Co-60.

    Response: The text has been modified.

26. **Page 4-1, Section 4.1.1:** See Specific Comment #2.

    Response: See Response to Specific Comment 2.

27. **Page 4-2, Section 4.2.1:** The plan should specify that all major changes will require approval of the EPA.

    Response: Text has been added to specify that all major changes will require approval from the USEPA.

28. **Page 4-2 and 4-3, Section 4.2.2.1:** It is not apparent that there is a data management plan or SOP that addresses the electronic data logging of the GPS and Ludlum 2221 ratemeter for the gamma walkover survey, nor is it apparent how gamma walkover survey related information will be accounted in the field log books. These issues should be addressed. Field log data of gamma dose rate measurements and the electronic data from the gamma walkover survey work (gamma count rate data and its associated geospatial coordinates) should also be compiled and ready to be provided to EPA upon its request. EPA may request this data as early as the end of daily gamma walkover survey activities.

    Response: Additional information was added to address data management in Sections 3.2.4 and 4.2.2.1. However, with regard to the electronic data logged during the walkover surveys, only the raw data (count rate and position) will be available immediately at the end of the surveys (expected on a daily basis). Data will not be placed on survey maps or be subject to analysis until after the surveys are complete. This should be acceptable given the fact that the soil sampling activities will not be concurrent with the walkover surveys.

29. **Page 4-3, Section 4.2.2.1:** The 5th paragraph on this page discusses taking photographs. Photographs should be taken of all soil samples, both as retrieved from the ground and after mixing, so as to create a photographic record.

Response: Text has been added to specify photographs to be taken during implementation of the SSC Work Plan.

30. **Page 4-4, Section 4.2.2.4:** The plan should explain why soil samples to be analyzed for radiological components require chilling, and the consequences of exceeding the temperature range should be specified in the plan.

Response: It has been noted in the text that soil samples for gamma spectroscopy do not require chilling, however, samples for metals analysis require chilling to 4° ± 2°C. Data validation actions for samples exceeding the temperature range are described in the QAPP (AECOM, 2005).

31. **Page 4-5, Section 4.2.3:** The project files should also include electronic data such as those produced during gamma walkover survey activities, the associated GIS data, and mapping and data interpretation products.

Response: References to the electronic data acquired during the gamma surveys have been added to this section.

32. **Page 4-5 and 4-6, Section 4.2.5:** The plan should specify the equipment that must be surveyed using a suitable detector (such as a pancake probe), contamination limits, decontamination procedures (if necessary), and whether this equipment will be resurveyed before release.

Response: The radiological survey of all sampling equipment has been added to the decontamination procedure as both an initial and final step. The release limits requirements are "background" levels.

33. **Page 4-8, Section 4.3.2.1:** See Specific Comment #11, 13, 15, 18, 19, and 20.

Response: All previous comment Responses have also been incorporated into Section 4.3.2.1.

34. **Page 4-8, Section 4.3.2.1:** It is stated in this section that the Ludlum 2221 scaler/ratemeter and the Ludlum 44-10 2"x2" NaI detector will be "calibrated by the manufacturer or a rental vendor who specializes in radiation survey equipment to optimize detector efficiency for the gamma energies associated with Ra-226 and its decay progeny." How a calibrator will optimize detector efficiency for the gamma energies associated with the decay products of Ra-226 should be explained.

The Draft SCC Work Plan should also determine whether a Ludlum Model 2221 scaler/rate meter is the most effective instrument to use on this type of survey. The field investigation methodologies section lacks a commitment to perform a daily operational check for instrumentation used for the gamma walk-over survey. Operational checks should be performed daily (at a minimum), prior to performing measurement work, and at the completion of measurement work to ensure the validity of measurement work that was performed that day.

Response: Section 4.3.2.1 has been revised in the same manner as Section 3.2.2 to address Comment #18. A description of the vendor's calibration procedures is not necessary for this work plan but AECOM will request one for USEPA's review. The 2"x2" NaI detector is selected in part because it was the same detector used by third parties in past surveys. Daily operational instrumentation checks are described in the SOPs, specifically RS-TPG, SOP 001.

35. **Page 4-8, Section 4.3.2.2:** It is recommended that, at each sample location where a gamma dose rate measurement is collected, a gamma count rate measurement (using the equipment for the gamma walkover survey) is also collected at a fixed distance of 2 inches from the ground. This will provide a static measurement with a lower MDC than possible with the gamma walkover survey as well as measurements that are comparable to the static measurements collected by members of the Pines community.

    Response: AECOM will collect a direct gamma measurement using a 2" x 2" NaI detector at each of the locations of a gamma dose rate measurement. A two-minute count time will be used as this was the count time used by third parties.

36. **Page 4-8, Section 4.3.3:** The text states that, "[t]he sample will be visually inspected for the presence of CCBs in the same manner as the previous visual inspections and logged in accordance with the soil characterization portion of AECOM SOP 109Pines – Split Spoon Sampling for Geologic Logging." As stated in this SOP, the procedures cover subsurface soil sampling by split-spoon only. If only using the soil characterization portion of this SOP, the specific sections of the SOP that will be used should be identified and stated.

    Response: The specific section of AECOM SOP 109Pines – Split Spoon Sampling for Geologic Logging has been specified in the text.

37. **Page 4-9, Section 4.3.4:** See Specific Comment #24.

    Response: See Response to Specific Comment #24.

38. **Table 1.** As a note, these PRGs may be subject to revision based on comments made to the recently reviewed draft Feasibility Study.

    Response: The PRGs for radionuclides have been revised and are consistent with those presented in the FS submitted February 2014.

39. **Table 2.** It should be noted whether any of these proposed locations were also used as background locations for survey work conducted by the Pines community. If not, adding background survey locations used by the Pines community may be advisable, whether they are recognized as background locations or as additional gamma survey locations, in order to understand the distribution of gamma count rate measurements in areas regarded as background by the Pines community.

    Response: None of the locations on Table 2 were used as background locations during the 2009 Jensen survey. Two background survey locations from the Jensen 2009 survey are included in Table 4, see response to Specific Comment 40 below.

40. **Table 4.** It should be noted whether these locations would all be considered as survey units or if any are considered to be background reference areas.

    Response: The locations in Table 4 are all considered survey units. Although locations Q and R were identified as background survey areas during the 2009 Jensen survey, background locations for this program are those identified and agreed upon with USEPA in the FS submitted February 2014. Therefore, locations Q and R will be considered survey units. No changes are proposed to the table.

41. **Appendix A** presents the procedures used and results of the calculation of a representative number of properties to sample. The primary problem with the procedure used (including the particular equation used) is that the equation selected is based on the end goal of calculating a grand mean

across properties in two strata: those with CCBs and those without CCBs. However, there is no intention to actually calculate such a grand mean for the Pines site. The intention is to compare the concentration of each analyte at each of the selected properties to the analyte-specific BTV calculated based on the background data set. Appendix A must be revised to follow a streamlined data quality objective (DQO) process (EPA 2000) and also (1) clearly state the decision criteria that will be used as well as (2) select an appropriate sampling design with a related equation or process that is consistent with the identified decision criteria and which will estimate the necessary number of properties to be sampled.

Response: We acknowledge that the equation is intended to calculate a mean of each of the two strata. However, random sampling is needed to estimate a mean, and it has always been the intention to conduct biased sampling of the properties expected to have the highest percentage of CCBs. Thus, if sampling five properties containing CCBs is sufficient to calculate a mean, clearly it is sufficient and conservative to sample double that number (nine) to establish likely worst-case conditions. The text in Appendix A has been updated to include this rationale.

A streamlined 7-step DQO process has been added to Section 1.4 of the SSC Work Plan.

42. **Appendix B, Section A.6, page 1 of 2:** Item #1 “gamma surveys” should be replaced with “gamma count rate and gamma dose rate surveys.”

Response: The change was made as recommended.

43. **Appendix B, Section B.4.1, page 2 of 3:** In the third paragraph of Section B.4.1, it is indicated that the analysis performed by the R.J. Lee group will be by Photo Light Microscopy. This is different from what is described in Section 3.3.3 of the Draft SSC Work Plan, which describes the method as “Polarized Light Microscopy.” This apparent discrepancy should be corrected.

Response: The third paragraph of Section B.4.1 has been updated with “Polarized Light Microscopy.”

44. **Appendix B, Section B.8, page 3 of 3:** This section lists analytical instrument calibration. Specifically, Table B-8 states that daily checks will be performed using a pulser. This depends upon a second instrument to validate the first instrument is operating correctly. Daily checks are better performed with a check source made up of several radionuclides. The acceptance limits for of all types of checks and calibrations are broad, within two or three standard deviations. A specific limit should be stated.

Response: The QAPP was updated based on information provided directly from GEL with regard to their standard calibration protocols.

45. **Appendix B, Table A-4, page 4 of 18:** The data quality levels (DQLs)/Residential Soil PRGs are provided in the far right column, but the risk level used for their computation should be stated in the notes (probably 10^{-6}). It may be prudent to provide PRGs for risk levels of 10^{-4}, 10^{-5}, and 10^{-6} to cover the full EPA risk range. Also, considering that the DQL/PRGs were taken from the EPA Preliminary Remediation Goals for Radionuclides website tables, the isotopes listed in Table A-4 and their respective PRGs are incorrect. For example, Ra-226 should be listed as “Ra-226+D” (proper isotope selection). Then, the 1.21x10-2 pCi/g PRG is correct. In general for the listed isotopes, the “+D” version should be used to account for risk due to the primary isotope and its short lived decay products. Also, please refer to “daughters” as “decay products” or “short-lived decay products” as appropriate.

Note that the minimum detectable activities (MDAs) for lead-210, radium-226, radium-228, and thorium-228 are greater than their respective DQLs/Residential Soil PRGs.

Response: “Decay products” has been used in the text. Table A-4 has been updated.

46. **Appendix B, Table A-5, page 5 of 18:** This table provides the quality control performance criteria for field and lab blanks as “<MDA” but the MDAs are not provided or otherwise specified. Please include all applicable MDAs. Also, an asterisk is present next to radium-226 but no note is provided; please provide the note.

    Response: Table A-5 was updated to include the revised gamma spec library based on conversations between GEL, AECOM, and EPA. The associated MDCs for the isotopes in the gamma spec library are indicated in Table A-4.

    The asterisk next to Ra-226 in Table A-5 was removed.

47. **Appendix B, Table B-1, page 8 of 18:** Please provide the basis for the preservation and holding time for radionuclides. A note is provided that the 45 days is a contractual rather than technical requirement, but a technical holding time or “not applicable” for technical requirements should be noted as appropriate.

    Response: The preservation for the radionuclides was changed to “None Required.” The holding time for the radionuclides was changed to “Not Applicable.”

48. **Appendix B, Table B-4, page 12 of 18:** It is recommended that the response check and instrument source check are performed daily at the start and again at the completion of a measurement work period to help ensure the validity of the measurements collected during that work period or, at least, at the beginning and end of the work day.

    Response: While it is not required in the procedure (RS-TPG SOP 001) to perform source checks at the beginning and end of each day, it is normally what is performed in the field. Section 4.3.2.2 has been modified to indicate that source checks will be done at the beginning and end of each work day.

49. **Appendix B, Table B-7, page 16 of 18:** What is labeled as a “Daily: Field calibration check” should be changed to “Daily: Field operational check” or “Daily: Field functional check.” A field tech is not actually checking the calibration in the field but checking the instrument’s response to a check source. The check source for the daily field operational/functional check does not need to be NIST-traceable. See ANSI N323B “American National Standard for Radiation Protection Instrumentation Test and Calibration, Portable Survey Instrumentation for Near Background Operation” for more information.

    Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). The current revision contains Attachment 1 for logging daily source checks. The form is titled “Radiological Instrument Daily Source Check Record.” Table B-7 has been modified to indication that the field response checks will be with an exempt sealed gamma source, not a NIST traceable source.

50. **Appendix C, Procedure Number SARSG, SOP 001:** Specific procedures should be included in the manual for the instruments actually used on site.

    Response: The SOPs provided in Appendix C are general SOPs used by AECOM’s radiolocation services technical practice group (RS-TPG) and they are not intended to be applicable to all site-specific needs. Site-specific survey details are provided in project work plans and survey plans. Unfortunately, the reviewers were not provided the most current revisions of SOPs 001, 007, and 011. These are now recognized by the procedure numbers RS-TPG SOP 001, RS-TPG SOP 007, and RS-TPG SOP 011.

51. **Appendix C, Procedure Number SARSG, SOP 001, Section 4.4, page 2:** The SOP states "[s]lowly enter areas of unknown radiation with instruments on the high scale to avoid off-scale readings and subsequent prolonged recovery time." This wouldn't be appropriate for assessments of environmental radioactivity. For example, when operating a Thermo/Bircon micro-rem tissue equivalent survey meter, one wouldn't want to have the instrument set on the highest x1000 scale (0 to 200,000 urem/hr) when operating in areas where near-background readings are expected (5 to 20 urem/hr where the x0.1 scale would be appropriate) or somewhat higher dose rates would be expected (20 to 200 urem/hr where the x1 scale would be appropriate).

    Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). The comment is not applicable to the current revision of the procedure.

52. **Appendix C, Procedure Number SARSG, SOP 001, Section 4.5, page 2:** The SOP states, "[a]lthough incidental contact with the surveyed surface will not generally contaminate the detector, minimize contact with the surface." Simply minimizing contact may be valid in cases of fixed contamination, but not where loose/removable contamination is present. When performing surface contamination surveys, contact with the surface should be avoided, but if contact does occur, the operator should check the response of the instrument and remove it from service if contamination is suspected.

    Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). However, the comment was applicable to the current version and a change has been made as suggested.

53. **Appendix C, Procedure Number SARSG, SOP 001, Section 4.6, page 2:** The SOP states, "[o]ccasionally verify instrument is responding properly if background appears low." It's more appropriate to verify instrument operation if background is outside the expected range, where a higher background may indicate contamination of the instrument.

    Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). However, the comment was applicable to the current version and a change has been made as suggested.

54. **Appendix C, Procedure Number SARSG, SOP 001, Section 5.1.1.2, page 2:** The SOP states, "[a] field calibration check will be performed daily prior to use of the instrument." Actually, what would be performed daily is a "source response check" or what is also commonly referred to as either a "functional check" or an "operational check." Section 5.1.5 refers to this as an "Instrument Source Check."

    Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). The comment is not applicable to the current revision of the procedure.

55. **Appendix C, Procedure Number SARSG, SOP 001, Section 5.1.3.1, page 3**: This section implies that a battery check checks the detector voltage. This only checks the condition of batteries and does not indicate whether or not the probe is being supplied with adequate voltage.

    Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). The comment is not applicable to the current revision of the procedure.

56. **Appendix C, Procedure Number SARSG, SOP 001, Section 5.1.5, page 3:** These sections appear to be describing the same operation. It may be possible to combine them. Section 5.1.5.4 instructs the operator to "[r]ecord the source check results on the Radiological Instrument Daily Calibration Record, Attachment 1." Section 5.1.6.1 states, "[d]ocumentation of these response checks is not

required." Section 5.1.9 instructs "(o)n the first source check of the month, the source check label shall be replaced on the instrument." These three statements should be reconciled.

Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). The current SOP requires that all response checks be documented.

57. **Appendix C, Procedure Number SARSG, SOP 001, Section 5.1.9, page 4:** The SOP states, "[o]n the first source check of the month, the source check label shall be replaced on the instrument." Is there an SOP that covers monthly source checks and the generation of "source check labels?" If the "source check label" is being replaced monthly, how is this being done? Usually, there is a calibration label applied to the instrument at the time of calibration, and this is replaced when the instrument is returned for calibration.

    Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). The comment is not applicable to the current revision of the procedure.

58. **Appendix C, Procedure Number SARSG, SOP 001, Section 5.2.1, page 4:** This section describes the orientation of detectors. For instruments used to measure exposure rate, detectors with isotropic responses should be used because the source of radiation may be extended.

    Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). The comment is not applicable to the current revision of the procedure.

59. **Appendix C, Procedure Number SARSG, SOP 001, Section 5.3, page 5:** This section should probably refer to the use of beta-gamma detectors (probes), such as the frequently used Geiger-Mueller (GM) "pancake" detector, for surface contamination count rate scanning.

    Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). The comment is not applicable to the current revision of the procedure.

60. **Appendix C, Procedure Number SARSG, SOP 001, Section 5.3.1, page 5:** This section states, "[c]ount the smear for a minimum of five seconds, or if positive indication is noted, count for at least 15 seconds or until the meter indication stabilizes." If counting, the count time should be based on the desired minimum detectable activity. What this section suggests is the field screening of smears and air filters, where actual quantitative measurement of the smears and filters would be performed in a lab with more appropriate equipment.

    Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). The comment is not applicable to the current revision of the procedure.

61. **Appendix C, Procedure Number SARSG, SOP 001, Section 5.4, page 5:** This section should probably refer to the use of alpha detectors (such as an alpha scintillation detector, a gas flow proportional detector, or a silicon PIPs detector) for surface contamination count rate scanning measurements. There should also probably be a subsection 5.4.1 called "Performing Surface Contamination Count Rate Scanning Measurements."

    Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). The comment is not applicable to the current revision of the procedure.

62. **Appendix C, Procedure Number SARSG, SOP 001, Section 5.6.1, page 5:** This section describes using a reference check source following receipt of the instrument. Instruments should be calibrated with reference check sources used at the point of calibration to verify that they have not changed in shipment. Section 5.5.3 or other sections do not specify or recognize applicable shipping

requirements for the check source that would be sent with the instrument when it's returned for calibration.

Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). The comment is not applicable to the current revision of the procedure. Since AECOM rents instruments on a project-by-project basis, instruments may not be received at the project site straight from calibration. The current procedure describes a source check following the receipt of an instrument that the project sends out for calibration.

63. **Appendix C, Procedure Number SARSG, SOP 001, Section 6.1, page 7:** This section states, "[r]eadings that deviate more than ± 20% from reference source check readings obtained at the time the instrument was first calibrated require instrument recalibration." The deviation intended is probably from the check source that's assigned to the instrument, and it's more likely from the "time the instrument was last calibrated" provided that the check source accompanied the instrument for its calibration and that a source response check was performed by the calibrator following calibration.

Response: The reviewer was not provided the most current revision of SOP 001 (now RS-TPG SOP 001). The comment is not applicable to the current revision of the procedure. Since AECOM rents instruments on a project-by-project basis, instruments may not be received at the project site straight from calibration. The current procedure describes a source check following the receipt of an instrument that the project sends out for calibration.

64. **Appendix C, Procedure Number RS-PPG, SOP 007:** It is not clear how this SOP supports the performance of gamma walkover surveys (count rate) and gamma dose rate surveys. The gamma walkover survey is intended to be, in short, a gamma surface scan with NaI detector swinging while walking across a survey unit in a serpentine pattern on 1-meter transects; this is not covered by this SOP. The gamma dose rate survey is intended to consist of a collection of static measurements at points on a triangular grid; this is not covered by this SOP. Also, the SOP does not provide clear instructions on using the attached forms.

Response: The reviewer was not provided the most current revision of RS-TPG SOP 007. The comment is not applicable to the current revision of the procedure.

65. **Appendix C, Procedure Number RS-PPG, SOP 007, Section 2.1, page 1:** gives an example of a Ludlum model 19 as a dose rate instrument. The Ludlum model 19 is energy dependent and it is not a suitable instrument for measurement of dose rate. A more suitable instrument is described in the text of the plan. This SOP should describe the same instrument as is in the plan.

Response: The reviewer was not provided the most current revision of RS-TPG SOP 007. The comment is not applicable to the current revision of the procedure.

66. **Appendix C, Procedure Number RS-SARSG, SOP 011, Section 2.1:** This section states "[b]eta-gamma contamination surveys are performed using a thin window Geiger-Mueller (GM) probe, a Bicron or equivalent." "A Bicron" is the name of a manufacturer and not a specific probe model. Thin window GM probes can come in end-window or "pancake" versions, where the pancake GM is more commonly used for beta/gamma surface contamination measurements.

Response: The reviewer was not provided the most current revision of SOP 011 (now RS-TPG SOP 011). The comment is not applicable to the current revision of the procedure.

67. **Appendix C, Procedure Number RS-SARSG, SOP 011, Section 2.5:** Note that the Ludlum Model 19 NaI scintillator is energy sensitive (energy dependent) and does not provide a linear response over the range of gamma energies that it detects. Therefore it shouldn't be suggested that a Bicron

Micro-Rem Tissue Equivalent Survey Meter (to be used for dose rate measurements) with its relatively linear energy response is equivalent to the Ludlum Model 19.

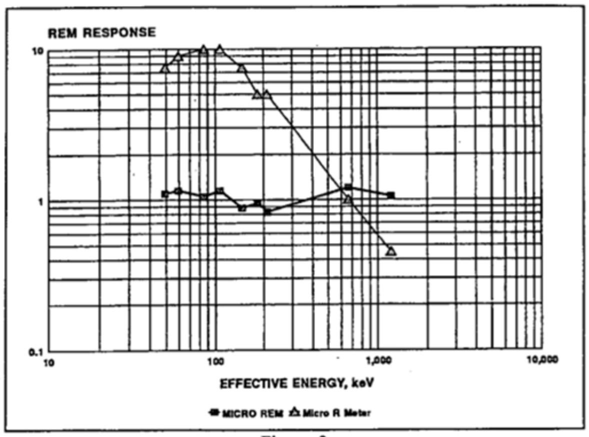

Figure 3
Rem Response value vs. Energy for
Bicron and conventional Micro R Meters.

Response: The reviewer was not provided the most current revision of SOP 011 (now RS-TPG SOP 011). The current revision of RS-TPG SOP 011 and RS-TPG SOP 001 distinguishes between microR and microRem meters.

68. **Appendix C, Procedure Number RS-SARSG, SOP 011, Section 3.1:** This section states, “[s]mears should be counted in an area where the background is less than 100 cpm for beta-gamma radiation.” With which instrument (GM or Ludlum 2929) and under what conditions (field or lab) does this apply? This falls under Section 3.0 (Instrument Operational Checks). When is counting smears a part of instrument operation checks, unless the smear is considered to be a check source or calibration source? Eckert and Ziegler manufactures sources that mimic filters. Is that what is implied? An instrument operational checks section should really be instrument-specific.

Response: The reviewers did not have the most current revision of SOP 011 (now RS-TPG SOP 011). The current version of RS-TPG SOP 001 states that count times should be sufficient to have acceptable MDAs when compared to release criteria.

69. **Appendix C, Procedure Number RS-SARSG, SOP 011, Section 4.0:** This section should either specify the basis for posting radiological control areas (contaminated area, radiation area, airborne radioactive material, etc.) or refer to an SOP that does.

Response: The reviewer was not provided the most current revision of SOP 011 (now RS-TPG SOP 011). The current version of RS-TPG SOP 001 references RS-TPG SOP 020, *License/Site Radiation Protection Program*, for posting requirements. Such posting requirements will not be applicable to the Pines investigation survey/sampling efforts.

70. **Appendix C, Procedure Number RS-SARSG, SOP 011, Section 5.1:**

- Beta emitters do not directly produce exposure. The instruments described in other SOPs are not capable of measuring beta dose and the beta dose rate equation provided is correct only for a specific thickness beta shield and a limited range of energies.
- This work does not include exposure rate surveys. What are being proposed are gamma dose rate surveys and gamma count rate surveys.

- The text states that, “[g]amma exposure rates are recorded as mR/hr (uSv/hr), or (uR/hr).” For this work to be done for this site, gamma dose rates should be recorded as urem/hr or a similar metric unit (uSv/hr or nSv/hr).
- Beta dose rate recording and calculation are discussed using an instrument that has a sliding shield for beta measurements (found on survey meters such as the Thermo RO-20 ion chamber). It doesn’t appear that this SOP is applicable to ion chamber according to Section 2.0 (Equipment) of this SOP.
- The text states, “[t]he beta correction factor used for each instrument shall be determined by the calibration facility”. You probably won’t get this for a Ludlum Model 19, a Bicron tissue equivalent survey meter, a Ludlum end-window, or a “pancake” GM.

Response: The reviewer was not provided the most current revision of SOP 011 (now RS-TPG SOP 011). However, the current revisions of both RS-TPG SOP 001 and RS-TPG SOP 011 address the types of surveys that will be conducted at the Pines sites in general terms. These SOPs are not designed for site-specific instructions. Site-specific instructions are provided in project work plans.

71. **<u>Appendix C, Procedure Number RS-SARSG, SOP 011, Static MDCs:</u>** Example static MDCs are provided for the Ludlum Model 43-89 alpha/beta scintillator and the Ludlum model 43-37 beta floor cart. It would probably be appropriate to include static MDCs for the instruments that will be used for this work.

Response: The reviewer was not provided the most current revision of SOP 011 (now RS-TPG SOP 011). However, the current revisions of both RS-TPG SOP 001 and RS-TPG SOP 011 address the types of surveys that will be conducted at the Pines sites. The determination of the minimum detectable count rate is discussed in RS-TPG SOP 001.

The details of converting gamma survey data (in cpm) to an estimated total radium activity (in pCi/g) will be addressed in final work plans after correlation measurements are made. This includes determination of the MDA.

72. **<u>Appendix C, Procedure Number RS-SARSG, SOP 011, Scan MDCs:</u>** Example scan MDCs are provided for the Ludlum model 44-9 “pancake” GM detector and the Ludlum model 43-37 beta floor cart. It would probably be appropriate to include scan MDCs for the instruments that will be used for this work. If necessary, a Ludlum model 44-9 “pancake” GM detector with an appropriate survey meter could be suitable for beta/gamma contamination monitoring, but this instrument was not previously mentioned in the SOP.

Response: The reviewer was not provided the most current revision of SOP 011 (now RS-TPG SOP 011). However, the current revisions of both RS-TPG SOP 001 and RS-TPG SOP 011 address the types of surveys that will be conducted at the Pines sites.

73. **<u>Appendix C, Procedure Number RS-SARSG, SOP 011, Section 5.3:</u>** In short, this section should be revised to support the instruments that would be used for this work, if a radiological control program is necessary.

Response: The reviewer was not provided the most current revision of SOP 011 (now RS-TPG SOP 011). However, the current revisions of both RS-TPG SOP 001 and RS-TPG SOP 011 address the types of surveys that will be conducted at the Pines Area of Investigation.

74. **<u>Appendix C, Procedure Number RS-SARSG, SOP 011, Section 5.5:</u>** References presumed SOPs (Re19, Re032v, Re033, etc.) that are not included in this document. “Grave Danger, Very High Radiation Area” is a posting required under 10 CFR 20 (NRC regs) if necessary but not specified by

OSHA. This is being mentioned because the Pines Area of Investigation isn't under a NRC license or subject to 10 CFR 20. The need for the postings described should probably be reviewed in the context of the work to be performed.

Response: The reviewer was not provided the most current revision of SOP 011 (RS-TPG SOP 011). This comment is not applicable to the revised procedure.

75. **Appendix C, SOP Number 7510Pines, Revision Number 5.0, Section 1.0:** The SOP states that "[e]nvironmental samples are not considered a Resource Conservation and Recovery Act (RCRA) classified hazardous waste by definition; therefore, more stringent RCRA and Department of Transportation (DOT) regulations regarding sample transportation do not apply."

It should be recognized that it is a shipper's responsibility to comply fully with the DOT and IATA regulations (and applicable courier requirements) when offering a dangerous good or hazardous material consignment for commerce.

It is recommended that you review 40 CFR Section 261.4(d), and especially 261.4(d)(2)(i) and 261.4(d)(2)(ii). The regulations at 261.4(d)(2)(ii) discuss requirements if the sample collector determines that DOT, USPS, or other shipping requirements do not apply to the shipment of the sample (IATA often looks at the consignment, which could be a collection of samples in one shipping container).

A summary on the shipment of samples is provided in the RCRA Waste Sampling Draft Technical Guidance (EPA530-D-02-002). Section 7.2.8.2 (Sample Shipping) of this guidance states the following:

In general, samples of drinking water, most ground waters and ambient surface waters, soil, sediment, treated waste waters, and other low concentration samples can be shipped as environmental samples; however, shipment of high concentration waste samples may require shipment as dangerous goods (not as "hazardous waste"). Note that RCRA regulations specifically exempt samples of hazardous waste from RCRA waste identification, manifest, permitting, and notification requirements (see 40 CFR §261.4(d)). The shipment of samples to and from a laboratory, however, must comply with U.S. DOT, U.S. Postal Service, or any other applicable shipping requirements. If a sample is a hazardous waste, once received at the laboratory, it must be managed as a hazardous waste.

In recent years, commercial overnight shipping services have adopted the regulations of the IATA for shipment of dangerous goods by air. The IATA Dangerous Goods Regulations contain all provisions mandated by the International Civil Aviation Organization and all rules universally agreed to by airlines to correctly package and safely transport dangerous goods by air. Contact IATA for a copy of the IATA Dangerous Goods Regulations and for assistance in locating suppliers of specialized packaging for dangerous goods.

Also, the following website provides information regarding the issue of DOT and sample preservation: http://www.epa.gov/osw/hazard/testmethods/resources.htm

Response: None of the samples collected and shipped during this investigation will meet the criteria of Hazardous Waste or Dangerous Goods.

Appendix E

Constituent Concentrations in Coal Combustion By-Products

Appendix E

Constituent List

This appendix provides the rationale for the list of constituents to be analyzed during the supplemental soil characterization (SSC) described in the main text of this Work Plan at the Pines Area of Investigation (AOC II – Docket No. V-W-'04-C-784)(2004). This list has been developed in discussions with the United States Environmental Protection Agency (USEPA).

The goal of the Superfund process and the human health risk assessment (HHRA) are to identify those constituents that pose potentially unacceptable risk to human health. Therefore, the first step of the HHRA was to select constituents of potential concern (COPC), as presented on Table E-1. As stated in USEPA guidance (USEPA, 1993):

> "Most risk assessments are dominated by a few compounds and a few routes of exposure. Inclusion of all detected compounds at a site in the risk assessment has minimal influence on the total risk. Moreover, quantitative risk calculations using data from environmental media that may contain compounds present at concentrations too low to adversely affect public health have no effect on the overall risk estimate for the site. The use of a toxicity screen allows the risk assessment to focus on the compounds and media that may make significant contributions to overall risk."

As shown on Table E-2, the COPC quantitative evaluation for metals and inorganics in the HHRA for the Pines Area of Investigation (AECOM, 2012) is consistent with similar evaluations of coal combustion by-products (CCB) data from a variety of sources, sources that were not available at the time the Municipal Water Service Extension (MWSE) sampling program was designed (USGS, 2011; ACAA, 2012; EPRI, 2009, 2010; USEPA Federal Register, Volume 75, No 118; USEPA, 2010). Of note is that 14 of the metals and inorganic constituents on the Extended List (i.e., the list of inorganic, metal, and radionuclide constituents analyzed during the Remedial Investigation) on Table E-1 do not have levels measured in any of the datasets (including the Pines MWSE dataset) exceeding the USEPA Regional Screening Level (RSL, USEPA, 2012) adjusted for a target hazard quotient of 0.1, as indicated by yellow highlighting in Tables E-1 and E-2. Also, six other metals and inorganic constituents on the Extended List (antimony, barium, beryllium, copper, molybdenum, and nickel) do not have levels in the Pines MWSE dataset that exceeded the adjusted RSLs. Table E-3 shows the same constituent information compared to the unadjusted RSLs for comparison.

Three of the radionuclide constituents were not detected in the MWSE dataset, indicated by green highlighting in Table E-1. Polonium-210, while technically a COPC, is included in the decay chain of lead-210 and is thus evaluated in the HHRA by the use of the lead-210 slope factor.

The constituents selected as COPCs were evaluated in a conservative and detailed HHRA (AECOM, 2012) approved by the USEPA. At the end of the HHRA, constituents of concern (COCs), as listed in Table E-1 were identified as those COPCs which potentially pose an excess lifetime cancer risk greater than $1x10^{-6}$ (the low end of USEPA's acceptable risk range) or a target endpoint specific hazard index of one. The COC selection was based on the assumption that residential properties contain 100% CCBs, which is conservative, as the maximum average percentage of CCBs identified on any property was 27%.

Based on the large body of information developed, collected and assessed with USEPA approval since the time of the MWSE sampling, the Respondents believe the COC list is appropriate for use with the private property sampling outlined in this SSC Work Plan. However, Respondents have agreed with USEPA not to limit the sampling to the COC list, but to expand the metals and inorganic list to test the samples from the private property sampling for the COPC list plus chromium and uranium, as listed below. a library of select gamma-emitting naturally occurring radioisotopes (Uranium-238 (U-238) series, Thorium-232 (Th-232) series, Uranium-235 (U-235) series, and Potassium-40 (K-40)) plus Beryllium-7 (Be-7), Americium-241 (Am-241), Barium-137 (Ba-137m), Cesium 137 (Cs-137) and Cobalt-60 (Co-60) (refer to Appendix B) will be used in the analytical program for the property-specific sampling under this SSC Work Plan.

Specifically, the metal and inorganic parameter list is, as follows:

- Aluminum
- Arsenic
- Chromium
- Chromium (hexavalent)
- Cobalt
- Iron
- Thallium
- Vanadium
- Uranium

References

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AECOM. 2012. Human Health Risk Assessment (HHRA). Pines Area of Investigation. July 2012.

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EPRI. 2009. Coal Ash: Characteristics, Management and Environmental Issues. Electric Power Research Institute, September 2009. Report No. 1019022. Available at www.epri.com.

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USEPA. 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening. EPA/903/R-93-001. United States Environmental Protection Agency, Region III. Hazardous Waste Management Division. Office of Superfund Programs.

USEPA. 2010. Human and Ecological Risk Assessment of Coal Combustion Wastes. Regulation Identifier Number (RIN) 2050-AE81. USEPA. Draft. April 2010. Table A-3-1. 2002 data.

USEPA. 2012. Regional Screening Levels for Chemical Contaminants at Superfund Sites. November 2012. http://www.epa.gov/region9/superfund/prg/index.html.

USGS. 2011. Geochemical Database of Feed Coal and Coal Combustion Products (CCPs) from Five Power Plants in the United States. Data Series 635. Available at: http://pubs.usgs.gov/ds/635/; Data summarized in ACAA, 2012.

Tables

AECOM

TABLE E-1
COMPARISON OF CONSTITUENT LISTS
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

Constituent	COCs	COPCs	Extended List
Metals and Inorganic Constituents			
Aluminum		X	X
Antimony			X (d)
Arsenic	X	X	X
Barium			X (d)
Beryllium			X (d)
Boron			X (d)
Cadmium			X (d)
Calcium			X (e)
Chromium	X (a)	X (a)	X (d)
Chromium (hexavalent)	X	X	X
Cobalt		X	X
Copper			X (d)
Iron	X	X	X
Lead			X (d)
Magnesium			X (e)
Manganese			X (g)
Mercury			X (d)
Molybdenum			X (d)
Nickel			X (d)
Potassium			X (e)
Selenium			X (g)
Silicon			X (d)
Silver			X (c)
Sodium			X (e)
Sulfur			X (d)
Thallium	X	X	X
Uranium			X (f)
Vanadium		X	X
Zinc			X (d)
Radionuclide Constituents			
Lead-210	X	X	X
Polonium-210		(b)	X (b)
Radium-226	X	X	X
Radium-228	X	X	X
Thorium-228		X	X
Thorium-230		X	X
Thorium-232		X	X
Uranium-234		X	X
Uranium-235		X (c)	X
Actinium -227			X (c)
Protactinium-231			X (c)
Uranium-238	X	X	

Notes:
COC - Constituent of Concern (i.e, the constituents carried through the Feasibility Study).
COPC - Constituent of Potential Concern (i.e., the constituents evaluated in the human health risk assessment).
HHRA - Human Health Risk Assessment.
MWSE - Municipal Water Service Extension.
RSL - Regional Screening Level.
Yellow highlighting - Indicates metals and inorganic constituents not identified as COPCs in other national coal combustion by-product datasets using the residential soil RSLs adjusted for a target hazard quotient of 0.1 (see text, Table E-2, and the Final HHRA, AECOM, 2012).
Green highlighting - Indicates radionuclide constituents not detected in the MWSE dataset.
(a) - Chromium was not identified as a COPC or a COC; it is included for comparison to hexavalent chromium data.
(b) - Included in the HHRA as a decay product of Lead-210, therefore, while considered a COPC, the analytical data were not used as the evaluation of Lead-210 includes Polonium-210.
(c) - Not detected in MWSE samples.
(d) - Detected below USEPA RSLs adjusted to a hazard quotient of 0.1 in MWSE samples (AECOM, 2012).
(e) - Essential nutrient, not included as a COPC (AECOM, 2012 provides additional detail).
(f) - Uranium was not included in the MWSE sampling program, but was included in the Remedial Investigation background sampling program.
(g) - Shown to be consistent with background (AECOM, 2012).

TABLE E-2

CONSTITUENT CONCENTRATIONS IN CCRs AND NATIVE MATERIALS (ADJUSTED RSLs)
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

	Pines MWSE Data - Suspected CCBs			USEPA RSLs (g)	Pines MWSE Data (h)		USGS Data (f)				EPRI Ash Data							USEPA Data		
				Adjusted (h) Residential Soil (mg/kg)	Suspected CCBs (mg/kg)		Fly Ash (mg/kg)		Bottom Ash (mg/kg)		Fly Ash (mg/kg)			Bottom Ash (mg/kg)				CCR (d) (mg/kg)	Landfill Waste (e) (mg/kg)	
Constituent	Analyzed in MWSE Data	COPC	COC		Min	Max	Min	Max	Min	Max	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile	Source	mean	50th %ile	90th %ile
Aluminum	X	X		7,700	5,220	44,600	NA	NA	NA	NA	70,000	NA	140,000	59,000	NA	130,000	(a)	NA	25,300	85,700
Antimony	X			3.1	1.4	1.4	0.982	22.4	0.401	3.2	BDL	BDL	16	BDL	BDL	BDL	(b)	6.32	15.6	46.2
Arsenic	X	X	X	0.39	3.6	97.2	7.3	93.8	1.24	18.1	22	71	261	2.6	7.2	21	(b)	24.7	27.9	105
Barium	X			1,500	47.4	346	336	5,730	474	2,990	381	932	5,064	378	768	3,604	(b)	246.75	222	1,050
Beryllium	X			16	0.63	5.5	1.69	32.7	2.99	10.3	2.2	10.6	26	0.21	5.8	14	(b)	2.8	4.1	17.6
Boron	X			1,600	45.9	151	NA	NA	NA	NA	118	322	1,018	2.7	82	335	(b)	NA	53.5	346
Cadmium	X			7	0.18	4.3	0.312	3.29	0.104	0.425	0.36	1.07	6.2	BDL	BDL	BDL	(b)	1.05	1.08	5.43
Calcium	X			EN	2,810	44,400	NA	NA	NA	NA	7,400	NA	150,000	5,700	NA	150,000	(a)	NA	NA	NA
Chromium	X			12,000	9.8	166	33.7	984	17.5	461	27	133	298	51	191	1,132	(b)	27.8	44.5	166
Chromium (hexavalent)	X	X	X	0.29	0.465	1.95	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	--	NA	NA	NA
Cobalt	X	X		2.3	1.8	19.5	14.5	264	7.29	55	7.4	7.9	101	NA	NA	NA	(b)	NA	10.2	62.2
Copper	X			310	3.1	42.1	55.1	692	40.4	148	62	140	216	39	73	118	(b)	NA	36.1	228
Iron	X	X	X	5,500	6,270	142,000	NA	NA	NA	NA	33,575	69,100	128,838	40,339	101,200	158,850	(b)	NA	NA	NA
Lead	X			400	2.9	117	14.4	293	7.59	40	21	49	143	8.1	20	53	(b)	25	28.7	80.6
Magnesium	X			EN	825	9,500	NA	NA	NA	NA	3,900	NA	23,000	3,400	NA	17,000	(a)	NA	NA	NA
Manganese	X	(c)		180	41.8	737	105	966	145	347	91	189	700	85	262	892	(b)	NA	111	510
Mercury	X			2.3	0.01	0.06	0.0127	1.15	0.0123	0.155	0.01	0.11	0.51	0.004	0.018	0.08	(b)	0.18	0.328	1.63
Molybdenum	X			39	0.93	13.2	4.95	90.5	2.15	10.2	9	19	60	4	11	27	(b)	NA	12	34.7
Nickel	X			150	3.6	50.7	17.3	572	28.8	255	47	102	231	39	123	445	(b)	32	42.3	329
Potassium	X			EN	291	8,760	NA	NA	NA	NA	6,200	NA	21,000	4,600	NA	18,000	(a)	NA	NA	NA
Selenium	X			39	0.45	3.5	1.03	22.5	0.121	1.28	1.8	11	18	BDL	BDL	4.2	(b)	2.4	5.12	21.4
Silicon	X	(c)		NA	558	3,500	NA	NA	NA	NA	160,000	NA	270,000	160,000	NA	280,000	(a)	NA	NA	NA
Silver	X			39	BDL	BDL	NA	NA	NA	NA	BDL	BDL	7.6	BDL	BDL	BDL	(b)	0.70	1.72	13.7
Sodium	X			EN	116	1,310	NA	NA	NA	NA	1,700	NA	17,000	1,600	NA	11,000	(a)	NA	NA	NA
Sulfur	X			NA	31.7	514	NA	NA	NA	NA	1,900	NA	34,000	BDL	NA	15,000	(a)	NA	NA	NA
Thallium	X	X	X	0.078	0.47	5	0.312	21	0.102	1.96	BDL	2.4	45	BDL	BDL	0.88	(b)	1.75	3.23	20.8
Uranium				23	NA	NA	0.682	34.1	5.27	11	BDL	NA	19	BDL	NA	16	(a)	NA	NA	NA
Vanadium	X	X		39	23.8	89.9	106	1,660	69.4	591	59	254	364	BDL	161	250	(b)	NA	224	907
Zinc	X			2,300	22.4	255	33.1	848	26.5	152	63	152	683	16	59	367	(b)	NA	45.8	293

See notes on page 3 of this table.

TABLE E-2

CONSTITUENT CONCENTRATIONS IN CCRs AND NATIVE MATERIALS (ADJUSTED RSLs)
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

Constituent	Pines MWSE Data - Suspected CCBs: Analyzed in MWSE Data	COPC	COC	USEPA RSLs (g) Adjusted (h) Residential Soil (mg/kg)	EPRI Rock and Soil Data: Rock (mg/kg) 10th %ile	Rock 50th %ile	Rock 90th %ile	Soil (mg/kg) 10th %ile	Soil 50th %ile	Soil 90th %ile	Source
Aluminum	X	X		7,700	9,800	NA	96,000	15,000	NA	100,000	(a)
Antimony	X			3.1	0.08	0.3	1.8	BDL	BDL	1.3	(b)
Arsenic	X	X	X	0.39	0.50	1.60	14	2	5.8	12	(b)
Barium	X			1,500	67	420	1,390	200	500	1,000	(b)
Beryllium	X			16	0.10	1.30	4.4	BDL	BDL	2.0	(b)
Boron	X			1,600	BDL	0.33	220	BDL	30	70	(b)
Cadmium	X			7	BDL	BDL	3.6	BDL	0.2	0.5	(b)
Calcium	X			EN	6,000	NA	83,000	1,500	NA	62,000	(a)
Chromium	X			12,000	1.9	28	309	15	50	100	(b)
Chromium (hexavalent)	X	X	X	0.29	NA	NA	NA	NA	NA	NA	--
Cobalt	X	X		2.3	0.86	16	53	BDL	7	15	(b)
Copper	X			310	10	30	122	5	20	50	(b)
Iron	X	X	X	5,500	8,800	NA	95,000	7,000	NA	50,000	(a)
Lead	X			400	3.8	15	44	BDL	15	30	(b)
Magnesium	X			EN	700	NA	56,000	1,000	NA	15,000	(a)
Manganese	X	(c)		180	49	430	1,740	100	300	1,000	(b)
Mercury	X			2.3	0.1	0.7	2.0	0.02	0.05	0.19	(b)
Molybdenum	X			39	0.24	1.6	18	BDL	BDL	BDL	(b)
Nickel	X			150	2	18	220	5	15	30	(b)
Potassium	X			EN	4,000	NA	45,000	4,500	NA	25,000	(a)
Selenium	X			39	0.60	1.90	4.9	BDL	0.3	0.8	(b)
Silicon	X	(c)		NA	57,000	NA	380,000	230,000	NA	390,000	(a)
Silver	X			39	0.03	0.9	3	BDL	BDL	BDL	(b)
Sodium	X			EN	900	NA	34,000	1,000	NA	20,000	(a)
Sulfur	X			NA	200	NA	42,000	840	NA	1,500	(a)
Thallium	X	X	X	0.078	0.1	0.5	1.8	0.2	0.50	0.7	(b)
Uranium				23	0.84	NA	43	1.2	NA	3.9	(a)
Vanadium	X	X		39	2.6	52	232	20	70	150	(b)
Zinc	X			2,300	25	72	138	22	50	99	(b)

See notes on page 3 of this table.

TABLE E-2

CONSTITUENT CONCENTRATIONS IN CCRs AND NATIVE MATERIALS
(ADJUSTED RSLs)
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

Notes:

[green shading] > USEPA Residential Soil RSL, adjusted to a hazard quotient of 0.1 for noncarcingens.
[yellow shading] Not identified as a COPC in any coal ash data set.
EPRI - Electric Power Research Institute.
USEPA - United States Environmental Protection Agency.
BDL - Below Detection Limit.
CAS - Chemical Abstract Service
CCB - Coal Combustion By product.
CCR - Coal Combustion Residual.
COPC - Constituent of Potential Concern.
COC - Constituent of Concern.
EN - Essential Nutrient.
NA - Not Available/Not Analyzed.
RSL - Regional Screening Level.
(a) - EPRI. 2009. Coal Ash: Characterisitics, Management and Environmental Issues. Electric Power Research Institute, September 2009.
Ranges (10th percentile - 90th percentile) in bulk composition of fly ash, bottom ash, rock, and soil, are presented in the table.
Report No. 1019022. Available at www.epri.com.
(b) - EPRI. 2010. Comparison of Coal Combustion Products to Other Common Materials Chemical Characteristics. Final Report, September 2010.
Report No. 1020556. Available at www.epri.com.
(c) - Data demonstrated statistically to be consistent with background.
(d) - Federal Register / Vol. 75, No. 118 / Monday, June 21, 2010 / Proposed Rules. Hazardous and Solid Waste Management System; Identification and Listing of Special Wastes;
Disposal of Coal Combustion Residuals From Electric Utilities.
(e) - USEPA. 2010. Human and Ecological Risk Assessment of Coal Combustion Wastes. Regulation Identifier Number (RIN) 2050-AE81. USEPA. Draft. April 2010. Table A-3-1. 2002 data.
(f) - Data from USGS. 2011. Geochemical Database of Feed Coal and Coal Combustion Products (CCPs) from Five Power Plants in the
United States. Data Series 635. Available at: http://pubs.usgs.gov/ds/635/ ; Data summarized in ACAA, 2012 available at: http://www.acaa-usa.org/displaycommon.cfm?an=1&subarticlenbr=109
(g) - USEPA. 2012. Regional Screening Levels for Chemical Contaminants at Superfund Sites. November 2012. http://www.epa.gov/region9/superfund/prg/index.html. Values for residential soil.
Where RSL is based on a noncancer endpoint, the RSL is adjusted to a hazard quotient of 0.1 by multiplying the RSL by 0.1. The risk level is 1E-6 where the RSL is based
on a cancer endpoint (arsenic and hexavalent chromium).
(h) - AECOM. 2012. Human Health Risk Assessment (HHRA). Pines Area of Investigation. Final. July 2012. Table 3-10.

TABLE E-3
CONSTITUENT CONCENTRATIONS IN CCRs AND NATIVE MATERIALS
(UNADJUSTED RSLs)
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

	Pines MWSE Data - Suspected CCBs			USEPA RSLs (g)	Pines MWSE Data (h)		USGS Data (f)				EPRI Ash Data							USEPA Data		
				Residential Soil (mg/kg)	Suspected CCBs (mg/kg)		Fly Ash (mg/kg)		Bottom Ash (mg/kg)		Fly Ash (mg/kg)			Bottom Ash (mg/kg)				CCR (d) (mg/kg)	Landfill Waste (e) (mg/kg)	
Constituent	Analyzed in MWSE Data	COPC	COC		Min	Max	Min	Max	Min	Max	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile	Source	mean	50th %ile	90th %ile
Aluminum	X	X		77,000	5,220	44,600	NA	NA	NA	NA	70,000	NA	140,000	59,000	NA	130,000	(a)	NA	25,300	85,700
Antimony	X			31	1.4	1.4	0.982	22.4	0.401	3.2	BDL	BDL	16	BDL	BDL	BDL	(b)	6.32	15.6	46.2
Arsenic	X	X	X	0.39	3.6	97.2	7.3	93.8	1.24	18.1	22	71	261	2.6	7.2	21	(b)	24.7	27.9	105
Barium	X			15,000	47.4	346	336	5,730	474	2,990	381	932	5,064	378	768	3,604	(b)	246.75	222	1,050
Beryllium	X			160	0.63	5.5	1.69	32.7	2.99	10.3	2.2	10.6	26	0.21	5.8	14	(b)	2.8	4.1	17.6
Boron	X			16,000	45.9	151	NA	NA	NA	NA	118	322	1,018	2.7	82	335	(b)	NA	53.5	346
Cadmium	X			70	0.18	4.3	0.312	3.29	0.104	0.425	0.36	1.07	6.2	BDL	BDL	BDL	(b)	1.05	1.08	5.43
Calcium	X			EN	2,810	44,400	NA	NA	NA	NA	7,400	NA	150,000	5,700	NA	150,000	(a)	NA	NA	NA
Chromium	X			120,000	9.8	166	33.7	984	17.5	461	27	133	298	51	191	1,132	(b)	27.8	44.5	166
Chromium (hexavalent)	X	X	X	0.29	0.465	1.95	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	--	NA	NA	NA
Cobalt	X	X		23	1.8	19.5	14.5	264	7.29	55	7.4	7.9	101	NA	NA	NA	(b)	NA	10.2	62.2
Copper	X			3,100	3.1	42.1	55.1	692	40.4	148	62	140	216	39	73	118	(b)	NA	36.1	228
Iron	X	X	X	55,000	6,270	142,000	NA	NA	NA	NA	33,575	69,100	128,838	40,339	101,200	158,850	(b)	NA	NA	NA
Lead	X			400	2.9	117	14.4	293	7.59	40	21	49	143	8.1	20	53	(b)	25	28.7	80.6
Magnesium	X			EN	825	9,500	NA	NA	NA	NA	3,900	NA	23,000	3,400	NA	17,000	(a)	NA	NA	NA
Manganese	X	(c)		1,800	41.8	737	105	966	145	347	91	189	700	85	262	892	(b)	NA	111	510
Mercury	X			23.0	0.01	0.06	0.0127	1.15	0.0123	0.155	0.01	0.11	0.51	0.004	0.018	0.08	(b)	0.18	0.328	1.63
Molybdenum	X			390	0.93	13.2	4.95	90.5	2.15	10.2	9	19	60	4	11	27	(b)	NA	12	34.7
Nickel	X			1,500	3.6	50.7	17.3	572	28.8	255	47	102	231	39	123	445	(b)	32	42.3	329
Potassium	X			EN	291	8,760	NA	NA	NA	NA	6,200	NA	21,000	4,600	NA	18,000	(a)	NA	NA	NA
Selenium	X			390	0.45	3.5	1.03	22.5	0.121	1.28	1.8	11	18	BDL	BDL	4.2	(b)	2.4	5.12	21.4
Silicon	X	(c)		NA	558	3,500	NA	NA	NA	NA	160,000	NA	270,000	160,000	NA	280,000	(a)	NA	NA	NA
Silver	X			390	BDL	BDL	NA	NA	NA	NA	BDL	BDL	7.6	BDL	BDL	BDL	(b)	0.70	1.72	13.7
Sodium	X			EN	116	1,310	NA	NA	NA	NA	1,700	NA	17,000	1,600	NA	11,000	(a)	NA	NA	NA
Sulfur	X			NA	31.7	514	NA	NA	NA	NA	1,900	NA	34,000	BDL	NA	15,000	(a)	NA	NA	NA
Thallium	X	X	X	0.78	0.47	5	0.312	21	0.102	1.96	BDL	2.4	45	BDL	BDL	0.88	(b)	1.75	3.23	20.8
Uranium				230	NA	NA	0.682	34.1	5.27	11	BDL	NA	19	BDL	NA	16	(a)	NA	NA	NA
Vanadium	X	X		390	23.8	89.9	106	1,660	69.4	591	59	254	364	BDL	161	250	(b)	NA	224	907
Zinc	X			23,000	22.4	255	33.1	848	26.5	152	63	152	683	16	59	367	(b)	NA	45.8	293

See notes on page 3 of this table.

TABLE E-3
CONSTITUENT CONCENTRATIONS IN CCRs AND NATIVE MATERIALS
(UNADJUSTED RSLs)
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

	Pines MWSE Data - Suspected CCBs			USEPA RSLs (g)	EPRI Rock and Soil Data						
				Residential Soil	Rock (mg/kg)			Soil (mg/kg)			
Constituent	Analyzed in MWSE Data	COPC	COC	(mg/kg)	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile	Source
Aluminum	X	X		77,000	9,800	NA	96,000	15,000	NA	100,000	(a)
Antimony	X			31	0.08	0.3	1.8	BDL	BDL	1.3	(b)
Arsenic	X	X	X	0.39	0.50	1.60	14	2	5.8	12	(b)
Barium	X			15,000	67	420	1,390	200	500	1,000	(b)
Beryllium	X			160	0.10	1.30	4.4	BDL	BDL	2.0	(b)
Boron	X			16,000	BDL	0.33	220	BDL	30	70	(b)
Cadmium	X			70	BDL	BDL	3.6	BDL	0.2	0.5	(b)
Calcium	X			EN	6,000	NA	83,000	1,500	NA	62,000	(a)
Chromium	X			120,000	1.9	28	309	15	50	100	(b)
Chromium (hexavalent)	X	X	X	0.29	NA	NA	NA	NA	NA	NA	--
Cobalt	X	X		23	0.86	16	53	BDL	7	15	(b)
Copper	X			3,100	10	30	122	5	20	50	(b)
Iron	X	X	X	55,000	8,800	NA	95,000	7,000	NA	50,000	(a)
Lead	X			400	3.8	15	44	BDL	15	30	(b)
Magnesium	X			EN	700	NA	56,000	1,000	NA	15,000	(a)
Manganese	X	(c)		1,800	49	430	1,740	100	300	1,000	(b)
Mercury	X			23.0	0.1	0.7	2.0	0.02	0.05	0.19	(b)
Molybdenum	X			390	0.24	1.6	18	BDL	BDL	BDL	(b)
Nickel	X			1,500	2	18	220	5	15	30	(b)
Potassium	X			EN	4,000	NA	45,000	4,500	NA	25,000	(a)
Selenium	X			390	0.60	1.90	4.9	BDL	0.3	0.8	(b)
Silicon	X	(c)		NA	57,000	NA	380,000	230,000	NA	390,000	(a)
Silver	X			390	0.03	0.9	3	BDL	BDL	BDL	(b)
Sodium	X			EN	900	NA	34,000	1,000	NA	20,000	(a)
Sulfur	X			NA	200	NA	42,000	840	NA	1,500	(a)
Thallium	X	X	X	0.78	0.1	0.5	1.8	0.2	0.50	0.7	(b)
Uranium				230	0.84	NA	43	1.2	NA	3.9	(a)
Vanadium	X	X		390	2.6	52	232	20	70	150	(b)
Zinc	X			23,000	25	72	138	22	50	99	(b)

See notes on page 3 of this table.

TABLE E-3
CONSTITUENT CONCENTRATIONS IN CCRs AND NATIVE MATERIALS
(UNADJUSTED RSLs)
SUPPLEMENTAL SOIL CHARACTERIZATION WORK PLAN
PINES AREA OF INVESTIGATION

Notes:
[green shading] > USEPA Residential Soil RSL.
[yellow shading] Not identified as a COPC in any coal ash data set.
EPRI - Electric Power Research Institute.
USEPA - United States Environmental Protection Agency.
BDL - Below Detection Limit.
CAS - Chemical Abstract Service
CCB - Coal Combustion By product.
CCR - Coal Combustion Residual.
COPC - Constituent of Potential Concern.
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EN - Essential Nutrient.
NA - Not Available/Not Analyzed.
RSL - Regional Screening Level.
(a) - EPRI. 2009. Coal Ash: Characterisitics, Management and Environmental Issues. Electric Power Research Institute, September 2009.
Ranges (10th percentile - 90th percentile) in bulk composition of fly ash, bottom ash, rock, and soil, are presented in the table.
Report No. 1019022. Available at www.epri.com.
(b) - EPRI. 2010. Comparison of Coal Combustion Products to Other Common Materials Chemical Characteristics. Final Report, September 2010.
Report No. 1020556. Available at www.epri.com.
(c) - Data demonstrated statistically to be consistent with background.
(d) - Federal Register / Vol. 75, No. 118 / Monday, June 21, 2010 / Proposed Rules. Hazardous and Solid Waste Management System; Identification and Listing of Special Wastes;
Disposal of Coal Combustion Residuals From Electric Utilities.
(e) - USEPA. 2010. Human and Ecological Risk Assessment of Coal Combustion Wastes. Regulation Identifier Number (RIN) 2050-AE81. USEPA. Draft. April 2010. Table A-3-1. 2002 data.
(f) - Data from USGS. 2011. Geochemical Database of Feed Coal and Coal Combustion Products (CCPs) from Five Power Plants in the
United States. Data Series 635. Available at: http://pubs.usgs.gov/ds/635/ ; Data summarized in ACAA, 2012 available at: http://www.acaa-usa.org/displaycommon.cfm?an=1&subarticlenbr=109
(g) - USEPA. 2012. Regional Screening Levels for Chemical Contaminants at Superfund Sites. November 2012. http://www.epa.gov/region9/superfund/prg/index.html. Values for residential soil.
(h) - AECOM. 2012. Human Health Risk Assessment (HHRA). Pines Area of Investigation. Final. July 2012. Table 3-10.

Appendix F

Gamma Survey – Alternate Calibration Method

Appendix F

Gamma Survey – Alternate Calibration Method

AECOM will conduct count per minute (cpm) to total radium in picocuries per gram (pCi/g) correlations for 2" x 2" NaI gamma scintillation detectors to be used for gamma walkover surveys at the Pines properties. As described in Section 4.3.2.1 of the Work Plan, AECOM intends to use the 10 pCi/g total radium soil source block set at the former Kerr McGee Rare Earths Facility in West Chicago for these correlations. However, in the event that the source block set is unavailable, AECOM will perform the correlation using the following procedure.

F.1 Dose Modeling

Using the MicroShield dose modeling software (Version 8.03 or higher), AECOM will determine the expected gamma exposure rate [measured in microR per hour (uR/hr)] using an infinite slab geometry and a source of 10 pCi/g total radium. To achieve the total radium activity, the modeled source will include 2.5 pCi/g Ra-226 and 2.5 pCi/g Ra-228, each in equilibrium with their respective decay progeny. Model parameters will include:

- Source thickness: 5 cm
- Source density: 1.6 g/cm^3
- Distance to dose point: 7.5 cm (~ 3 in)
- Source: 4 μCi/cm^3 Ra-226 and 4 μCi/cm^3 Th-232 decayed for 10 years to provide approximate equilibrium for Ra-226 and its progeny and Ra-228 and its progeny.

The output of the MicroShield model is gamma exposure rate in mR/hr. With the inputs above, the modeled exposure rate is 6.8 x 10^{-3} mR/hr or 6.8 μR/hr.

F.2 Correlation

To determine the cpm-to-pCi/g correlation, exposure rate in uR/hr obtained from the MicroShield analysis is multiplied by the expected 2" x 2" NaI instrument response provided in Table 6.4 of NUREG-1507. This table includes the following correlation factors:

Material	Weighted cpm/uR/hr
Ra-226 (In equilibrium with progeny)	760
Th-232 (Sum of all radionuclides in thorium decay series, in equilibrium – including Ra-228)	830
Average	795

Because the project needs to correlate total gamma count rates to total radium in soil, AECOM will use the average of the two values above in the following final correlation equations. A table providing some specific count rates and approximate total radium activities is also provided.

$$Measured\ total\ cpm\ \times \left(\frac{1}{795}\ \frac{\frac{\mu R}{hr}}{cpm} \times \frac{5\frac{pCi}{g} Total\ Ra}{6.8\frac{\mu R}{hr}} \right) = Approximate\ Total\ Ra\ Activity\ \left({}^{pCi}/_{g} \right)$$

$$Measured\ net\ cpm\ \times \left(9.45 \times 10^{-4}\ \frac{{}^{pCi}/_{g}}{cpm} \right) = Approximate\ Total\ Ra\ Activity\ \left({}^{pCi}/_{g} \right)$$

Total Gamma Counts (cpm)	**Total Radium (pCi/g)**
1000	1.0
2000	1.9
3000	2.8
4000	3.8
5000	4.7
6000	5.7
7000	6.6
8000	7.6
9000	8.5
10000	9.5
11000	10.4

The correlation above assumes that all detected gamma activity in the field is from Ra-226, Ra-228 and their progeny. This is a conservative assumption given that there are other naturally occurring isotopes such as K-40.

About AECOM

AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With approximately 45,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation, and collaborative technical excellence in delivering solutions that enhance and sustain the world's built, natural, and social environments. A *Fortune 500* company, AECOM serves clients in more than 130 countries and has annual revenue in excess of $8.0 billion.

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250 Apollo Drive, Chelmsford, MA 01824
978-905-2100
www.aecom.com